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CREEL CENSUS, SPAWNING ENUMERATION AND OTHER STUDIES OF KOKANEE IN THE KATHLEEN LAKE DRAINAGE, KLUANE NATIONAL PARK, YUKON.

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CONTENTS

ABSTRACT

A study was made of the land locked sockeye salmon, or kokanee, (*Oncohorynchus nerka*), in the Kathleen lakes drainage in Kluane National Park, Yukon, during 1980 and 1981. Information on a neighbouring population in Frederick Lake in the upper Dezadeash River drainage was compared. Natural distribution, which is confined to these two drainages in the Yukon, is outlined and possible origins are discussed, the most likely of which stems from previous glacial ice blockages on the Alsek River. The biology of the kokanee in this drainage is outlined and compared with that from other areas, the most prominent features being its average five year life cycle and large size at maturity. Comparative details are given about its spawning biology. The physical, chemical and biological features of the stream habitats of this species in both drainages is outlined with reference to other work.

These waters are northern in latitude (60^{o}), moderately high in altitude (681-789 m a.s.l.), have relatively mean depths (55.2-17.3 m), low TDS (summer means approximately 160-150 umhos/cm) and low summer mean temperatures (^{o} C.), indicating that the waters are oligotrophic and relatively unproductive.

Results of a two year creel census are discussed, showing that angling pressure has increased slightly over the study period and the number of kokanee harvested more than doubled rising from 164 to 386 in 1981, which reflects the increase observed in the adult population spawning that year.

Spawning enumeration carried out since 1975, shows that the population increased from a low of slightly more than 1000 in 1975 to 3,600 in 1978 and fluctuated around 4,000 until 1981 when it almost doubled to 7,200 spawning adults.

Previous interim management measures appear to have been effective in aiding the population increase, which may continue to rise for several more years, although saturation of the best spawning areas is believed to be occurring, which should eventually limit the numbers.

ACKNOWLEDGEMENTS

I wish to thank the staff of Kluane National Park for the numerous contributions to this project. Although initial investigations carried out prior to this more recent work were started under previous Park staff members who have since retired, I would nevertheless like to express my thanks to two of these. Former superintendent, S. Rolfson, took particular interest in the fish resources and park warden, Jack Christiansen, provided initial background information about the kokanee during our numerous talks. Both of these men along with Chief Warden, Larry Trembly were responsible for the rapid application of the interim management guidelines in 1975 which I feel provided the turning point for the subsequent rise in the kokanee population. In this regard, Mr. G. Wickware, formerly of Parks Canada's regional office in Winnipeg, also contributed by recognizing the need for rapid application of interim guidelines.

The present Park staff have also contributed to the conduct of the project: Mr. Jim Maysk, present superintendent, has always allowed time in his busy summer schedule to discuss the progress of the field work routinely, and has generously, congenially provided for the assistance of his staff and facilities.

Mr. Larry Trembly, Chief Warden, has been on staff since the Park's organization, and has over the years willingly provided material, transportation, manpower, encouragement and discussion through all various aquatic studies, besides this one. Many of the wardens on his staff, in particular, Mr. Lloyd Freese, who has also been on staff since the Park's beginning, has over the years provided assistance on many field trips and has continued the kokanee enumeration and other measurements after my departure from the field in the autumn. Mr. Ray Frey, has been particularily helpful in arranging the use of Park facilities and providing extra help when needed.

Other park staff have also contributed; the office staff for handling mail, ~~mail~~, messages and typing various ~~drafts~~ items. The interpretive and visitor services staff helped in many ways and took an active interest in the work, often integrating my summer field work into their programs for visitor interest.

As well as the Park staff, many of the local people co-operated in the project by allowing their fish catches to be sampled and related many minor but important observations about the fish, the lake and angling. Collectively this information has been most useful. In particular, I wish to thank Mr. Rod Tait, one of the most ardent and knowledgeable fishermen, Mr. Frank Kovack and his family who always permitted us to sample his catch and that of his guests. Much of the creel information came from their catches. Mr. Bill Magnusson and his family and guests were equally co-operative; in particular, Mr. Magnusson's extensive personal knowledge of Kathleen Lake was most interesting since it extends back into the late 1940's. Mr. Keith Weller and his wife Fran also helped in various ways. All of these families were extremely hospitable to the field staff over the course of the summer work. To Brent Liddle and Doug Thomas, who as neighbours during the two summer seasons, aided the kokanee work in numerous ways, and extended commraderie.

I wish also to thank my assistants, Mr. Clare Hawkins, for his energetic help and cheerful companionship in the field and Mr. Bob Hutchison for his perseverant and accurate data compilations.

Finally, but not least, I wish to thank Mrs. Donna Wilson and Mrs. Frances Zdrill for typing the manuscript.

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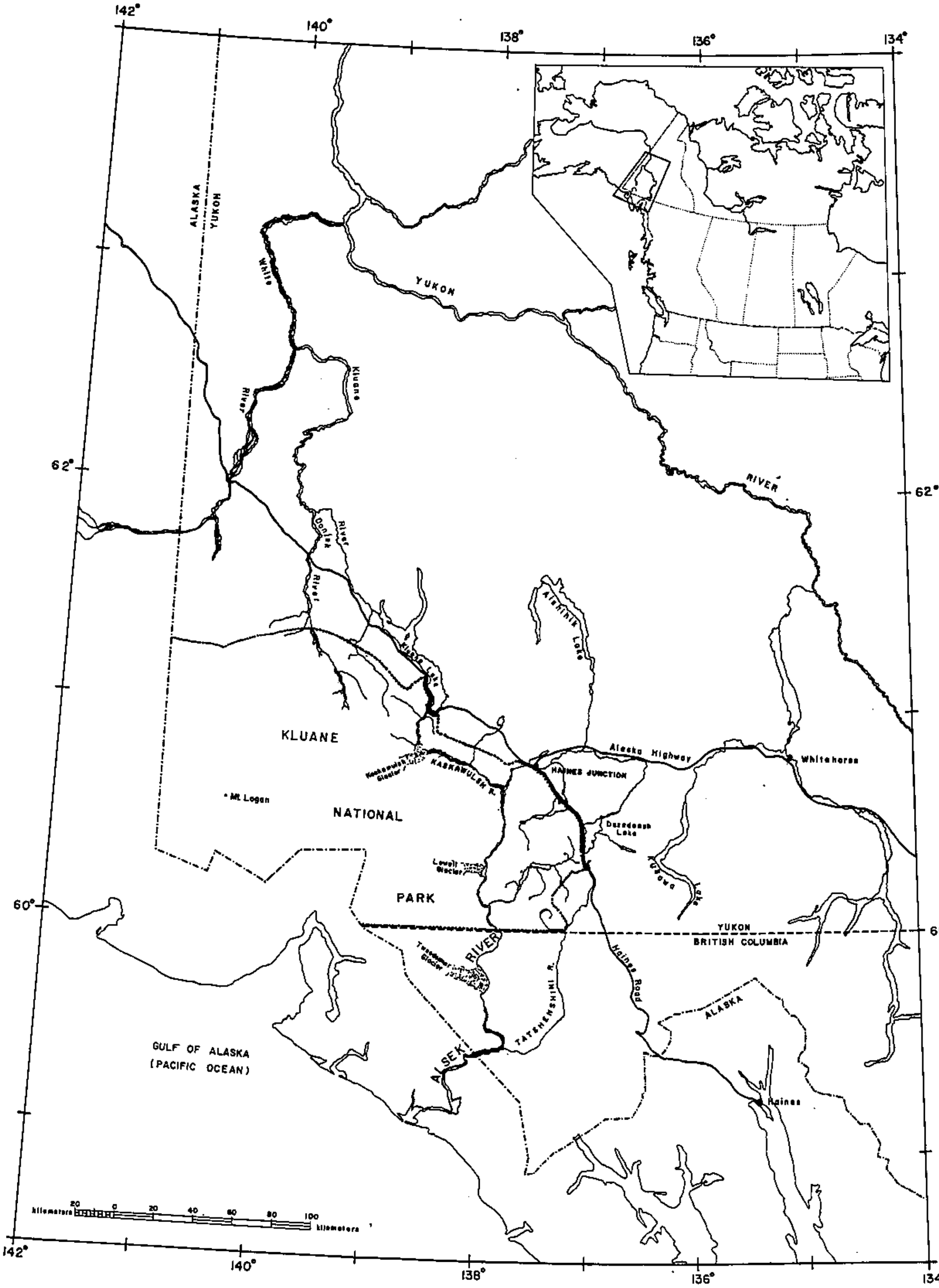
INTRODUCTION

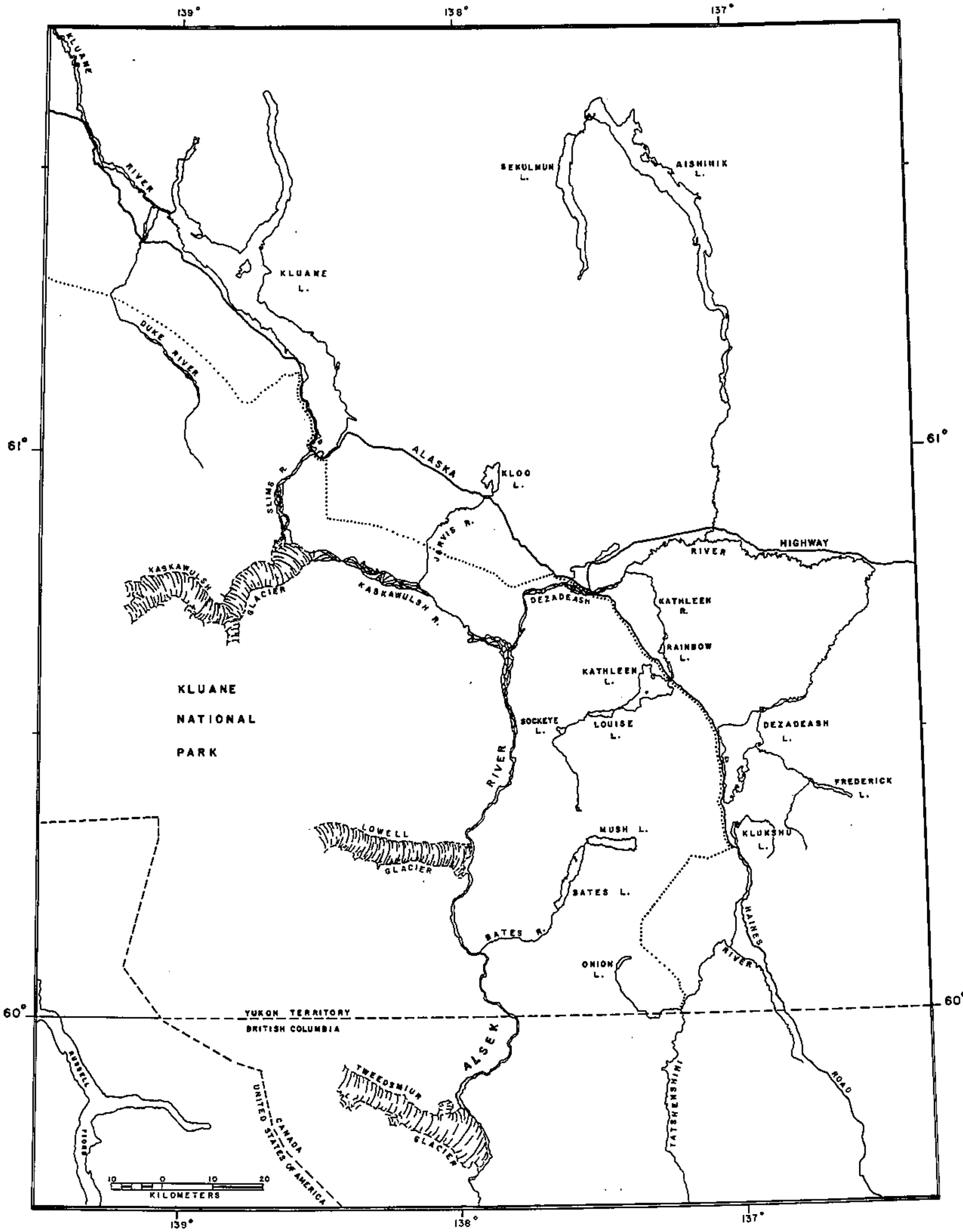
Kokanee are the landlocked variety of sockeye salmon (*Oncorhnchus nerka*) and many populations of this freshwater form are known from natural locations along the Pacific coast and from introductions to various waters throughout North America (Scott and Crossman, 1973).

The population of kokanee found in the Kathleen Lake drainage in Kluane National Park, and in Frederick Lake, Yukon Territory, adjacent to the Park, (Maps 1 , 2), is the only naturally occurring population in the Yukon (Clark, 1946, Wynn-Edwards, 1947). In addition, this population has an unusual origin in this drainage, resulting from great natural physical processess, which will be discussed below. Because of these features of its origin and limited distribution the fish is unique to the Yukon and Park where its occurrence provides a subject of interpretive value of the physical and biological processes interacting in the Southwest Yukon.

During the course of an initial aquatic survey of Kluane National Park between 1973 and 1976 (Wickstrom, 1978) the kokanee which occur only in the upper three lakes of the Kathleen Lake drainage (Map 2) were found to have decreased drastically in relative abundance (Wickstrom, 1977). Kathleen, Louise (Upper Kathleen) and Sockeye lakes had an acceptable proportion of kokanee when first test netted in July, 1973. Later, in 1975, when an initial attempt to prepare a special report on the biology of kokanee in the Park was begun, a decrease in relative numbers and proportion of kokanee was discovered. In 1973, 93 kokanee were netted, representing 27.3% of all species in the catch. In 1975, only 11 were caught, comprising 4.3% of the total catch. Active study was stopped at this time because it was felt that any further stress, especially by



MAP 1 Location of Kluane National Park in southwest Yukon.



Map 2. Location of Sockeye, Louise, Kathleen and Frederick lakes.

netting, may have been fatal to the population. Observations on the spawning grounds where total spawning adults could be enumerated, commenced as a method of passive study.

These findings were reported to Parks Canada and temporary management measures were recommended and instituted until an in-depth study of the situation could be made. Essentially, waters above Louise Lake were closed to all fishing and the daily catch and possession limit was reduced from 10 to 2. These findings, correspondance and interim management measures are noted in a report on the status of kokanee in Kluane Park by Wickstrom (1977).

Their vulnerability to disturbance and harvest by anglers, made the need for understanding and management a high priority. Although the biology of kokanee is generally known for populations in more southern latitudes, little specific information is known about those in the Kluane area. As an example, kokanee are normally found to have a four year life cycle while those in Kathleen Lake usually have a five year cycle.

Since 1975, when the interim management measures were effected, the size of the spawning population has been monitored passively and it appeared in the following years that the numbers began increasing steadily, with fluctuations, until in the late '70's it seemed strong enough to permit further study.

The present report records the findings of a two year project to study the kokanee, commensing in May 26th, 1980, and concluded in the field, September 13th, 1981.

The purpose of the study was to collect and analyse biological and limnological information needed to expand our understanding of kokanee in Kluane Park and its nature as a vulnerable resource of questionable strength. By incorporating data from previous limnological work and other aquatic studies, together with information on life history population dynamics and creel census data gathered in this study, this report compiles what is known about the kokanee in this area and its present status in the Kathleen Lake drainage. This will provide the basis for preparation of a kokanee management plan.

Study Area

Location and Terrain

Kluane National Park is located in the southwest Yukon, boardering Alaska on the west and British Columbia on the south (Map 1). Although the southern most boarder of the Park is barely [illegible] ~~20 miles~~ from the Pacific Ocean at its closet point, it is separated from the coast by the St. Ellias Mountains, the highest range in North America, with numerous peaks over 4,572 m.

Kluane Park comprises an extensive area of mountainous terrain lying at high elevation, most of which is perpetually covered with ice and snow, fed by precipitation of snow from moist sea air, form the source for the many large valley glaciers flowing into the lower valleys. The interior Park climate is cold in the winter with short warm summers, a mixture of a slight maritime climate and continental arctic (Webber, 1974). Mean annual temperature for Haines Junction (584 m a.s.ℓ.), 32 km north of Kathleen Lake, is -3.0° C. Mean daily temperature for July is 11.8° C and for January, [illegible] ° C. Haines Junction has only 21 frost-free days, 282 mm of annual precipitation (163 mm rain, 1282 mm snow), 8.4 hours of bright sunshine in July and .7 during January.

Upper winds are westerly while surface winds are very much influenced by relief. Katabatic winds caused by large valley glaciers are particularly evident in Slims River, Alsek River and Kathleen Lake Valleys.

Average evaporation from May to September at Haines Junction was 421 mm which is approximately 3 times the average precipitation. This value is not unusual compared to typical prairie evaporation rates which are twice this amount.

The geologic composition of the drainage area consists primarily of sedimentary and volcanic materials. Much of the lower levels are overlain with lacustrine or fluvatile deposits, largely the work of past glacial periods.

Tree line is generally around 1016 m a.s.ℓ. and the lower slopes of the montane zone of the eastern valleys are forested primarily by white spruce, although marsh, fern, shrub, herb and other vegetation types also occur within this zone. Forested lowland valleys lie along the eastern and northern periphery of the Park, and follow corridor-like projections of river and glacial valleys into the interior through gaps in the frontal ranges. The major lakes and streams lie along these valleys.

Drainage

The present drainage of the southwest Yukon reflects the passage of previous glacial periods. An outline of their occurrence, past drainage and its effect on present fish distribution in the southwest Yukon is given by Lindsey, 1975 and for the Kluane area by Wickstrom, 1977, 1978.

The Kluane region is drained by two principle river systems, the Yukon and Alsek. All waters of the northern slopes unit to form the White River, a major tributary of the Yukon River system which ultimately empties into the Bering Sea (Map 1). The Alsek system drains the eastern and southern area of Kluane Park and adjacent terrain, and is noteworthy as the only major river of the Yukon discharging its waters into the Pacific Ocean (Map 2). Kathleen River, with its chain of lakes, including Kathleen, is a medium sized tributary of the Alsek drainage via the [illegible] (Map 2).

Two upper lakes, Sockeye and Louise, drain into Kathleen Lake. This three lake chain is navigable for fish, but boat traffic cannot continue beyond the upper end of Louise Lake. This chain in turn is drained by Kathleen River, a tributary of the Dezadeash/Alsek rivers. Kathleen River below the lakes has a falls/rapids near its confluence with the Dezadeash that imposes a restriction to the upward movement of fish from the lower drainages.

Distribution of Kokanee

General

The natural distribution of kokanee is thought to be present over most of the range of sockeye salmon, which extends along the Pacific coast from northern California to the northern part of Alaska. Stragglers have been known along the Arctic coast as far east as Bathhust Inlet (Scott & Crossman, 1973). Sockeye salmon also occur naturally in Asia, from northern Japan to USSR.

Apart from their natural range, kokanee have been widely introduced in North American, from eastern regions through the mid-west and prairies.

Southwest Yukon

Naturally occurring population of kokanee are found in only two water systems in the southwest Yukon, the Kathleen Lake drainage and Frederick Lake. Both of these drainages are adjacent to each other and tributary to the Alsek River via the Dezadeash. Neither system has a sea-run population in the drainage at present. Anadromous sockeye are not known to run up the Alsek past the Tatsenshini River which is a salmon stream, although numerous unconfirmed reports suggest this. These reports, some by local residents, say that kokanee have been seen in the upper Alsek and lower Dezadeash. However, this has never been confirmed over a 10 year period during continued studies in the local area. It remains as speculation.

Anadromous sockeye salmon utilize the headwaters of the Tatsenshini River for spawning in Klukshu and Neskeetaheen lakes, the former of which lies just south of the height of land separating it from the upper drainages of the Alsek/Dezadeash rivers (Map 2).

The kokanee population found in the Kathleen lakes drainage occurs only in Kathleen Lake and its upper two tributaries, Louise and Sockeye lakes. All three lakes and their drainage areas lie within Kluane National Park. Each lake appears to have its own resident population. None of the tributaries to the lakes, in particular, the three small lakes of the ultimate tributaries to Sockeye Lake, are known to have kokanee. Kokanee are occasionally caught in the outlet stream of Kathleen Lake, although they are not believed to normally occur below the lake, but stray downstream.

Kokanee do not normally utilize the cold, fluctuating streams forming the upper tributaries of Sockeye Lake (Map 2), although strays have been observed in Cottonwood Creek. These streams, some of which drain small ponds and lakes further upstream, are shallow and have little cover. Small cataracts may impede or prevent fish movement upstream to these lakes, except in times of very high flow. These lakes in turn are also not known to have kokanee, although precise information on their fish fauna has not been made on all of them. The highest, Cottonwood Lake, is a small lake (28 ha) in the subalpine zone with adjacent ponds. When netted in 1976, it contained arctic grayling and lake trout. None of the much smaller lakes in this group were investigated. Appearing quite shallow, although they may, in fact, support a small population of fish, but very doubtfully, kokanee.

The other small lake tributary to Sockeye Lake via Cottonwood Creek is Johobo Lake, a small lake of 26 ha and shallow depth. Although it has not been test netted, it is unlikely to support fish because of its shallow depth and extensive amounts of aquatic vegetation which, it is presumed, would cause winter kill conditions. Reports from longstanding local residents have never suggested that kokanee or other species use this water. It is possible that during the operation of Johobo mine, which was adjacent to the lake, that workmen may have attempted to stock this lake, although this is only speculation, since no evidence is known.

A third and final lake is tributary to Sockeye Lake. Campsite Lake (13 ha) is a small lake lying in the sub-alpine zone west of the lake. A small outlet stream, undoubtedly seasonal, flows down a steep grade to the marshy western bay of the west side of Sockeye Lake. Its channel at this point becomes indefinite, difusing into the marsh on the west side of Sockeye Lake. The lake is believed to be fishless.

The second population of kokanee in the southwest Yukon occurs in Frederick Lake, near Kluane Park and also tributary to the Alsek (Map). Frederick Lake lies southeast of Kathleen Lake and is an upper tributary of Dezadeash Lake which drains via the Dezadeash River, a moderately sized tributary of the Alsek River. Kathleen Lake and its upper lake chain are also tributary to the Dezadeash River. A small rapids/falls on the Lower Kathleen River (Plate) prevents the upward movement of fish from the Dezadeash River. From observations, it may be possible for fish to navigate this barrier in high water, but not during normal flows. Both Dezadeash and Frederick lakes are open to fish navigation from the lower drainages of the Alsek.

Plate The falls on the lower Kathleen River, which are about 1.5 - 2.0 m high, are shown in mid August during moderate flow condition.s

Frederick Lake is fed, principally, by an inlet stream at the east end, arising from a series of small lakes in the alpine zone much higher in the drainage. Although these lakes contain lake trout, no kokanee were found. The present upstream movement of fish from Frederick Lake is blocked several hundred yards above the lake by a cataract. Kokanee are believed to be resident in the lake only.

No other kokanee populations are known in the southwest Yukon. Other fish distribution is given by Lindsey, 1975 and Wickstrom, 1977, (Tables 7 & 8).

Origin of kokanee populations

Several theories for the origin of the kokanee populations in the Kathleen and Frederick lakes drainages have been proposed. The most widely held is that an ice blockage occurred on the Alsek River (c.a.1850) (c.a.1725). Blockage was caused by the foot of the Lowell Glacier which thrust across the Alsek during a Neoglacial surge of the glacier (Kindle, 1952) (Map 2). This ice lobe abutted into the foot of Goatherd Mountain which rises about 750m above the Alsek at this point (Plate 3). The thickness of the ice must have been considerable at this time as perhaps evidenced by the high level kame visible on the left hand side of the present glacier as shown in the photograph (Plate). An elongated lake arose and filled the Alsek, Dezadeash and Kaskawulsh valleys; this lake was named Recent Lake Alsek (Kindle 1952). This process has occurred at least twice in the recent past: an earlier first phase approximately 250 B.P. (c.a.1725 A.D.) and the more recently, approximately 125 B.P. (c.a.1850 A.D.). Water rose to a maximum elevation of approximately 682 m (2,240') ASL in the earlier phase (80 m or 265' above present river level) and 642 m (2,105') ASL the last time. A series of wave-cut beaches are still easily observed throughout the flooded area (Plate). Some lower beaches are still littered with windrows of driftwood, which does not occur above 642 m (2,105'). Well established spruce trees grow on the upper beaches; little vegetation occurs below 640 m and much younger spruce grow well only in favoured localities. McConnell (1905) was the first to note the beaches, and information from local natives and his own observations of the vegetation in the valley led him to believe the lake responsible for cutting the beaches had been very recent.

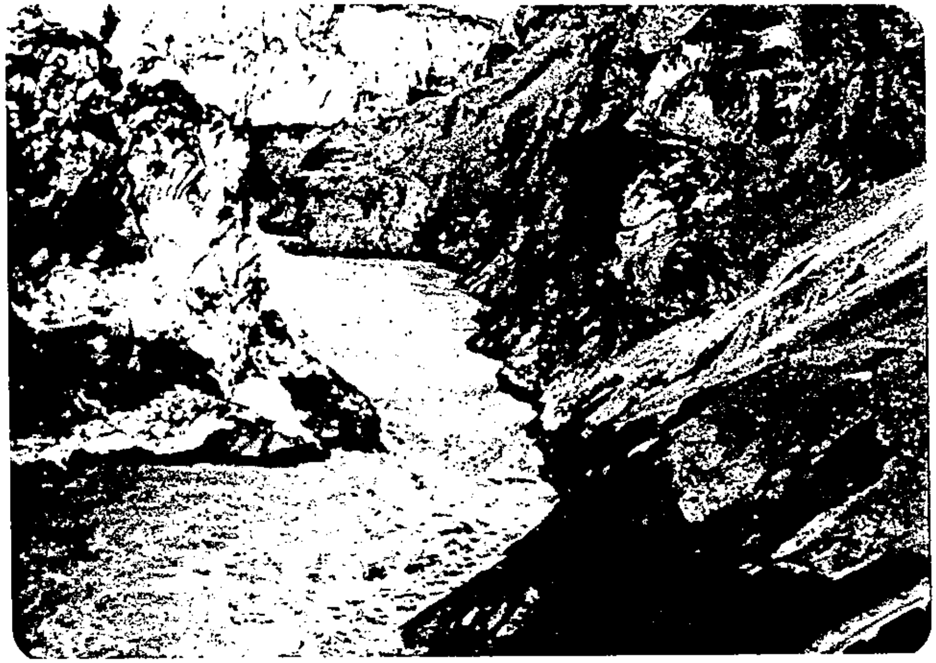


Plate Tweedsmuir Glacier threatening to block the Alsek River in 1974. The width of the river which appears narrow, is deceptive. Further upstream, the Lowell Glacier blocked the Alsek in recent times, causing large river valley lakes.

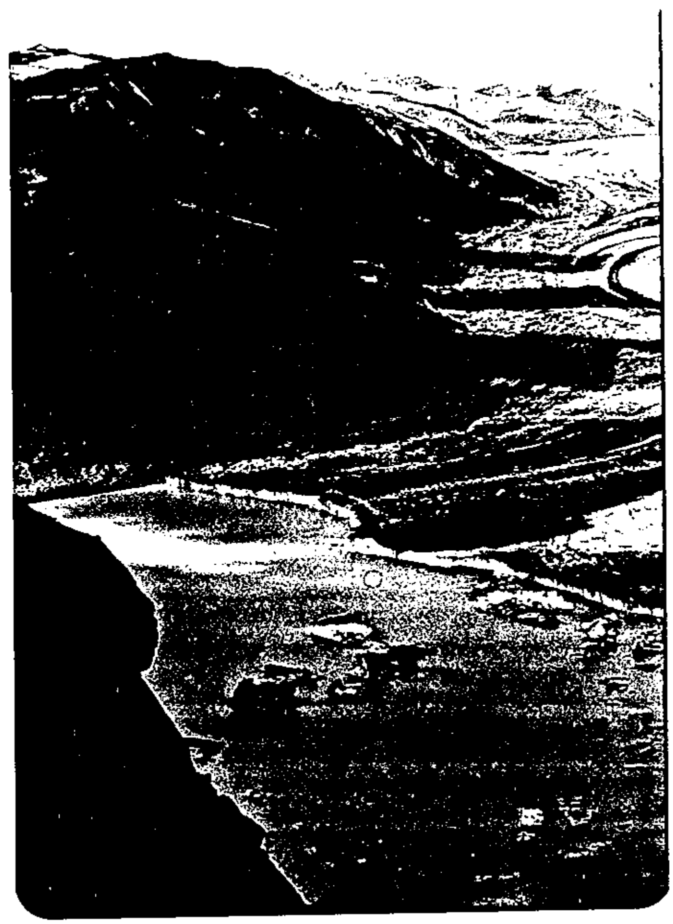


Plate Lowell Glacier meeting Alsek River at foot of Goatherd Mountain, 675 m below. Elevated strand visible along left side of glacier valley indicates previous thickness of ice.

The extent of Recent Lake Alsek can be traced upstream along the Dezadeash River Valley; however, this lake did not reach Dezadeash or Kathleen lakes. It inundated the lower part of Bear Creek and an arm extended to Pine Lake; this arm left the hill on which the present Experimental Farm site is situated as an island. The lake extended 13 km up Kaskawulsh River beyond its confluence with the Alsek. Large granitic rocks and sedimentary boulders were ice-freighted from Lowell Glacier and presently lie strewn over the former basin of Recent Lake Alsek.

In earlier times, as native information suggests, sea-running salmon migrated to the headwaters of the Kathleen and Dezadeash rivers for spawning (Wynn-Edwards, 1947). Bear Creek was one such stream ( ). The ice dam is supposed to have prevented the anadromous sockeye from leaving or returing to spawn. Today the Alsek discharges to the sea without blockage (except for the turbulent gorge of Turn Back Canyon at the foot of the Tweedsmuir Glacier which is threatening to block the Alsek (Plate), but its headwaters have not been re-exploited by sea-running salmon (although they utilize the Tatshenshini River, a lower tributary of the Alsek), nor have the land-locked kokanee of the Kathleen or Frederick lakes returned to anadromous behaviour.

The turbulent waters of Turn Back Canyon have been thought to present a hydrology barrier on the Alsek River above the Tatshenshini River confluence which prevents re-exploitation or migration at present. Wynn-Edwards(1947) made an aerial reconnaissance of the Alsek River above the Tatshenshini and did not feel that the canyon presented a barrier suspecting a falls downstream which were reported at the time but do not exist, to be the cause for the present lack of anadromous salmon in the upper Alsek. Later, another investigator made aerial observations of Alsek hydrology in the vacinity of the Tweedsmuir Glacier and suggested that velocity barriers make it impassable to fish (Alaska Department of Fish and Game, 1962). During the course of earlier limnological work in Kluane Park, in 1974, the writer also made aerial observations of the Alsek below Lowell Glacier to the Tweedsmuir and felt that the currents present at this time were ~~considerably~~ less than those observed at some places in southern British Columbia which are navigated by salmon.

A second explaination for the origin of the kokanee populations in Kathleen and Frederick lakes as suggested by Clark (C.H. Clark, in Wynn-Edwards, 1947), considers headwater capture between Klukshu Lake and adjacent Dezadeash Lake (Map 2). Klukshu Lake still has anadromous sockeye salmon which return each year via the Tatshenshini, a lower tributary of the Alsek. The Dezadeash and Klukshu lakes watersheds are separated by a narrow height of land. Anadromous salmon may have gained access to Dezadeash Lake by crossing a low, swampy height of land which separates the lakes. This common height of land area contains several small ~~lakes~~ ponds and marshes which appear~~ed~~ to have ambiguous drainage. The indefinite drainage of the area was conspicuous. When low level aerial observations were made by the writer in 1975 and 1978. Once into Dezadeash Lake, kokanee would then have access to Frederick Lake and possibly to Kathleen Lake if the previously mentioned rapids/falls could be navigated during high water times.

* * *

HABITAT

Lakes

General

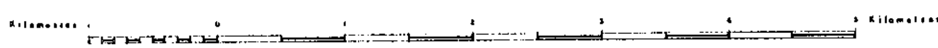
The lakes habitat for kokanee in the Kathleen and Frederick lakes drainages all share similar characteristics in their physical, chemical and biological composition. The four lakes, Kathleen, Louise, Sockeye and Frederick are lakes lying in the wooded montane zone of lower mountain valleys.

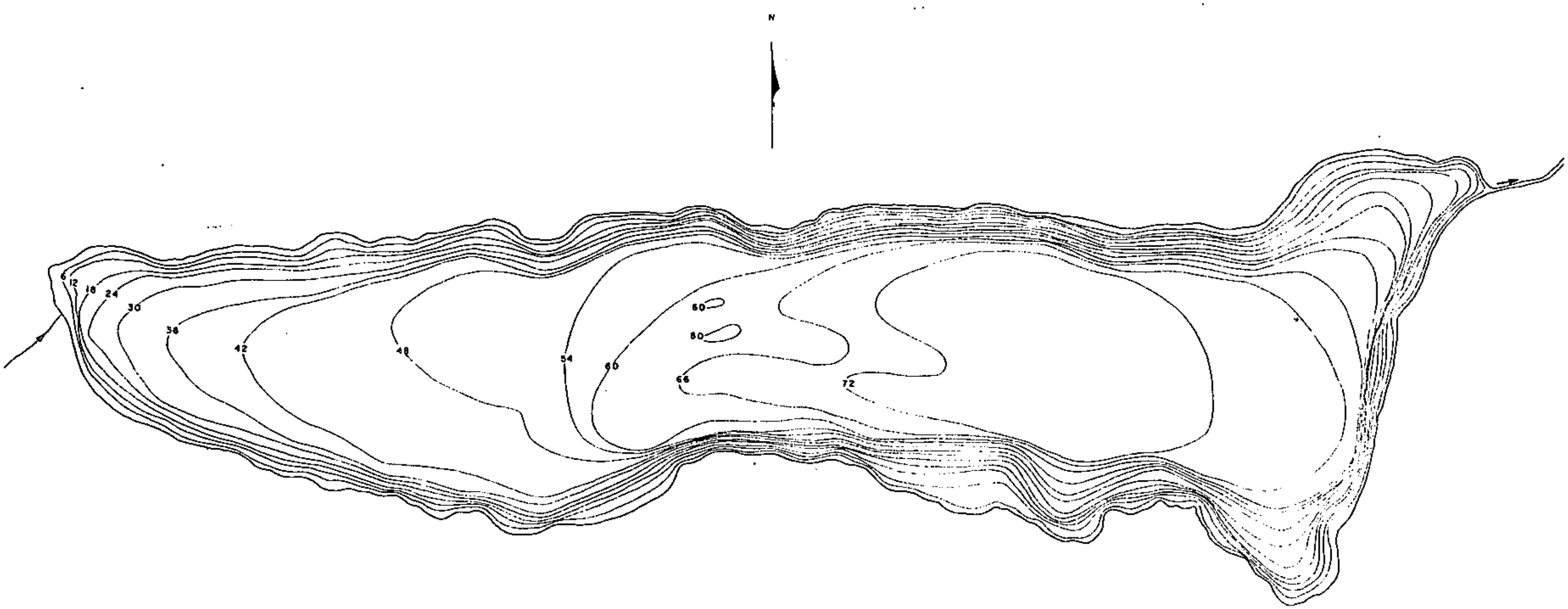
Physical Setting

Kathleen Lake, located at 60° 35' N. 137° 18' W. and 681 m a.s.l., is the largest lake in Kluane National Park (3376 ha) with maximum and mean depths being 111 m and 52.2 m respectively (Maps 2 &). Most of the lake consists of a large open expanse, with a smaller western basin, and a medium sized bay on the north shore. One solitary island is situated near the junction of the main body with the western basin. Much of the northeast portion of the lake is relatively shallow, while the south side and west basin are deepest. Steep mountain slopes form the shores on the northwest and southeast sides. The shoreline development is 2.07. The large expanse of open lake is almost perpetually swept by western katabatic winds generated by the proximity of the large Lowell Glacier, approximately 40 km to the west. These incessant winds are a very significant factor in angler use and in the continual mixing of the waters, elevating the temperature of the hypolimnion.

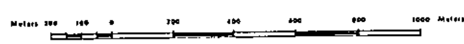
Louise Lake, located at 60° 32' N. 137° 28' W. is the middle lake of the Kathleen Lake drainage chain, lying at 739 m a.s.l. It is also known as Upper Kathleen Lake in some earlier reports and publications and part of the Kathleen Lake: on National topographic maps. Although the surface area of Louise Lake (490.3 ha) places it as the

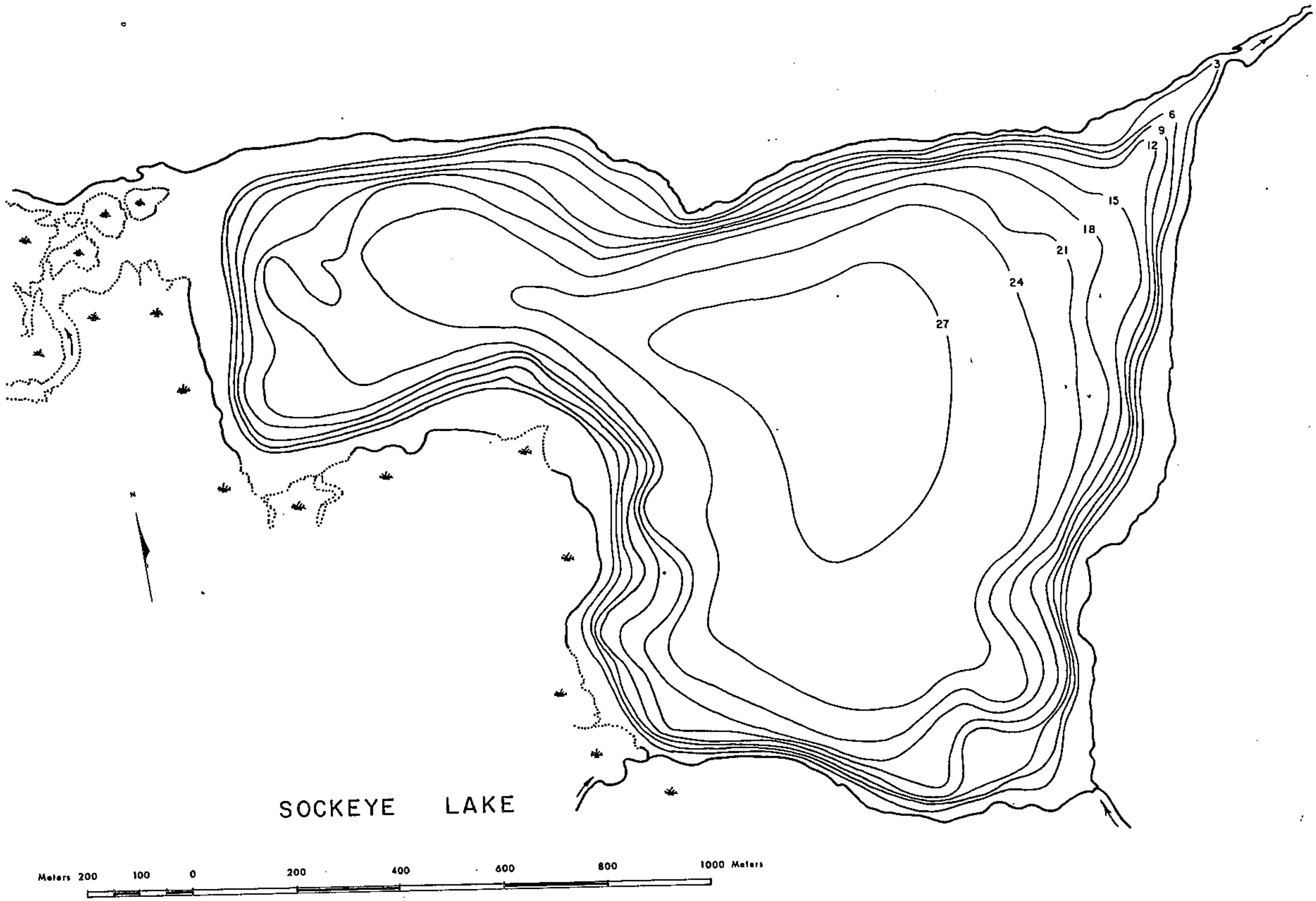
KATHLEEN LAKE





LOUISE LAKE





SOCKEYE LAKE

fourth largest lake in Kluane Park, it is the second deepest (76.5 m), having a mean depth of 47.6 m. The lake is rectangular in shape and has a uniform basin (Map 4) and low shoreline development (1.65).

Sockeye Lake is located at 60° 30' N. 137° 37' W. and is the uppermost (789 m a.s.l.) and smallest lake (72.8 ha) in the three lakes chain utilized by kokanee. Maximum depth is 27.4 m and mean depth is 17.3 m (map 5). The lake is fairly regular in shape, with a shoreline development of 1.58.

Frederick Lake, located at 60° 24' N. 136° 40' W. lies at 716 m a.s.l. in a small wooded upper valley running somewhat perpendicular to the main direction of the broad Shakwak Trench. Frederick Lake lies to the east of Dezadeash Lake, outside Kluane National Park. The main tributary ~~of the lake is a~~ stream entering at the east end, ~~which~~ arises from a series of small, high alp~~h~~ine lakes lying well above treeline. Another smaller inlet from the south, arises in a swampy area located along the height of land separating it from neighbouring Klukshu Lake. Frederick Lake has a surface of 508.1 ha and a maximum depth of 23.5 m (Lindsey et al., 1981).

Shoreline Substrate

The basins of all four lakes were formed by glacial scouring during the previous Wisconsin ice period; glacial debris and end morraine material forms part of their shores while mountain slopes comprise the shore in other places. Shoreline substrates are composed of various combination of sand, gravel, cobble, mud/silt and rock out-croppings, in general appearing suitable for shore and shoal spawning.

Littoral extent

Generally, the extent of the littoral zone is reduced in these lakes. Kathleen Lake has north eastern shallows and Louise is shallow only in the westend. Sockeye Lake has the most extensive littoral area of the four, with a large marsh forming a western bay on the lake. Off-shore slopes are generally steep in Frederick Lake, limiting the extent of littoral area.

Little information is available on annual lake levels, although they are known to be highest, usually in late June as snowmelt from the mountains reaches a maximum. Levels have been recorded over a 9 year period from Kathleen Lake during the summer months on an intermittant basis and less frequently from Louise and Sockeye lakes. Summer fluctuation from Kathleen Lake are usually about 500 mm (Table) although record high levels were recorded in 197_, with a recorded summer seasonal fluctuation of mm.

Ice Cover

Dates of ice cover formation are unknown exactly and vary considerably because of their different heat capacities. Sockeye freezes first, around early November, while freeze-up is known to occur in Kathleen Lake in mid to late December, which is unusually late for a lake at this northern latitude and elevation. Break-up for these lakes is more normal, and all four lakes open in mid to late May or early June.

Table Physical measurements of Kathleen Lake, 1980.

Date	Benchmark[1] Island	Dock	Conductivity (µmhos/cm^2)	Surface Temp. (°C)	Secchi Disc (m)	Water Profile
May 30	1200	-	127.0	4.0	-	-
Jun 7	960	-	-	-	-	-
Jun 8	-	-	149.0	7.5	20.6	P
Jun 9	740	742	-	-	-	-
Jun 12	-	620	-	-	-	-
Jun 15	-	630	-	-	-	-
Jun 21	-	770	-	-	-	-
Jun 22	-	790	-	-	-	-
Jun 27	-	790	150.0	7.9	12.5	P
Jul 2	-	815	-	-	-	-
Jul 7	-	810	-	-	-	-
Jul 13	-	880	-	-	-	-
Jul 21	-	895	165.0	12.0	12.6	-
Aug 4	-	960	-	-	-	-
Aug 15	1035	-	152.0	10.2	-	P
Aug 24	1025	-	150.0	10.0	16.1	-
Sep 2	1070	1120	-	-	-	-

[1] Distance of benchmark (brass screw) above water surface. Locations of B.M. described in text.

Table   Physical measurements of Kathleen Lake, 1981.

Date 1981		Benchmark Island (mm above water)	Dock	Conductivity (μmhos/cm)	Surface Temp. (°C.)	Secchi Disc (m)	Water Profile Made
Jun.	3	920	1300	-	-	17.5	-
	6	895	1290	148.0	6.2	19.25	P
	12	915	1315	144.0	6.8	18.5	P
	15	885	1290	-	-	-	-
	19	885	1270	-	8.2	18.5	P
	22	870	1270	-	-	-	-
Jul.	1	900	1310	-	7.8	-	P
	5	910	1305	162.0	-	18.5	-
	12	930	-	167.0	10.0	17.8	-
	17	910	1295	155.0	9.2	-	P
	22	880	1280	171.0	12.8	-	P
	24	890	1290	161.0	9.8	-	P
	27	910	1310	164.0	10.4	15.7	P
Aug.	4	960	1365	156.0	9.8	-	P
	11	-	-	165.0	-	-	-
	16	-	1400	-	-	-	-
	17	1000	1410	166.0	9.7	16.0	P
	23	1015	1415	179.0	9.5	17.25	P
	31	-	-	178.0	10.4	-	P
Sep.	2	-	1415	-	-	-	-
	8	1036	1415	-	-	-	-
	12	-	1410	168.0	9.5	-	-

Thermal Development

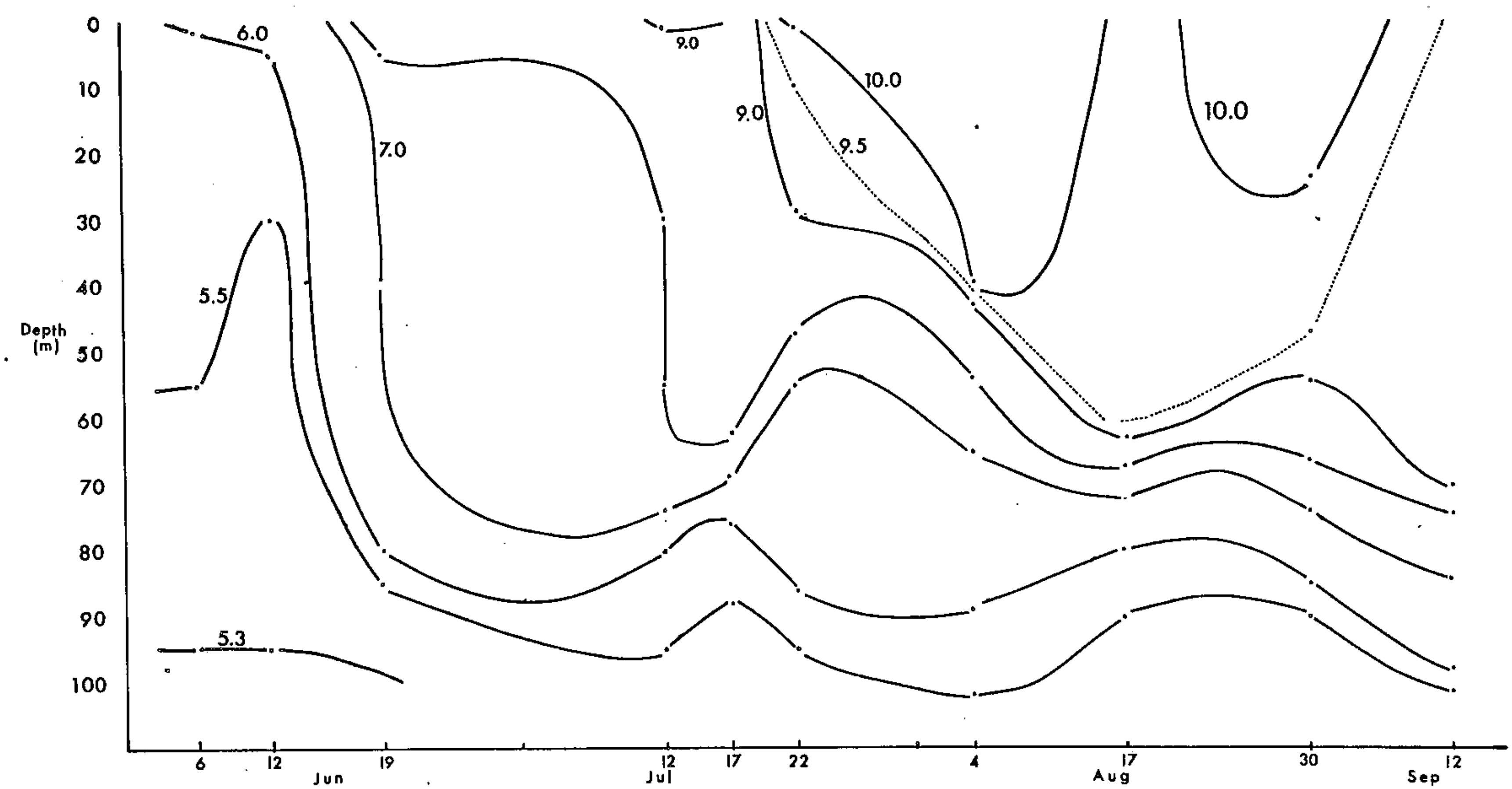
The development of thermal stratification is not known for Frederick Lake although it is expected to be typical of this region. Lindsey et al. measured temperatures of [illegible] ° C., but no profile date is avaiable. Temperature profiles have been made periodically for Sockeye and Louise Lake, (Wickstrom, 1978) which shows stratification, with surface temperatures reaching 13 and 11 ° C. respectively and hypolimnia of 4° C. Depth of the metalimnion was about 10 m, July 3, 1973, on Sockeye Lake and 2.5 m on Louise Lake.

On Kathleen Lake, continual mixing by strong, prevailing katabatic winds allows only weak stratification and causes elevated temperatures in the hypolimnia, bringing it up to nearly 5.5° c. by late August (Fig. 1). It is this latter effect that permits the lake to have a relatively high heat content, which in turn is responsible for the unusually late freeze-up.

Water Transparency

Light penetration as measured by standard Secchi disc measurements varies from 6 m on Sockeye Lake to a maximum of 22 m on Kathleen. Lindsey et al., (1981) measured 6.1 m on Frederick Lake. Louise Lake is considerably more turbid then Kathleen, receiving a major silt input from Victoria Creek. Kathleen Lake transparency was found to be greatest in the early summer, soon after break-up, and then reducing somewhat as the summer advanced (Tables 1 and 2).

Fig. 1. Temperature isopleths for Kathleen Lake, 1981.



Specific Conductivity

Specific conductivity for Sockeye, Louise and Kathleen Lakes was ___, ___, and ___ umhos/cm. Repeated measurements were made of Kathleen and Sockeye showing a seasonal variation of from 127 to 178 umhos/cm in Kathleen and 125 to 152 umhos/cm in Sockeye. Little information is available for Frederick Lake, although it is assumed to be much higher than the levels found in the Kathleen drainage. Conductivity measured on two occasions gave readings of near 300 umhos/cm which are in doubt, although possible (Table 65).

Aquatic Macrophytes

Aquatic vegetation is scant in Frederick, Kathleen and Louise Lakes, while Sockeye Lake is, for most of its area, similarly barren, except for an extensive marshy bay extending on the west side of the lake. On all of the lakes small forms of _Potamogeton filiformis_ and _Drepanocladus revovens_ are thinly scattered over some of the inshore littoral areas, while _P. richardsonii_, _Hippus vulgaris_, _Myriophyllum spicatum_ occur occasionally in scattered pockets. Emergent shoreline vegetation is limited, and is usually _Carex aquatilis_, _C. rostrata_, and _Calamagrostis_ spp.

Phytoplankton

Phytoplankton data is limited. It appears that the Diatomcae and Chrysophyta predominate with some representation from the Pyrrophyta. Only in Louise Lake did Chlorophyta show a significant presence. Cyanophyte was low in all samples.

Table Physical measurements of Louise Lake, 1980.

Date	Benchmark[1] (mm)	Temp. (°C)	Specific Conductivity (μmhos/cm^2)	Temp. Profile	Secchi Disc (m)
Jun 9		8.0	156	P	0.7
Aug 10	1340	11.0	143	-	7.5
Aug 15	-	11.0	142	P	-
Aug 20	1410	-	-	-	-
Aug 24	1450	10.6	143	-	-
Sep 2	1500	-	-	-	-

[1] Distance of benchmark (brass screw) above water surface. Location of B.M. given in text.

Table Physical measurements of Louise Lake, 1981.

Date 1981	Benchmark (mm above water)	Surface Temp. (°C.)	Specific Conductivity (μmhos/cm)	Temp. Profile Made	Secchi Disc (m)
Jul. 17	-	10.0	158.0	-	-
Aug. 4	-	11.0	154.0	P	-
Sep. 12	-	9.6	158.0	-	-

Table Physical measurements of Sockeye Lake and outlet, 1980.

Date	Lake					Outlet	
	Benchmark[1] (mm)	Surface Temp. (°C)	Specific Conductivity (μmhos/cm^2)	Secchi Disc (m)	Vertical Temp. Profile	Temp. (°C)	Specific Conductivity (μmhos/cm^2)
Aug 10	965	-	-	-	-	13.5	138
13	-	12.5	-	-	P	14.0	139
15	-	11.8	125	-	P	-	-
16	-	-	-	-	-	11.8	125
17	985	12.5	136	6.9	P	11.2	124
20	1018	-	-	-	-	11.1	129
24	1010	11.8	134	6.6	-	12.1	129
Sep 2	1060	-	-	-	-	10.9	127

[1] Distance of benchmark (brass screw) above water surface. Location of B.M. described in text.

Table Physical measurements of Sockeye Lake and Outlet, 1981.

Date 1981	Lake: Benchmark (mm above water)	Lake: Surface Temp. (°C.)	Lake: Specific Conductivity (μmhos/cm)	Lake: Secchi Disc (m)	Lake: Vertical Temp. Profile	Outlet: Temp. (°C.)	Outlet: Specific Conductivity (μmhos/cm)
Jul. 17	840	13.2	147.0	-	P	-	-
Aug. 4	990	12.1	137.0	-	P	11.9	137.0
11	-	-	-	-	-	13.0	-
13	995	12.5	153.0	-	-	12.2	149.0
16	-	-	-	-	-	11.7	145.0
18	-	-	-	-	-	11.1	149.8
20	-	-	-	-	-	11.1	149.6
22	965	11.2	149.5	-	-	11.2	149.2
24	-	-	-	-	-	11.9	150.2
26	-	-	-	-	-	~11.8	~152.0
29	-	-	-	-	-	11.8	155.0
Sep. 2	1035	11.9	-	-	P	11.9	151.0
8	955	11.0	152.0	-	-	10.9	149.0
12	-	10.0	151.0	-	-	10.1	149.0

Table Frederick Lake Observations

Date	Surface Temp. (^{o}C.)	Specific Conductivity (μmhos/cm)	Remarks
Aug. 10/79	-	-	RCMP officer noted pike, lake trout, grayling and kokanee on south shore of east end near inlet. Few schooling kokanee, in spawning colour.
Aug. 21/80	13.6	198	No kokanee observed at Frederick Lake (716 m ASL) or in entire stream to upper group of lakes (1084 m ASL). Spoke to cabin owners on lake but did not know when or where kokanee spawn. Observations made around entire lake shore for spawning. Believe spawning over. Gravel shoals and banks approximately 300 m upstream from lake at foot of first cascade may be spawing location.
Jul. 30/81	15.9	340 (?)	Inlet stream 11.8^{o} C. and 330μmhos/cm. Kokanee observed schooling in deep water near east end inlet; red in colour ; Specimens taken by angling, mostly males. Males and females ripe and running; Specimens preserved.

Zooplankton

The dominant summer zooplankton species are Diaptomous pribilofensis which was present in largest total individuals per litre in Kathleen and Louise lakes and next in Sockeye Lake. Cyclops scutifer was most abundant (number of individuals/litre) in Sockeye Lake and second in Kathleen and Louise lakes. Senecella calanoides, was also present in all three lakes in small numbers. Daphnia middendorffiana and D. pluex were found in low numbers in Kathleen Lake only. In Frederick Lake, D. longispina microcephala was the dominant zooplankton with C. scutifer and D. pribilofensis also present in large numbers.

These zooplankton species are commonly found ~~to dominate~~ in southern Yukon lakes (Lindsey et al., 1981).

Benthos

Benthic species are diverse and major components are represented by Chironomidae, Oligockaeta, Plecoptera, Ephemeroptera and Trickoptera, all of which occur in kokanee stomach contents.

Fish Species

Kokanee, lake trout and arctic grayling are the three dominant sport fish in Kathleen, Louise and Sockeye lakes. Rainbow trout and round whitefish have also been caught rarely. Besides these species, slimy sculpin burbot and pygmy whitefish occur (Table), the last two apparently low numbers (Wickstrom, 1978).

TABLE . . Common and scientific names of fish species in waters of Kluane National Park and selected peripheral areas.[1]

SALMON FAMILY	Salmonidae
WHITEFISHES	Coregoninae
lake whitefish	*Coregonus clupeaformis*
pygmy whitefish	*Prosopium coulteri*
round whitefish	*Prosopium cylindraceum*
GRAYLING	Thymallinae
Arctic grayling	*Thymallus arcticus*
SALMONS, TROUTS, CHARS	Salmoninae
chum salmon	*Oncorhynchus keta*
coho salmon	*Oncorhynchus kisutch*
kokanee/sockeye salmon	*Oncorhynchus nerka*
chinook salmon	*Oncorhynchus tshawytscha*
rainbow/steelhead trout	*Salmo gairdneri*
Dolly Varden	*Salvelinus malma*
lake trout	*Salvelinus namaycush*
PIKE FAMILY	Esocidae
northern pike	*Esox lucius*
SUCKER FAMILY	Catostomidae
longnose sucker	*Catostomus catostomus*
COD FAMILY	Gadidae
burbot	*Lota lota*
SCULPIN FAMILY	Cottidae
slimy sculpin	*Cottus cognatus*

1. from Scott and Crossman, 1973.

Table Fish distribution in Kluane National Park and vicinity by drainage basin, based on investigations with supplements from the literature.

Waters by Drainage	Data Source	lake whitefish	pygmy whitefish	round whitefish	Arctic grayling	chum salmon	coho salmon	sockeye salmon	kokanee	chinook salmon	steelhead trout	rainbow trout	Dolly Varden	lake trout	northern pike	longnose sucker	burbot	slimy sculpin
		Species																
ALSEK RIVER DRAINAGE	L	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Alsek River		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dezadeash River		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kathleen River	W,C	.	.	+	+	.	.	.	+	.	.	+	+	+	.	.	.	.
Rainbow Lakes	W,C	.	.	+	.	.	.	.	.	.	.	+	.	+	.	.	.	.
Kathleen Lake	W	.	+	+	+	.	.	.	+	.	.	+	+	+	.	.	?	+
Louise Lake	W	.	+	+	+	.	.	.	+	.	.	.	.	+	.	.	?	+
Sockeye River*	W	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Sockeye Lake	W,E	.	+	+	+	.	.	.	+	.	.	.	.	+	.	.	+	+
Cottonwood Creek		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cottonwood Lake*	W	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	?
Johobo Lake*		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dezadeash Lake	B	+	.	+	+	.	.	.	.	.	.	.	+	+	+	+	+	+
Frederick Lake	B	.	.	.	+	.	.	.	+	.	.	.	.	+	+	.	+	?
Tatshenshini River	D	.	.	+	.	+	+	+	.	+	+	.	+	+	.	+	+	+
Village Creek	D	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
Neshketaheen Lake	D	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Klukshu River	D	.	.	+	.	.	+	+	.	+	.	+	+	+	.	.	.	+

+ present; ? suspected; * local name

W - R.D. Wickstrom; E - V.C. Wynne-Edwards, 1947, 1952; L - C.C. Lindsey, 1975; C - Scott and Crossman, 1973; S - Schouwenburg, 1974; D - Fisheries and Marine Service, 1977; B- R.A. Bodaly, 1977.

Table Calculation of Morphoedaphic Index for Kathleen Lake

Date	Conductivity (μmhos/cm2)	Temp. (°C)	TDS (mg/ℓ)	MEI* (Imperial)	MEI (metric)
Jul 31/76	160	11	162	0.894	2.933
May 30/80	127.0	4	160	0.883	2.90
Jun 8/80	149	7.5	175	0.966	3.17
Jun 27/80	150.0	7.9	172	0.949	3.11
Jul 21/80	165	12	168	0.927	3.04
Aug 15/80	152.0	10.2	162	0.927	3.04
Aug 20/80	150	10.0	160	0.883	2.90
				$\bar{M}$ 0.923	$\bar{M}$ 3.027
				S.D.± 0.034	± 0.110
Jun 6/81	148.0	6.2	180	0.993	3.26
12/81	144.0	6.8	170	0.938	3.08
Jul 12/81	167.0	10.0	177	0.977	3.21
17/81	155.0	9.2	166	0.916	3.01
22/81	171.0	12.8	175	0.966	3.17
24/81	161.0	9.8	172	0.950	3.12
27/81	164.0	10.4	175	0.966	3.17
Aug 4/81	156.0	9.8	165	0.911	2.99
11/81	165.0	(9.8)est.	175	0.966	3.17
17/81	166.0	9.7	177	0.977	3.21
23/81	179.0	9.5	190	1.049	3.44
31/81	178.0	10.4	185	1.022	3.35
Sep 12/81	168.0	9.5	180	0.994	3.26
				$\bar{M}$ 0.955	$\bar{M}$ 3.19
				± 0.068	± 0.13

* MEI = TDS/$\bar{z}$ TDS = total dissolved solids $\bar{z}$ = mean depth = 55.2 m or 181.2 ft.
Imperial x 3.281 = metric

In Frederick Lake, five species in addition to kokanee occur: lake trout, arctic grayling, northern pike, burbot and slimy sculpin (Lindsey et al., 1981).

It is apparent from the foregoing description that the four lakes utilized by kokanee in this region are oligotrophic and consequently low in production, a function of their northern latitude, deep mean depths, low TDS and low summer temperature. A measure of this can be gained using Ryder's morphoedaphic index (MEI) which incorporates physical, chemical and climatic features of the water as a basis for estimating fish production and therefore and indication of lake productivity (Ryder, 1965, Ryder et al., 1974).

Kathleen Lake was found to have the lowest MEI of about 3.0-3.2, Louise Lake 3.3-3.5, and Sockeye Lake 7.9-8.8. Optimal MEI is considered to be 40. Mean depth information was not available for Frederick Lake, precluding a calculation of MEI for this water, but it is expected to be greater than 9.0.

Estimations of the corresponding fish production from these MEI values places Kathleen Lake as the least productive, having an theoretical annual production potential of 3.5 $kg \cdot ha^{-1} \cdot yr^{-1}$., Louise Lake with 3.7 $kg \cdot ha^{-1} \cdot yr^{-1}$ and Sockeye Lake with 5.8 $kg \cdot ha^{-1} \cdot yr^{-1}$. These values are low when compared to more southern temperate lakes. Lac La Ronge, with with an MEI in the range of 11.6 is a fairly productive north temperate lake with an estimated annual harvest of about 6.8 $kg \cdot ha^{-1} \cdot yr^{-1}$.

(Ryder, 1965), Great Bear Lake (MEI=0.8) and Great Slave Lake, (MEI=2.4) (Ryder, 1965) on the other hand, are lakes of low production, having estimated annual fish production of 1.8 and 3.1 kg. ha^{-1}. yr^{-1}., which are ~~similar~~ comparable to values found for Kathleen Lake.

HABITAT

Streams

Except for the outlet stream draining Sockeye Lake and Louise Lakes none of the tributary streams to any of the lakes in the Kathleen Lakes drainage are used by kokanee. Observations of kokanee in the lower reaches of Cottonwood Creek made during the course of this study were considered to be strays and not spawners returning to a natal stream. Local reports of larger numbers of kokanee in Cottonwood Creek, Goat Creek and others in years prior to the Park's administration and aquatic studies may have been the result of displacement spill-over from the choice spawning grounds as will be discussed latter.

These upper tributaries are not utilized by spawning kokanee because they are unsuitable for spawning and egg survival.

The tributaries to Sockeye, Louise and Kathleen lakes fall into two categories: 1/ those arising from upper slope drainages of the surrounding mountains having ice and snow melt as their primary sources together with run-off from precipitation events. Victoria, Little Victoria, Goat and all the smaller creeks tributary to these lakes are in this category. These streams are generally turbid, carrying moderate suspended loads which increase during, and for a short time following precipitation events. More importantly, though, they are seasonal, and their flows either diminish and cease during the winter or the small discharge will freeze and overflow continuously, forming sheets of ice in the stream channel. In either case, the success of eggs deposited in the gravel would be very doubtful.

2/ the other category of tributaries includes those having small lakes or ponds as part of their source. Two streams of this type are tributary to Sockeye Lake; Cottonwood Creek the main inlet and Campsite Creek, a small, indefinite and temporary tributary. (Louise and Kathleen lakes do not have streams of this category as tributaries. Kathleen, however, has two small lakes located along the north east shore which connects to the lake. These lakes are actually more like extensions to the lake because of their navigable channel and very slow flow, if any).

Although winter measurements have not been made, general observations seem to indicate that the flow of Cottonwood Creek diminishes in late summer, and may in fact, cease for short periods in the winter. Freezing and overflow conditions may also occur in the smaller upper reaches. Also, because of its low flow in late season and its shallow depth, widely fluctuating temperatures could be expected. These factors would be detrimental to egg survival. Of the several small ponds and two small lakes at the source of Cottonwood Creek, only one has suitable shoreline substrate for spawning and its position at the upper end of the drainage can only be reached by a long, shallow cascading stream and it is doubtful if kokanee can navigate this water course.

The other Sockeye Lake tributary arising from a small lake source is the drainage from Campsite Lake. It is very small and apparently seasonal, draining down a cascading channel and ultimately seeps into the extensive marsh area boardering the west basin of the lake.

* * *

BIOLOGY

Life History

The life history of the kokanee is very similar to that of the sea-running sockeye, which is outlined by Ricker, 1966, and by Foerster, 1968. The biology of the kokanee in the Kathleen lakes drainage will be described with reference to the sea-run form and with the description for kokanee as given by Scott & Crossman, 1973 and McPhail and Lindsey, 1970. Where information is known about the Frederick Lake population, this is given for comparison to the Kathleen lake population.

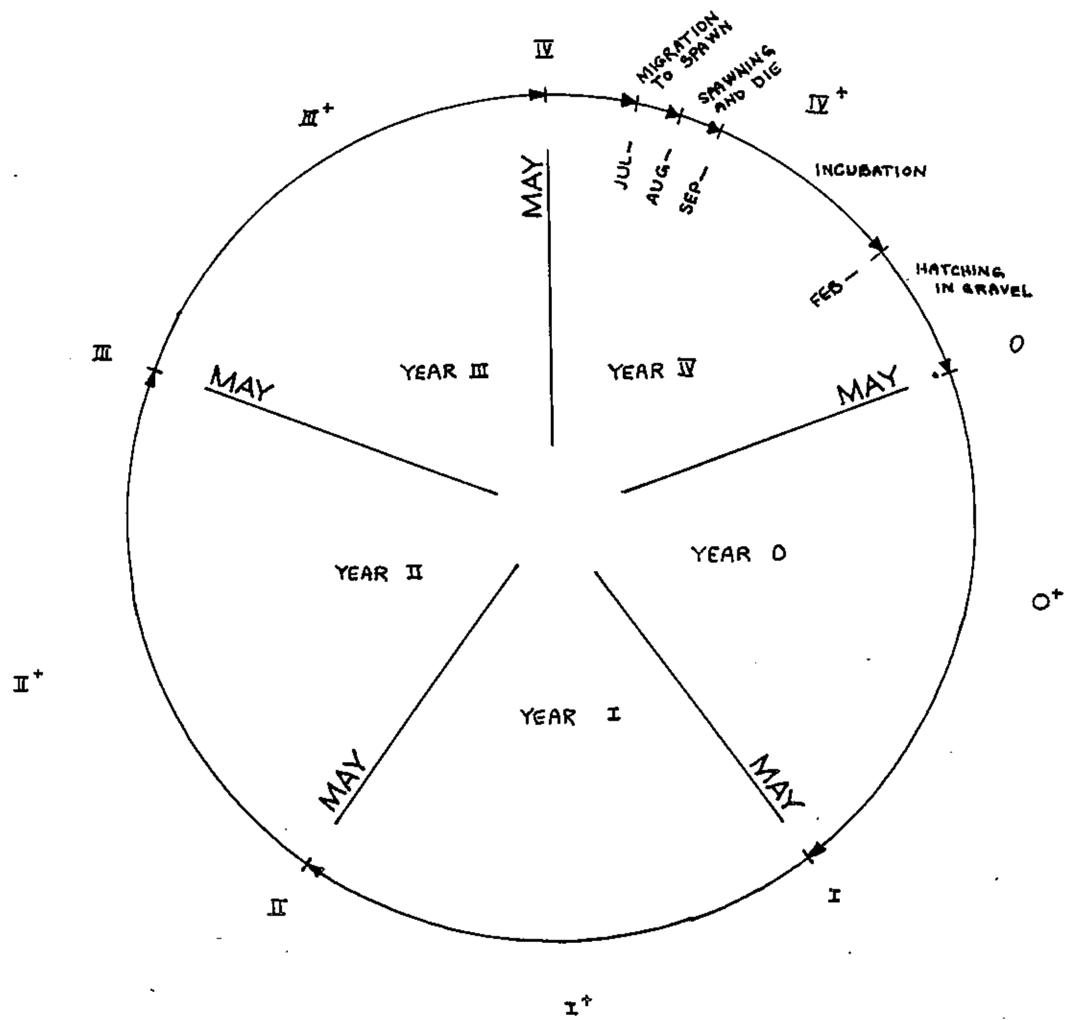
Sockeye salmon or kokanee (*Oncorhnchus nerka*) (*Walbaum*), belongs to the salmon family, *Salmonidae* which is composed of three sub families: *Coregoninae*, the Whitefishes and ciccoes; *Thymallinae*, the graylings; and the *Salmoninae*, which includes the salmons, charrs and trouts (Scott & Crossman, 1973).

All of the waters in which kokanee are naturally found are (or were) tributary to the Pacific and support a run of anadromous sockeye or did in the past. In some locations the waters are shared by both forms. A third strain of sockeye, sometimes found in salmon lakes, is termed "residual sockeye" (Ricker, 1966). These confusing variants only occur in drainages where there are anadromous stocks from which they are derived and mature in freshwater at a smaller size, do not migrate and do not reproduce. This variant of kokanee is not known in either Kathleen or Frederick lakes, which are populated ~~entirely~~ solely by the kokanee variety. It is not known whether Klukshu Lake, or Neskeetahen Lake at the upper end of the Tatshenshini River drainage which lie just across the height of land separating the

the Kathleen/Dezadeash drainages supports this variant along with the common anadromous sockeye spawning in these tributaries.

The typical life cycle for kokanee is outlined below in general terms (Fig.). Known variations which occur in the Kathleen Lake populations are outlined in detail under separate sections following. Where details are known about the Frederick Lake kokanee, they are compared with that of the Kathleen lakes drainages and with other populations recorded in the literature.

Kokanee usually migrate to the upper waters of their habitat drainage and spawn in the autumn, depositing their eggs in gravel substrate in stream-riffles or along similar substrate along lakes shore. The eggs incubate over the winter and hatch in early spring but the tiny kokanee with their yolk sacs, called alevins, remain in the gravel for several more weeks, emerging from the gra about May. The free-swimming, feeding fry may linger in the stream (Foerster, 1968) but eventually swim downstream (in some cases, upstream, Foerster, 1968) and commence living pelagically in the lake, feeding on plankton. Growth continues for five years in the Kathleen and Frederick drainages until the fifth summer when the adults migrate upstream to their natal spawning grounds to spawn and then die.



Kokanee live pelagically in upper strata of lake

Fig. Kokanee life cycle, Kathleen Lake.

Movement/Migration

A. Within the lake

1. Kathleen lakes drainage

Each of the three lakes in the Kathleen lakes drainage, Sockeye, Louise, and Kathleen itself, are thought to contain their own resident population, although this hypothesis has not yet been tested. Part of the circumstantial evidence for this stems from the late winter and early summer angling catches from Kathleen and Louise lakes. At approximately the same time, five year old maturing adult fish have been caught in each lake. It is presumed that this is prior to the commencement of the annual spawning movement and these fish are therefore adult members of their respective lake populations. Another point concerning individual lake stock, to be discussed under the Spawning section, is the question whether individual lake populations have their respective spawning areas in the outlet of Sockeye Lake or along the lake shore.

2. Frederick Lake

Little is known about the movements of kokanee in Frederick Lake. As discussed in the foregoing section under distribution, it was noted that kokanee in this lake are not able to move upstream more than several hundred metres because of a cataract, although downstream movement into Dezadeash Lake via the Frederick Lake outlet stream (Kluhini Creek) is possible. However, Dezadeash Lake is considered to be unsuitable habitat for kokanee because of the high turbidity, shallow depth (7.6 m), and warm summer temperatures. Kokanee are not known to have been caught by angling in this lake over the ten years during studies in the region despite the close aquaintance of several of the local residents around the lake.

Movement/Migration

B. Migration

The commencement of spawing migration from the lower lakes to Sockeye Lake appears to occur about mid July. In 1980, kokanee angling success dropped off considerably by early July and no more were caught for about a two week period in the latter part of this month (Tables). In 1981, the pattern was similar, although a few kokanee were continually harvested in late July, probably because of the much larger year class this season. As will be discussed more fully later, most of the fish caught were around 400 mm and in their fifth year, while those captured later in July and into the later portion of the summer season were usually one year younger and of a smaller size and immature (Table). Adult kokanee from the lower lakes, Kathleen and Louise, migrate upstream to Sockeye Lake for spawning, although judging from the few five-year-old fish in the anglers harvest in late summer, some apparently do not leave Kathleen Lake for (or cannot find) Louise and the upper waters. There are no barriers to upward migration between the lakes, although ~~the~~ Sockeye ~~Lake outlet stream~~ has a shallow stream bed strewn with riffles and log jams. Beaver activity has varied considerably over the past ten years and although dams were constructed across some branches of the lower outlet stream from Sockeye Lake, they are not considered to impede kokanee migration at the present time. This aspect of kokanee management requires close attention and may some years, require removal to permit easier passage for the migrating kokanee.

Time of migration commencement from Louise Lake is not known. In Frederick Lake kokanee are able to move upstream in the inlet stream only to the gravel bars and riffles below the first cataract.

BIOLOGY

Spawning

Time

The commencement of migration for spawning from Kathleen Lake as described appears to be from early to mid-July as shown by the drop in 4^+ kokanee in the angler's creel. Large kokanee schools appearing near the outlet in Sockeye Lake are observed in late July. During the first few days of August ~~after~~ they slowly move downstream onto the spawning grounds. The movement ~~from~~ of the schools from lake outlet to the spawning grounds appears to be quite rapid once begun. In 1980 and 1981, this movement from lake to spawning grounds occurred within two days. Most of the kokanee which move into the stream and onto the spawing grounds continue to school, although numerous pairs secure positions in the spawning flats (Map 7).

The actual time of spawning commencement is not known precisely, but first deposition of eggs is believed to occur just prior to the third week in August. The peak of spawning is reached by the latter part of August, then rapid reduction of numbers occurs (Fig 11).

Locations of spawning grounds

The only known areas of kokanee spawning in the Kathleen Lake chain occurs in 1.) the shallow reaches of the outlet stream of Sockeye Lake, about 200 m below the lake and 2.) at several locations along the north shore of Sockeye Lake. These lake and stream locations are occupied by almost all of the spawners although one isolated and small group was observed in different years to appear to be spawning along the east shore near a small ground water tributary to the lake (Maps &).

In the outlet stream the majority of kokanee spawn over a shallow smooth-flowing reach termed the [illegible] (Map 7, Plate). Large schools of kokanee are usually observed in the pools in deeper channels above this spawning reach. Large schools of kokanee in spawning appearance are also usually found in the immediate vacinity of the outlet. Whether or not these groups of fish spawn in these areas or more downstream to fill vacancies left by spent, departing fish is not known. Redds have not been observed in these pools nor have pairs of adults. It may be possible that these kokanee constitute another "wave" of spawners, awaiting their turn. It has also been observed that the number of kokanee in these pools decline in numbers while those on the spawning grounds also dwindle. Then both groups disappear.

The lake shore spawners are found predominantly in two major groups, one just east of the rocky promentory near the west end of the north shore, and another group just beyond this point (Map 6). Scattered between these two areas, other small groups of spawning kokanee occur in the shallows. The possitions of these small groups are fairly constant from one year to the next, although the number in the group varies.

Park warden staff report that a pair or small group of kokanee were observed to be in spawning activity along the mud shallows on the west shore. This is considered to be unusual and has not been observed again over the past two years. Several more Shore Spawners were observed adjacent to Cottonwood Creek inlet in 1981.

Kokanee have not been observed in tributaries ~~in~~ of the three main lakes, except for the lower reaches of Cottonwood Creek. These kokanee observed in the lower portion of Cottonwood Creek have been present for the past three years, and in all cases, only two or three fish were counted. These were not observed to be engaged in spawning behaviour. Further observations were made along the full length of this stream without finding more kokanee.

Local sources of information claim that in former years when kokanee populations were supposed to be higher, that kokanee spawned in Cottonwood, Victoria and and Goat creeks. If this were so, the likeliness of successful incubation and egg survival in these streams is doubtful because of the considerable reduction in stream flow over winter with overflowing and freezing to the bottom likely. ~~to occur.~~

Biology

Spawning

Capacity of the Spawning Grounds.

The best spawning grounds for kokanee in the Kathleen lakes drainage appears to be along the outlet stream of Sockeye Lake, on a shallow smooth-flowing reach termed the spawning flats (Map 7). It was thought that as the number of the spawning population increased, those utilizing this limited area would saturate the space forcing ~~the~~ later-arriving or less aggressive fish to accept poorer quality spawning grounds in other places or to be forced to marginal ground. The numbers utilizing this area would then level off. This process is known to operate for anadromaous sockeye populations in other areas (Ricker, 1968).

In the years prior to 1981, the total spawners rose from a low just over 4000 in 1975 and then fluctuated around 4,000 (Tables 22 - 28). The number on the prime spawning grounds remained around 1,300, about 30% of the total spawners (Table 9.1 and fig. 21). In 1981 the spawning population increased almost two fold from the previous years, and the numbers on the spawning flats increased similarily to about 2,250 at the peak of the run, which is almost double the previous amount. The proportion on the spawning flats still remained about 30% of the overall total.

Although the expected levelling off of numbers did not occur on the spawning flats, ~~but~~ the limit of the spawning area may be approaching saturation. Saturation may be setting in, which could account for the appearance of spawning kokanee in locations where they have not been observed before (around the east and west side of the lake) and for the greater numbers found schooling in the pools above the spawning flats and crowding around the edges. The number spawning along the lake shore in the usual places has also increased (Tables 9.1).

More aggressive behaviour was observed in 1981 than in previous years suggesting that the limited area for redds is being more heavily contested.

The average size of the redd on the spawning flats was not determined previously precluding comparison of saturation on the basis of the number of spawning pairs utilizing the available space for redds. If the redd size were known and the number of spawning pairs determined then these fish would be the saturation maximum and the other fish present around the spawning flats would be excluded contenders. There would be compression of redd size to some extent (Ricker, 1968), but this too, would presumably level off. At present the population appears to be still increasing, judging from the increase in counts in 1981. The extent to which the lake shore spawning areas will be utilized to obsorb the overflow from the prime outlet spawning area is still uncertain. The possibility of waves of spawning adults utilizing the spawning areas is also possible or of those bystanders which had been forced to the edges utilizing redds relinquished by spent and dying spawners. Although this is of course, possible, but it is not thought to be happening at present because of the short period over which spawning occurs and the ~~steady~~ constant numbers of adults in the upper pools that remain through the spawning period and then disappear as rapidly as the last of those on the spawning grounds.

Saturation is a process of self regulation and may impose a limit to the population size. Ricker (1968) notes that it has been shown that a lower percent of fry production results from a heavy spawning run of sockeye salmon than from a moderate one because many redds have been dug in inferior gravel. The population in good gravel areas tend to be greater.

One of the most important tasks of future management should be to determine the average redd size and number of spawning pairs on the prime outlet stream spawning area using this space. This would indicate the saturation level. This would reveal the optimum spawning number for future management guidelines, and would be more useful than numerical total of all spawners.

Fig.___. Maximum annual counts of spawning kokanee for all spawning areas, as compared with that of the prime river spawning beds

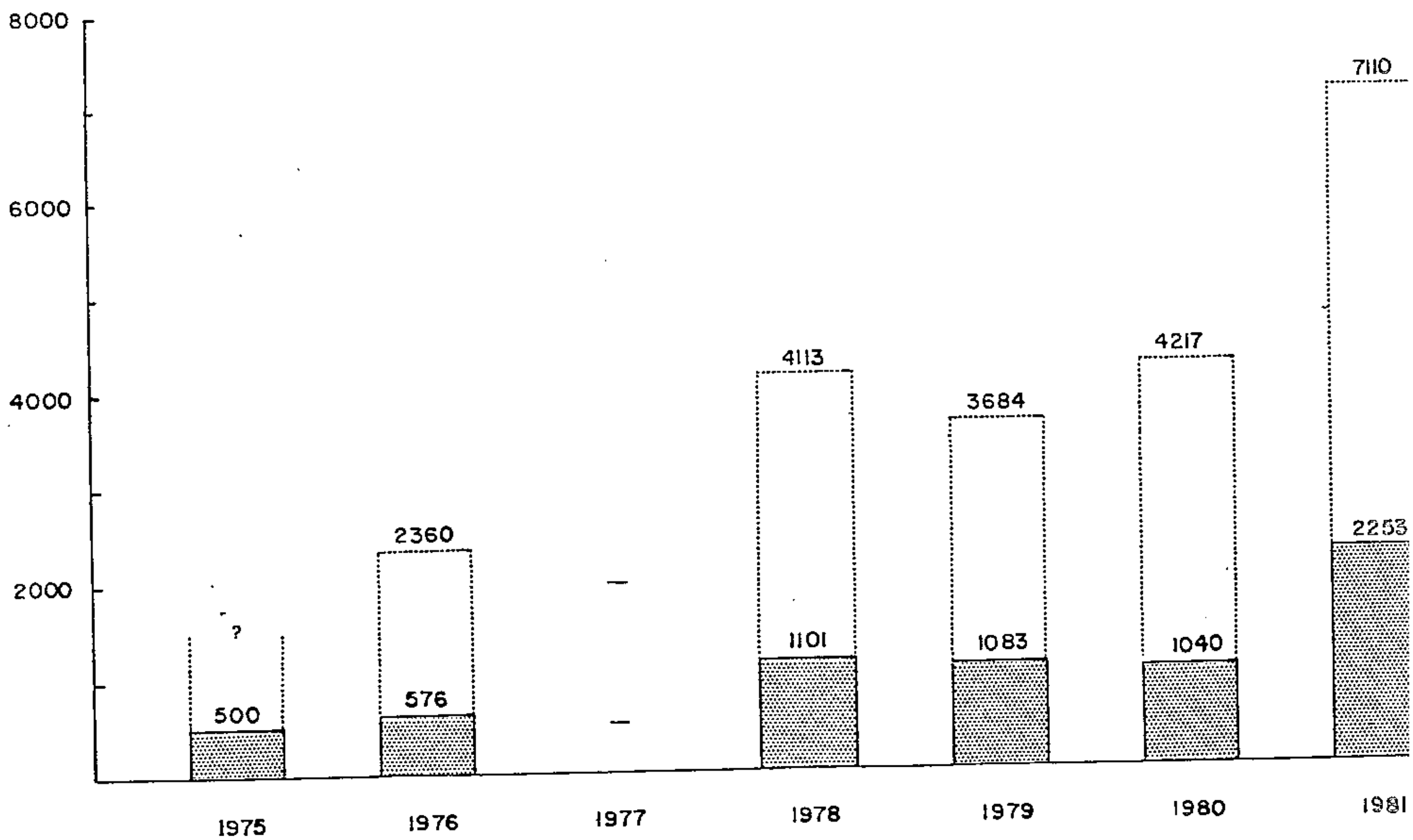


Table Kokanee utilization of spawning areas in Sockeye Lake and outlet.

	Maximum Spawners Lake and Stream		Total in outlet pools and lake narrows		Spawning Flats		Along lakeshore	
	#	%	#	%	#	%	#	%
1976	2360	100	792	34	576	24	545	23
1977	-	-	-	-	-	-	-	-
1978	3872	100	1626	34	1346	35	567	15
1979	3684	100	1617	44	1283	35	443	12
1980	4217	100	2283	54	1331	32	432	10
1981	7110	100	3225	45	2253	32	953	13

Spawning behaviour

Migrating kokanee from the lower lakes gather in large schools in Sockeye Lake near the outlet, numbering over several hundred in 1980 and 1981. These schools may move about the lake but are known to concentrate along the east side. Evidence for this comes from earlier gill net sets in 1973 and 1975 (Wickstrom, 1977), when kokanee were only captured in sets along the eastern and northern areas of the lake.

At the time of schooling in late July and very early August, no fish were yet observed in the outlet stream or on the spawning grounds along the lake shore. Over the next few days, from about the first week in August to about the second, kokanee begin to move on to the spawning ground along the outlet reaches of Sockeye Lake and along the spawning areas along the north shore of the lake as shown in Maps 7 & 8. For the first number of days many of the kokanee continue to school in the several deep pools in the outlet adjacent to the shallow spawning flats, although a few pairs take up positions on the spawning areas immediately. During most years, the spawning area in the outlet stream becomes filled by the 15th to the third week in August.

Numbers on the spawning flats in the river and at the spawning areas along the northern shore of Sockeye Lake slowly peak until about the 24th of August when the numbers begin to decline (Fig. 11, Table 27). Some of the dying fish are observed along the banks downstream, and in the shallow back eddies, but never nearly as many as would be expected.

Behaviour observed on the spawning grounds is very similar to that outlined in Scott and Crossman 1973, and has not been ~~(observed and)~~ recorded in detail.

Only occassional redd building activity has been seen and few spawning acts have been observed. The aggressive behaviour is similar as described in the above reference. Females defend their redd from females and attendent males continually drive off other challenging males until, after a period of about 7-10 days, they become too weak and more aggressive fish take over. Various males with identifying marks (cuts) have been observed at the same redd over a period of several days. Apparently, behaviour of the females in defense of her redd and the protection of the dominant attendant male continues well after actual spawning has taken place, and probably continues until the individuals are too weak to continue and are driven off by stronger aggressive fish.

Stronger physical contact between aggressive males was observed in 1981. Many fish bore open wounds and scrapes. This may have been due to the most dense occupation of the spawning area than had been observed to date.

Spawning

Sexual dimorphism and colour

As the kokanee migrate through the upper waters to reach Sockeye Lake they have probably not yet begun to show sexual dimorphism or change colour. In late July, as the kokanee are observed schooling in the shallow waters near the outlet of Sockeye Lake, the colour change and physical change of the male is just beginning to be noticable. As they begin moving down the outlet stream to the spawning flats, both male and female have turned red in colour, the males more so than the females. The head becomes dark green. Males develop the typical hooked jaw characteristic of all male spawning salmon, and humped back. These features are in considerable contrast to the normal appearance of the kokanee. (Plate ...

Age

The age of the Kathleen lakes kokanee population at spawning is usually ~~5+~~ 4+, that is, they are in their fifth year. This is different from their anadromous form which normally has a life cycle of four years as do most other kokanee populations, although some variation in age at maturity occurs, from 3 to 8 (Scott & Crossman, 1973).

Spawning Kokanee from Frederick Lake were found to be ~~similar~~ younger in age to those from the Kathleen drainage. Spawning ... 3+.

Size at muturity

The size of the spawning adults in the Kathleen Lake drainage was found to be 358 mm in 1981 and 372 mm in 1980. This is larger than the size range given by Scott & Crossman, 1973. In this reference, mature fish spawned at age 4 and were 215 - 275 mm at Nicloa Lake, B.C., 254 - 305 mm in Pend Oreille Lake, Idaho, and 179 mm for kokanee in Boulter Lake, Ontario. The difference between these mature kokanee and those from the Kathleen drainage is of course the result of the extra year of growth for the Kathleen fish. [illegible] This compares [illegible]. Although the sample size was small, the kokanee from Frederick Lake were found to be similar in size as those from the Kathleen lake drainage, having an average length of 300 mm and an average weight of 290 gms.

BIOLOGY

Spawning

Sub Populations

The presence of two distinct spawning groups, those in the outlet stream and those along the lake shore, invites the question as to their habitat origin: whether those spawning along the north shore of Sockeye Lake, which are considerably fewer in number, are representatives of a discrete Sockeye Lake population and those spawning along the outlet reaches came from the lower lakes. Whether each spawning group represents a discrete population could be investigated by tagging in the future. It is possible that kokanee from Sockeye Lake may move downstream to spawn along the flats below the outlet since it is known that newly hatched fry of sockeye salmon will move upstream into a parent lake upon emerging from the gravel after hatching (McPhail & Lindsey, 1970).

Spawning Substrate

The spawning substrate chosen by the kokanee consists of coarse gravel and small cobble. There appears to be a light covering of sediment in the lake shore substrate. In the stream and lake spawning sites the redds made by the spawning fish show a distinct colour difference in substrate from the cleaning action resulting from redd digging.

Depth of Spawning grounds

The depth of the river spawning flats appears to be about .5 m. Along the lake shore, the depth varies considerably and ranges from about .3 m to over 1 m. The distance out from shore also varies, depending on the slope of the shore. Redds have been observed from about 1 to 15 m offshore. Scott & Crossman, 1973 give the range of spawning depths to be from 0.3 to 9.2 m.

Spawing

Spawning release factors

Temperature is usually considered to be one of the key factors in initiating spawing. Scott & Crossman, 1973, note that spawing is known to take place in waters where temperatures range between 3 - 7° C. In the outlet of Sockeye the stream temperature varied ~~over~~ between 11.9° C. and 11.1 °, during the later part of August, and lake surface temperatures for Sockeye Lake during the same period were similar, ranging between 12.5°C & 11.2 °C. (Tables 5 & 6).

Other factors which may, in part, stimulate the spawning process are: day length which for the 24th of August at this latitude is 05 to 19 hours. Although specific conductance may not be a factor in initiating, it was measured during the same period and varied with the temperature, dropping slightly as August advanced. Conductivity ranged between 125 and 129 µ mhos/cm ~~(Table~~ in 1980, and 145 and 149 µ mhos/cm in 1981 (Tables 5 and 6).

Lake values

The dissolved oxygen content of the outlet stream and lake were saturated and although not measured during the winter period, they are expected to remain high because of the considerable depth of Sockeye Lake and the little biological oxygen demand for the sparse aquatic vegetation found in the lake, which would decay over winter.

These conditions as outlined above were similar to those measured in 1975 and 1978, suggesting that the limnolocical conditions in Sockeye Lake and its outlet stream have remained consistant over the years.

Predation of spawning kokanee

Bears can not be considered a significant predator on the spawning kokanee in this area based on the observations made over the course of the past nine years. Although bear activity at the spawning site varies over the years, it have never been numerous, even during the peak of the spawning activity. Tracks are usually monitored and often days or sometimes a week will pass with no fresh activity observed. Black bear tracks are commonly seen alongside the spawning grounds at the stream outlet although the animals themselves have not. They have, however, been seen on three occasions along the north shore spawning areas of Sockeye Lake. Grizzly bear tracks are not as common. In 1981 a bear of this kind was observed fishing for kokanee.

Wolf tracks are common around the spawning area, both along the lake outlet stream and along the northern shore spawning areas. On one occasion a juvenile wolf was observed to be fishing for kokanee. Wolves are presumed to be a minor predator on the spawning kokanee.

Both wolves and bears, although not significant predators on the kokanee, nevertheless are believed to have an impact on the spawning fish to the extent by which they disturb the process: disruption the spawning pairs, displacing pairs from their redds and churning up the eggs in the gravel so that they may be swept downstream onto undersirable substrate.

Eagles, both bald and golden, are constant preditors on the spawning kokanee. Rarely a visit to the spawning grounds is made without encountering from one to several of these birds. Being wary and timid, they invariably move away during approach and have never been observed fishing although on numerous occasions fresh kokanee catches have been seen along shore.

Another common predator on the kokanee is the mew gull. This bird swims over the shallowest places of the spawning beds and bobbs for eggs in the substrate. It is not uncommon to observe several of these gull working over the shallows at one time. The extent of its predation has been difficult to estimate.

BIOLOGY

Post-spawning

As the peak of spawning passes some time after the third week in August, the number of kokanee on the spawning grounds begins to dwindle at first and as the end of August approaches, the numbers then drop rapidly until by the first week in September only a small percentage of the previous maximum remain. Although several thousand are usually tallied over the spawning flats, only very few are actually observed to die and wash up on shore or get caught in the back currents and pools (Plates). The fate of those fish which disappear from the spawning beds is not known. They may possibly grow weaker as the exhausting processes of redd defence and energy consumptive process of aggressive behaviour simply wears them out until they can no longer maintain position in the stream and are swept along downstream. This has been observed to occur, as would be expected, however, the number observed in this condition never seems equal to the average that is being lost from the spawning area. Continued searches downstream have failed to reveal the number of carcasses that would be expected. Predation by bears or birds, although constant, is not extensive or would not account for the decrease on the spawning fish. Whether or not numbers of kokanee survive the spawning period, lingering on into the late autumn, as has been noted in other areas, (Scott & Crossman, 1973), before dying, is not known at present. Net sets in the west end [illegible] Louise Lake adjacent to the inlet from [illegible] [illegible] mid to [illegible] September would be of interest in this regard.

BIOLOGY

Age Determinations

Prior to 1981, all age determinations were made from scales; after which both scales and otoliths were used. The annuli were highly evident on both scales and otoliths. Determining the position of the first annulus was done using 1^+ fish captured by trap net and comparisons to growth study data at constant temperatures provided by B. Fallis, (personal communication). Because kokanee die after spawning at age 4^+, fish older than this (and few at 5^+) are not found, simplifying age determinations.

Deposition of the new annulus is first noticed about early to mid July. Resorbption of peripheral edges of scales and otholiths has not been as great in pre-spawning kokanee from Kathleen Lake as in those from Frederick Lake.

Photos to be included showing

3°, 3^{+}, 4^{+} and 5^{+} otoliths

Plate Kokanee caught in late June. The large fish was IV+ and would spawn in August while the smaller is III+ and immature.

.Plate Male (upper) and female with (two eggs visible at end of ruler) showing extent of sexual dimorphism and colour change in early August compared with upper photo.

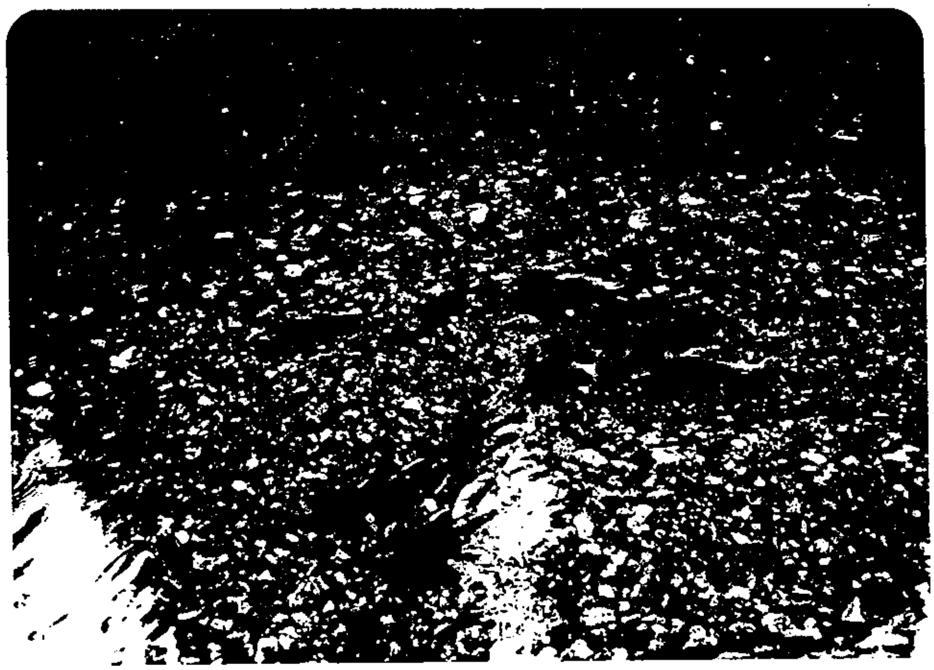


Plate Several kokanee pairs with outlying contenders for redd area. Texture of bottom substrate is evident.

Plate Spawing kokanee in the outlet stream of Sockeye Lake, distributed in low numbers over the "Spawning Flat" reach as located in Fig. .

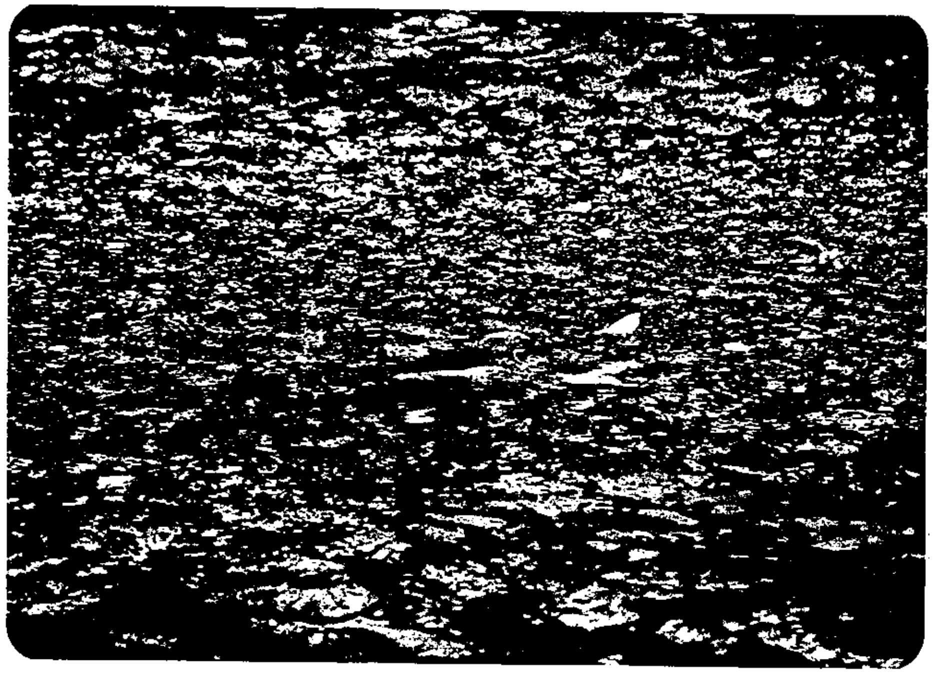


Plate Post-spawning kokanee pair showing evidence of advancing white discolouration of fins, and general physical deterioration.

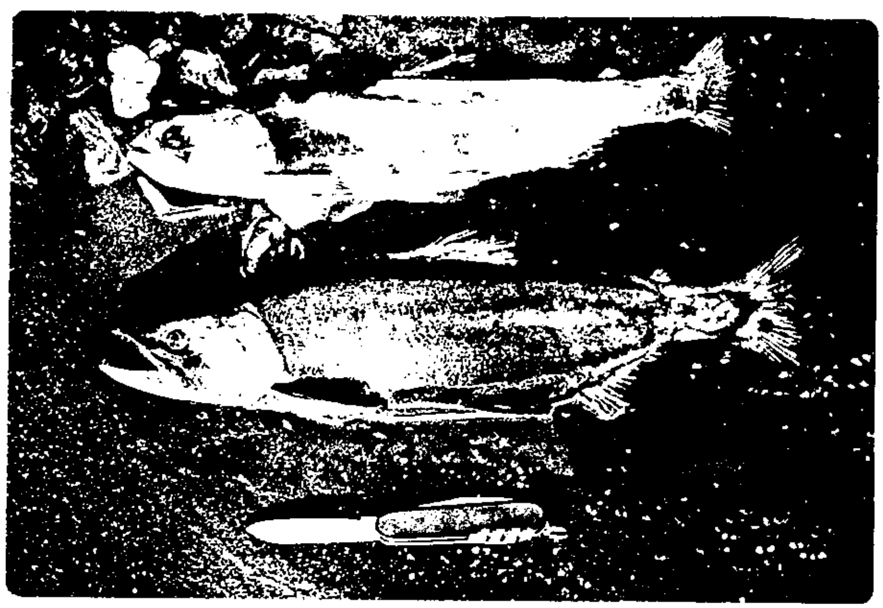


Plate Very recently expired kokanee (both were barely alive prior to photograph) showing the severe physical degredation which occurs during the course of the 3 week spawing period.

Plate View westward across Kathleen Lake. Kathleen River outlet in foreground at Haines Road.

Plate Public access and boat landing at Kathleen Lake, from which creel census was made.

Creel Census

Introduction

Creel census information was collected, primarily, to determine the extent of angler harvest. Although kokanee was the primary species of interest, data was also gathered on other fish so that complete angler harvest data is available. A separate report has been prepared considering lake trout (Wickstrom, 1982, in prep.).

Methods

Times of Creel Cenus

Creel cenus estimations were made over two consecutive years, 1980 and 1981. Each annual estimation was compiled from three periods:

1. a winter and spring estimation of ice fisherman's harvest (covering the period from freeze-up in late December to break-up in late May),
2. a summer openwater period and,
3. an autumn period (September through to freeze-up).

Creel data for the ice fishing period was compiled from records of warden staff weekend patrols, later interviews of the local anglers, and from estimations. Most of the fishermen come from the small local community and are all known to the census takers. An evaluation of estimation accuracy is included later.

Continuous creel census records kept over the summer period, beginning in 1980 on May 29th, the day ice break-up allowed navigation from the launching access road, until August 10th and in 1981, from break-up on May 16th* (exceptionally early) until September 13th, when the field staff left.

Fishing estimates for the third, autumn period, were made on the basis of warden assessment of angling activity, information from local fishermen and the climatic data reflecting short daylight, cold weather and the consideration that slight to zero visitor use occurred as the autumn advanced. The actual creel data that was collected over the summer months and the winter-spring and autumn estimations were arranged to conform to the same format.

Due to the almost 24 hour daylight for much of the summer period at this latitude, (61°), an attempt was made to record all angling activity throughout the 24 hour day, seven days per week. A normal day's observation by the recorder was from 08:30 to 23:00 h, but often earlier and later times were included (see appendix). Time off for staff varied between one or two afternoons midweek, depending on the angling activity. A record was kept of all observation times missed and estimates of angling activity for these periods were prepared on "spacer cards" as discussed later.

* Warden staff maintained creel census patrol from May 16th to 29th until summer creel census staff began duty.

Location of Creel Census observer

Only one public access point was available, on Kathleen Lake, for launching boats. Because of this simple situation, almost all foot and vehicle traffic was directed to one place, the landing bay, making this an ideal location for positioning a creel census obseervation. Both anglers and lake fishermen using boats, both initiated and terminated their efforts from this point.

Other access points which provided only a very small fraction of fishing were:

1. A little known, unpublicized, seldom used trail from the lookout point on the Haines Road, approximately one mile from east bay of Kathleen Lake. This trail is occasionaly used by local residents who usually reported their angling times and catches to the census staff.

2. Kathleen River, at the highway bridge, where anglers were able to reach the lake with a short hike along river bank trails. However, the lake is not visible from the highway bridge and most fishermen angle downstream, (away from the lake) for rainbow trout, grayling and river dwelling lake trout. Local residents did not use this access to the lake and it is considered to receive little use.

3. The Johobo Mine road to Sockeye Lake which skirts the shore of Kathleen Lake. Hikers using this trail usually travelled lightly,

carrying their own food and were generally not serious fishermen. The contribution hikers make to angling pressure on Kathleen Lake is thought to be very minimal.

Creel Data Records

A creel card was prepared for each angler, recording as much of the following information as could be obtained: data, lake (Kathleen or Louise) and area(s) fished, time of departure and return, time spent fishing, species and number caught*, number of fish released and retained, angling methods used (boat or shore), type of fishing gear and lure or bait, weather conditions and angler's place of origin. Sampling the fishermen's catch was carried out whenever practicable. Weight, length, sex, maturity, stomach contents and amount, parasites and other pertinent observations were noted. Otoliths were collected and stomach's with contents were preserved for some specimens. Each creel card was numbered in sequence and a new card was prepared for fishermen returning next day. A spacer card was inserted in sequence with the creel cards at the end of each day, recording times when observer was not on duty and gave estimates of angling activity and catches.

* A fish caught but released is counted as caught in the summaries in calculating angling success; in harvest calculations by weight, only those fish kept were considered.

Estimations

Estimates of angling activity and catches for times when creel census observer was not on duty were noted on spacer cards inserted in sequence among the creel cards at the end of each day. Estimations were made as soon as possible after an absence. All estimations were qualified whether good, fair or poor to indicate the confidence. Estimations were greatly facilitated by a number of aids:

A. Factors affecting fishing:

i. Weather., a. Wind. Kathleen Lake is notoriously windy for days on end making it too treacherous for boating or unpleasant to angle from shore because of prevailing on shore winds at access area on east shore.

b. Rain. This reduced fishing efforts considerably and combined with wind and low temperatures was responsible for whole days with no fishing efforts.

ii. Time of day. Few fishermen started early in the morning and few fished beyond midnight, even during the early summer months when 24 hour daylight prevailed. Fishermen seldom started before 08:30 and the occasional party set out after 23:00. As the summer advanced the hours of darkness increased, facilitating estimations.

iii. Time of week. Weekends were always more active with local fishermen contributing significantly.

iv. Time of year. Considerations of peak tourist season, the early summer when shore angling for kokanee is very popular among local residents, hunting season commencement in August, and public holidays, all these have a bearing on estimations.

v. Territorial fishing regulations. The opening and closing of the anadromous salmon seasons, particularily on the Klukshu River just outside the Park, diverted anglers from Kathleen Lake and had a bearing on estimations.

vi. Various fishing derbies and other social activies. These reduced the regular local anglers from Kathleen Lake to other areas. Community fairs, Discovery Day celebrations et cetera, had a marked influence on local angler fishing activity.

vii. Alaska State Ferry schedual. The arrival and departure of this ferry from Haines, Alaska, south of the Park concerted waves of vehicle and visitor traffic, many of which visited Kathleen Lake. An increase in fishing activity correlated very closely to ferry departure days.

B. Reports

Another useful aid in estimating angler activity for times when direct observations were not recorded were reports contributed by cottage owners in the access bay area, park wardens, other park staff, the local outfitter, visitors and other anglers, both visitors and local people who of course were all personally known to the creel cencus staff and who were most cooperative.

The creel census officer often combined comments about the weather with local reports and boat trailers, parked cars or campground attendance were used to assess an estimate of fishing activities. Good cross checks were usually possible and often estimated weights of catch as well as numbers and species were obtained with confidence.

Further details indicating the reliability of local reports of angling activity can be seen in the following:

1. Kathleen Lake Lodge. This family, all of who fished, reported on; i. their own activity, plus offered good indicators of activity at, ii. their cafe, gas sales and lodge occupancy, some of these patrons were fishermen, iii. sale of fishing licences, iv. report on highway traffic volume, and v. in 1980 had the campground maintenace contract, therefore, they were active contact with Park visitors.

2. Kluane Adventures - local outfitter. These people i. maintained the campground facilities in 1981 thereby supplying reports of angling

observations for certain times, ii. rented boats, canoes, and guides and often not only reported on angling of fishing party, but made catches available for sampling, iii. reported on their own personal angling efforts for times when creel census staff were on other duties.

3. Warden Staff. These members of the Park staff patrolled the lake and campgrounds occasionally, and reported information about anglers.

4. Park Interpretive Staff. Often these people spoke with visitors, gave lectures and were generally in a position to note the fishing activity.

5. Local residents with cabins in Access Bay. These people provided the best information for estimates of angling activity by: i. observing beach and surrounding shore from inside their cabins, ii. gave positions of anglers fishing on lake, iii. accurately reported their own catch and almost always made their catch available for sampling.

6. Local residents from Haines Junction and Whitehorse. Many of the regular local residents cooperated extensively with the creel census staff and would: i. make sure their catch was recorded, ii. would record their catch data for creel census in absence of census staff, iii. would inform staff of next fishing visit, iv. would often comment on previous catch during their next visit, or even stop the census staff in the street in town to report !

In short, creel census staff enjoyed excellent cooperation from everyone.

Summaries

Daily, weekly and total season summaries were prepared from the creel cards and spacer cards giving the following information: Total anglers, lake anglers [1] and shore anglers; total time, lake time and shore time [2]; total fish caught, lake fish and shore fish; totals by species, and overall success (success = fish/time), lake success and shore success.

Computer Analysis

Length-weight relationship were computed using a power function. Where length was not available, it was determined by the W-L equation $y = 5.10473E\text{-}07(x)^{3.476}$. Weights were similarily determined.

1 A lake angler is a fisherman using a boat beyond the access bay, on the lake proper.

2 A lake fisherman who spends some time shore fishing was considered as 1 man lake fishing, although his respective times are divided up in the totals. Therefore, in the totals, if the number of lake fishermen are subtracted from the total number of people who were angling from shore, you will not always have the number of shore anglers. This occurred infrequently and one manner of fishing dominated.

Creel Census

Results and Discussion

Creel census coverage

The extent of census coverage over a 24 hour, 7 day week basis was 37.8 ~~35.3~~% in 1980 and 23.1 % in 1981 (Tables &).

When percent of coverage was calculated excluding the night period (from midnight to 06:00), and later in the summer, as the hours of darkness increased, that period between sunset and ~~sunrise~~, the percent coverage increased considerably. In 1980 the effective percent coverage was 54.1 and in 1981 43.3 . Considering the days when adverse weather discouraged angling, these ~~high~~ percentages of actual coverage in conjunction with very reliable estimations for absent periods allowed the preparation of complete creel data. (Appendix).

Table 10. Extent of creel census coverage, Kathleen Lake, Yukon.

	1980					
	MAY (26-31)	JUN (1-30)	JUL (1-31)	AUG (1-10)	SEP (1-11)	Overall total
Total hours available	144	720	744	240		1848
Total hours covered	65.8	291.6	253.7	74.0		687.1
% covered over 24 hour day	45.7	40.5	34.1	31.0		37.8
% coverage for daylight hours	47.2	45.1	40.1	33.9		41.6
% coverage from 0600 'til dark	57.0	74.0	47.7	38.8		54.4

	1981					
	MAY (29-31)	JUN (1-30)	JUL (1-31)	AUG (1-31)	SEP (1-11)	Overall total
Total hours available	54	720	744	744	264	2526
Total hours covered	6.3	237.6	133.9	232.1	67.3	677.2
% coverage over 24 hour day	11.7	33.0	18.0	31.2	25.5	29.9
% coverage for daylight hours	16.8	41.7	23.9	42.5	44.6	42.4
% coverage from 0600 'til dark	22.1	50.6	28.9	48.5	47.1	49.3

Number of Anglers

The total number of annual anglers as determined from actual and estimated assessment, appears to have remained constant from 1980 to 1981 being 1228 and 1270, respectively (Table). The actual number of anglers counted over the summer census months was also very similar both years, with 1,056 anglers in 1980 and 976 for the same period in 1981. The number of shore and lake anglers was also similar over the summer period.

The number of anglers was highest in the early summer of both years and gradually dropped as the summer advanced. Over 100 anglers per week was typical in both years until early to mid July when the numbers decreased to around 60. Later in August, the number declined further to about 40 per week. This decline is attributable to the opening of anadromous salmon fishing in the area and to the opening of hunting season, which detracted local anglers.

A marked increase in the number of anglers spring fishing through the ice in 1981 was estimated to be two fold over 1980. This information was based primarily on warden service observations. It seems that the best locations and methods for ice fishing are being learned by local anglers and a continued increase can be expected. This spring activity accounted for a significant increase in lake trout harvested. Three years ago there was very little spring fishing. The extent of autumn angling is largely based estimation.

Table Creel Census Summary, May 26 - Aug. 10, 1980,
Kathleen Lake, Kluane National Park

Week	Anglers shore	Anglers lake	Anglers (total)	Time shore	Time lake	Time (total)	Fish shore	Fish lake	Fish (total)	Kokanee shore	Kokanee lake	Kokanee (total)	Grayling shore	Grayling lake	Grayling (total)	Lake Trout shore	Lake Trout lake	Lake Trout (total)	Rainbow Trout shore	Rainbow Trout lake	Rainbow Trout (total)	R.Whitefish shore	R.Whitefish lake	R.Whitefish (total)	Success* shore	Success* lake	Success* (overall)
May 26 June 1	128	10	(138)	144.3	39.3	(183.6)	84	11	(95)	67	5	(72)	10	3	(13)	1	3	(4)	5	0	(5)	1	0	(1)	0.582	0.280	(0.517)
June 1 June 8	80	25	(105)	111.2	99.7	(210.9)	46	27	(73)	13	6	(19)	31	4	(35)	1	17	(18)	1	0	(1)	0	0	(0)	0.414	0.271	(0.346)
June 9 Jun 15	41	46	(87)	55.8	113.8	(169.6)	14	46	(60)	5	1	(6)	9	2	(11)	0	43	(43)	0	0	(0)	0	0	(0)	0.251	0.404	(0.354)
Jun 16 Jun 22	67	45	(112)	67.2	157.5	(224.7)	22	22	(44)	5	4	(9)	14	0	(14)	1	18	(19)	2	0	(2)	0	0	(0)	0.327	0.140	(0.196)
Jun 23 Jun 29	68	22	(90)	70.5	55.6	(126.1)	24	4	(28)	2	1	(3)	12	0	(12)	7	3	(10)	3	0	(3)	0	0	(0)	0.340	0.072	(0.222)
Jun 30 Jul 6	62	61	(123)	66.8	222.3	(289.1)	32	70	(102)	2	2	(4)	23	44	(67)	6	24	(30)	1	0	(1)	0	0	(0)	0.479	0.315	(0.353)
Jul 7 Jul 13	69	44	(113)	81.0	139.3	(220.3)	27	12	(39)	8	1	(9)	10	1	(11)	8	10	(18)	1	0	(1)	0	0	(0)	0.333	0.086	(0.177)
Jul 14 Jul 20	48	61	(109)	54.3	255.8	(310.1)	18	51	(69)	0	0	(0)	17	16	(31)	3	35	(38)	0	0	(0)	0	0	(0)	0.332	0.199	(0.223)
Jul 21 Jul 27	30	33	(63)	33.0	95.3	(128.3)	16	36	(52)	0	0	(0)	14	15	(29)	2	19	(21)	0	2	(2)	0	0	(0)	0.485	0.378	(0.405)
Jul 28 Aug 3	39	8	(47)	56.7	23.2	(79.9)	11	2	(13)	0	0	(0)	9	0	(9)	1	2	(3)	1	0	(1)	0	0	(0)	0.194	0.086	(0.163)
Aug 4 Aug 10	41	28	(69)	22.3	100.0	(122.3)	7	20	(27)	0	4	(4)	6	6	(12)	1	10	(11)	0	0	(0)	0	0	(0)	0.314	0.200	(0.221)
	673	383	(1,056)	763.1	1301.8	(2,064.9)	301	301	(602)	102	24	(126)	153	91	(244)	31	184	(215)	14	2	(16)	1	0	(1)	0.394	0.231	(0.292)

* Success = catch/unit effort (fish/hour)

Excellent = over 0.75; Good = 0.50-0.75; Fair = 0.25-0.50; Poor = below 0.25;

Table Creel Census Summary, May 16 - Sept. 10, 1981, Kathleen Lake, Kluane National Park, Yukon

Week	Anglers			Time			Fish			Kokanee			Grayling			Lake Trout			Rainbow Trout			R. Whitefish			Success[1]		
	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(total)	shore	lake	(overall)
May 16 - May 28*	33	12	(45)	99.0	36.0	(135.0)	45	13	(58)	36	9	(45)	4	0	(4)	4	4	(8)	0	0	(0)	1	0	(1)	0.455	0.361	(0.430)
May 29 - Jun 4	131	2	(133)	174.7	3.8	(178.5)	81	0	(81)	72	0	(72)	7	0	(7)	2	0	(2)	0	0	(0)	0	0	(0)	0.464	0.0	(0.464)
Jun 5 - Jun 11	78	23	(101)	89.7	55.2	(144.9)	48	24	(72)	39	9	(48)	7	0	(7)	2	15	(17)	0	0	(0)	0	0	(0)	0.535	0.435	(0.497)
Jun 12 - Jun 18	78	52	(130)	75.6	159.7	(235.3)	17	102	(119)	13	34	(47)	4	22	(26)	0	46	(46)	0	0	(0)	0	0	(0)	0.225	0.639	(0.506)
Jun 19 - Jun 25	66	47	(113)	77.9	198.6	(276.5)	19	119	(138)	15	29	(44)	2	20	(22)	2	68	(70)	0	2	(2)	0	0	(0)	0.244	0.599	(0.499)
Jun 26 - Jul 2	38	22	(60)	40.6	118.8	(159.4)	16	32	(48)	13	6	(19)	2	4	(6)	1	21	(22)	0	1	(1)	0	0	(0)	0.394	0.269	(0.301)
Jul 3 - Jul 9	44	22	(66)	51.3	82.2	(133.5)	13	36	(49)	12	4	(16)	0	0	(0)	1	32	(33)	0	0	(0)	0	0	(0)	0.253	0.438	(0.367)
Jul 10 - Jul 16	40	39	(79)	31.4	144.8	(176.2)	10	39	(49)	3	7	(10)	5	2	(7)	2	30	(32)	0	0	(0)	0	0	(0)	0.319	0.269	(0.278)
Jul 17 - Jul 23	39	37	(76)	38.2	135.0	(173.2)	13	93	(106)	4	3	(7)	8	50	(58)	1	39	(40)	0	1	(1)	0	0	(0)	0.340	0.689	(0.612)
Jul 24 - Jul 30	44	17	(61)	35.5	56.3	(91.8)	6	19	(25)	3	1	(4)	0	0	(0)	3	18	(21)	0	0	(0)	0	0	(0)	0.169	0.338	(0.272)
Jul 31 - Aug 6	55	13	(68)	43.0	51.0	(94.0)	8	8	(16)	6	2	(8)	1	0	(1)	1	6	(7)	0	0	(0)	0	0	(0)	0.186	0.157	(0.170)
Aug 7 - Aug 13	33	11	(44)	36.3	29.7	(66.0)	5	8	(13)	3	0	(3)	1	0	(1)	1	8	(9)	0	0	(0)	0	0	(0)	0.138	0.269	(0.197)
Aug 14 - Aug 20	25	26	(51)	32.5	139.5	(172.0)	3	34	(37)	3	0	(3)	0	6	(6)	0	28	(28)	0	0	(0)	0	0	(0)	0.092	0.244	(0.215)
Aug 21 - Aug 27	11	27	(38)	16.2	163.0	(179.2)	1	36	(37)	0	2	(2)	0	7	(7)	0	27	(27)	1	0	(1)	0	0	(0)	0.062	0.221	(0.207)
Aug 28 - Sep 3	16	25	(41)	19.0	125.2	(144.2)	0	66	(66)	0	6	(6)	0	24	(24)	0	34	(34)	0	2	(2)	0	0	(0)	0.000	0.527	(0.458)
Sep 4 - Sep 10	12	25	(37)	15.6	75.0	(90.6)	8	53	(61)	0	0	(0)	2	2	(4)	1	51	(52)	5	0	(5)	0	0	(0)	0.513	0.707	(0.673)
	743	400	(1143)	885.9	1574.4	(2460.3)	293	682	(975)	222	112	(334)	43	137	(180)	21	427	(448)	6	6	(12)	1	0	(1)	0.331	0.433	(0.395)

* Based on Warden census plus partial estimate.

[1] Success = catch per unit effort. (fish per hour)

Excellent = over 0.75; Good = 0.50-0.75; Fair = 0.25-0.50; Poor = below 0.25.

Table Estimates of angler's creel for winter, spring and autumn periods not covered by actual census, Kathleen Lake, Kluane National Park, Yukon

Period	Anglers shore lake (total)	Time shore lake (total)	Fish shore lake (total)	Kokanee shore lake (total)	Grayling shore lake (total)	Lake Trout shore lake (total)	Rainbow Trout shore lake (total)	R. Whitefish shore lake (total)	Success[1] shore lake (overall)
1980									
Jan May 25	0 30 (30)	0 360 (360)	0 180 (180)	0 30 (30)	0 20 (20)	0 130 (130)	0 0 (0)	0 0 (0)	0.0 0.500 (0.500)
Aug 11 Aug 18	24 24 (48)	25 75 (100)	8 12 (20)	0 2 (2)	4 4 (8)	2 8 (10)	0 0 (0)	0 0 (0)	0.280 0.160 (0.200)
Aug 19 Aug 26	8 22 (30)	25 50 (75)	5 13 (18)	0 1 (1)	4 3 (7)	0 9 (9)	1 0 (1)	0 0 (0)	0.160 0.261 (0.240)
Aug 27 Sep. 3	8 20 (28)	20 48 (68)	2 16 (18)	0 2 (2)	2 4 (6)	0 10 (10)	0 0 (0)	0 0 (0)	0.100 0.333 (0.265)
Bal. of Sep	12 12 (24)	27 38 (65)	6 8 (14)	1 1 (2)	4 2 (6)	1 5 (6)	0 0 (0)	0 0 (0)	0.222 0.211 (0.215)
Oct	8 4 (12)	22 16. (38)	2 6 (8)	0 1 (1)	1 2 (3)	1 3 (4)	0 0 (0)	0 0 (0)	0.091 0.375 (0.211
Nov - Dec	-	-	-	-	-	-	-	-	- -
TOTALS	60 112 (172)	119 587 (706)	23 235 (258)	1 37 (38)	15 35 (50)	4 165 (169)	1 0 (1)	0 0 (0)	0.193 0.400 (0.365)
1981									
Jan May 15	0 48 (48)	0 600 (600)	0 300 (300)	0 40 (40)	0 30 (30)	0 230 (230)	0 0 (0)	0 0 (0)	0.0 0.500 (0.500)
Bal. of Sep	20 30 (50)	60 90 (150)	5 35 (40)	1 5 (6)	0 0 (0)	4 30 (34)	0 0 (0)	0 0 (0)	0.083 0.388 (0.267)
Oct	15 10 (25)	45 30 (75)	2 18 (20)	0 2 (2)	0 0 (0)	2 16 (18)	0 0 (0)	0 0 (0)	0.044 0.600 (0.265)
Nov	4 0 (4)	2 0 (2)	0 0 (0)	0 0 (0)	0 0 (0)	0 0 (0)	0 0 (0)	0 0 (0)	- - (-)
Dec	-	-	-	-	-	-	-	-	- -
TOTALS	39 88 (127)	107 720 (827)	7 354 (361)	1 47 (48)	0 30 (30)	6 276 (282)	0 0 (0)	0 0 (0)	0.065 0.498 (0.437)

[1] Success = catch/unit effort. (fish per hour) Excellent = over 0.75, good = 0.50 - 0.75, fair = 0.25 - 0.50, poor = below 0.25.

Table [illegible] Annual creel census summaries, including actual census observations and estimates, for Kathleen Lake, Kluane National Park, Yukon.

	Anglers shore lake (total)	Time shore lake (total)	Fish shore lake (total)	Kokanee shore lake (total)	Grayling shore lake (total)	Lake Trout shore lake (total)	Rainbow Trout shore lake (total)	R. Whitefish shore lake (total)	Success* shore lake (overall)
1980									
Jan - May 25	0 30 (30)	0 360 (360)	0 180 (180)	0 30 (30)	0 20 (20)	0 130 (130)	0 0 (0)	0 0 (0)	0.0 0.500 (0.500)
May 26 - Aug 10	673 383 (1056)	763.1 1301.8 (2064.9)	301 301 (602)	102 24 (126)	153 91 (244)	31 184 (215)	14 2 (16)	1 0 (1)	0.394 0.231 (0.292)
Aug 11 - Sept 3	40 66 (106)	70 173 (243)	13 43 (56)	0 5 (5)	10 11 (21)	2 27 (29)	1 0 (1)	0 0 (0)	0.186 0.249 (0.231)
Sept 4 - Dec	20 16 (36)	49 54 (103)	8 14 (22)	1 2 (3)	5 4 (9)	2 8 (10)	0 0 (0)	0 0 (0)	0.163 0.259 (0.214)
	733 495	882.1 1888.8	322 538	103 61	168 126	35 349	15 2	1 0	0.365 0.285
	(1228)	(2770.9)	(860)	(164)	(294)	(384)	(17)	(1)	(0.310)
1981									
Jan - May 15	0 48 (48)	0 600 (600)	0 301 (301)	0 40 (40)	0 30 (30)	0 230 (230)	0 1 (1)	0 0 (0)	0.0 0.502 (0.502)
May 16 - Aug 13	679 297 (976)	802.3 1072.4 (1874.7)	281 493 (774)	219 104 (323)	41 98 (139)	20 287 (307)	0 4 (4)	1 0 (1)	0.350 0.460 (0.413)
Aug 14 - Sep 10	64 103 (167)	83.6 502.0 (585.6)	12 189 (201)	3 8 (11)	2 39 (41)	1 140 (141)	6 2 (8)	0 0 (0)	0.144 0.377 (0.343)
Sep 11 - Dec	39 40 (79)	107 120 (227)	7 53 (60)	1 7 (8)	0 0 (0)	6 46 (52)	0 0 (0)	0 0 (0)	0.065 0.442 (0.264)
	782 488	992.9 2294.4	300 1036	223 159	43 167	27 703	6 7	1 0	0.302 0.451
	(1270)	(3287.3)	(1336)	(382)	(210)	(730)	(13)	(1)	(0.406)

* Success = catch/unit effort. (fish per hour)
Excellent = over 0.75; Good = 0.50-0.75; Fair = 0.25-0.50; Poor = below 0.25.

Time spent angling

Although the number of anglers remained constant from 1980 to 1981, there was a small increase in the time spent fishing. Over the annual period, an increase of 516 hours (18.6%) was calculated for 1981. (Tables , , &). This increase was due to more angling activity (240 hours) in the late winter by ice fishermen, and also by more angling activity in the late summer and early autumn (~~3666.6~~ 342.6 hours). In the latter case, this late summer increase was primarily the influence of two local cottage owners who were not active the previous year.

Although there was a general increase from early to mid summer In 1981, the time spent by anglers decreased slightly from 1980. This reduction accompanied a slight drop in fishermen as well (Table).

Number of fish caught

The total number of fish caught in 1980 was estimated to be 860 of all species (Table , , &). This increased to 1336 in 1981, ~~almost twice~~ one and a half times that of the previous year. This is more significant considering that the number of anglers remained almost constant over the two years and the time spent was only 1/5 more in 1981.

This increase in catch was composed of greater numbers of both kokanee and lake trout. In the case of kokanee the catch more than doubled, from 164 in 1980 to 382 in 1981. Most of the kokanee were caught from ~~the~~ shore in the vacinity of the landing bay (63% in 1980 and 58% in 1981). In both years the number of kokanee caught was highest in the spring and dropped of considerably by the second week in July, remaining low for the rest of the season.

For lake trout, the increase in harvest almost doubled, rising from 384 in 1980 to 730 in 1981 (Tables , , &). Most of this increase was accumulated during late winter ice fishing and later in the season, during the latter part of summer. In the late winter period, an increase in both fishermen and time spent, contributed to the larger catch in 1981. For a 60% increase in anglers and a 67% increase in time spent angling, the trout harvested rose by 77%. The late summer trout harvested rose from 29 in 1980 to 141 in 1981, mostly because of increased use by local cottage owners who were not active the previous year. In both cases, that of the early and late angling seasons, the impact that local anglers exert appears to be quite significant on a small fishery.

The only other fish species caught in similar numbers were arctic grayling. In 1980 about 294 were retained and in 1981 about 204. Many of the grayling were released, especially in 1981. A small number of rainbow trout were also caught and kept (17 in 1980 and 13 in 1981) and only one round whitefish was reported caught in each year.

Angling Success

Angler's success, measured as catch per unit effort and expressed in number of fish per hour showed a 57% increase in 1981, overall. This improvement was due to the increase in kokanee caught in the early summer period (for the same effort) and to the more numerous lake trout harvested later in the summer season. From other indications, particularily the enumeration of spawning kokanee in August of 1981, it appears that the increased success correlates to a marked increase in the kokanee spawning population which almost doubled, rising from 4,200 in 1980 to 7,200 in 1981. Most of the kokanee caught in the early summer are five year old fish that spawn later in the season.

The improved lake trout success in the late summer reflects the experience of the local cottage residents who are very familiar with the lake and who were not active the previous season to the same extent. There did not appear to be any pattern in the angler's success over the summer months, with good success recorded some weeks and poor for others.

Little change in success was found in the late winter and late autumn periods of angling, which remained about .50 and .22 respectively in 1980 and 1981. In the first case, that of the late winter period, the number of fishermen increased, and the catch remained good for the time spent. This data, in part, comes from park warden spot checking and from estimations, and is considered to be representative. The other fishing period which showed no appreciable change in angling success between 1980 and 1981 was the late autumn. This portion of the estimate comprises the weakest section of the creel census and is mostly compiled from estimates. It is known, though, that very little fishing occurs in the autumn since most visitors have left, school has commenced, the weather grown much colder and hours of darkness increased. Few reports are available about the success of fishermen determined to brave the elements in autumn. This period, therefore, is not expected to favour angling and its contribution to the annual harvest would be small.

Angling success over the main part of the summer, that is, from break-up until September, shows a large increase in 1981 compared to 1980. In 1980, angler success from break-up until early August was calculated to be 0.292 while in 1981 it climbed to 0.404. This significant increase reflects the higher number of kokanee caught in early summer in 1981 than in the previous year. Better success for this later period rose from 0.231 to 0.343. In this case the much higher number of lake trout caught by local cottage owners contributed to the increase. These people were not active during this period in 1980.

Angler harvest by weight

Total angler harvest by weight of all species for 1980 was 901 kg, while in 1981 it rose to 1280 kg, an increase of 42% (Table ,). These weights are based on both actual creel data which covers the most active portion of the summer (of total angler time), and on various estimates which cover the remainder of the year. These estimations were considered conservative.

The species most heavily harvested in both years was lake trout with 608 kg removed in 1980 and 1009 kg removed in 1981 (Tables). Production, harvest and discussion of the lake trout in Kathleen Lake is given in a separate report, Wickstrom, 1982, in preparation.

Arctic grayling were harvested more heavily than kokanee in both numbers and weight in 1980, with 294 yielding a weight of 220 kg. In 1981, the order switched with 204 arctic grayling harvested having a weight of 107 kg (Table_). Arctic grayling were usually caught inadvertently by anglers attempting to catch lake trout or kokanee. Many grayling were released.

By comparison, in 1980, 145 kokanee were harvested by anglers, having a weight of 73 kg, while in 1981, 326 were harvested, weighing 164 kg. Not enough kokanee were measured in 1980 to establish mean weight by sex or combined, therefore, the mean weight from 1981 was used in estimating weights for 1980. Kokanee have only five year classes which appear to vary slightly from year to year, as noted in the length-frequency distribution shown for 1980 and 1981 (~~Table~~ Fig 3 and 4). Since 1980 fish were, on the average, larger than those of 1981, it is assumed that their weights would also be greater. Therefore, using 1981 mean weights to calculate total kokanee weight harvested in 1980 would give a conservative value.

The amount of rainbow trout and round whitefish caught were almost negligible by comparison (Table). Seventeen rainbow trout and one round whitefish were caught in 1980, totalling 12 kg, while in 1981 there were 13 and 1 caught, respectively, totalling 9.5 kg*.

* Discrepancies in numbers of sample size in tables showing creel summaries used for success calculations (Tables 11, 12, 13 & 14) may not tally with sample size in the harvest Tables 16, 17, 18 and 19 because in the first set of tables, total catch was used while in the harvest tables, only fish retained were considered.

Yield

Combined harvest by angling of all species in Kathleen Lake was 0.267 kg/ha/yr in 1980 and 0.379 kg/ha/yr in 1981 (Table). Lake trout, the largest portion with 0.180 kg/ha/yr in 1980 and 0.299 in 1981, which is equivalent to [illegible] % and [illegible] % respectively. Kokanee total led 0.022 kg/ha/yr in 1980 and 0.049 kg/ha/yr in 1981 which, by percent is [illegible] % and 12.9 % respectively. Arctic grayling were harvested at 0.065 kg/ha/yr in 1980 and 0.032 in 1981, which comprised [illegible] % and [illegible] % of the total harvested in Kathleen Lake.

*

Table Total weight (kg) of actual and estimated kokanee harvested[1] by anglers, Kathleen Lake, Kluane National Park, Yukon, 1980.

	male	n	female	n
Actual				
Sum of fish weighed	-		-	
Mean weight[2]	.507		.498	
Standard deviation	± .105		± .100	
Field weights[3]	7.098	14	5.976	12
Calculated weights of fish not sampled[4]	26.871	53	13.944	28
Total	33.969	67	19.920	40
Combined total		53.889	107	
Estimated				
Weight of ice fishing and pre-census harvest[5]	10.140	20	4.980	10
Weight of late summer catch (post-census)[4,5]	1.521	3	.996	2
Weight of autumn angler harvest	1.014	2	.498	1
Total				
Annual weight of fish harvested	46.644	92	26.394	53
Combined total		73	145	

1 Based on total number of fish not released.
2 1981 mean weights used because data for 1980 not numerous enought. See text for substantiation of year class similarity.
3 Based on fisherman's weight estimations. Sex known.
4 Estimated weight of harvested fish counted without measurements, proportioned by sex ratio (1.9:1), using male and female mean weights of 1981 summer census.
5 Creel census in 1980 terminated Aug. 10th.

Table Total weight (kg) of actual and estimated kokanee harvested[1] by anglers, Kathleen Lake, Kluane National Park, Yukon, 1981.

	male	n	female	n
Actual				
Sum of fish weighed [2]	25.845	51	12.935	26
Mean fish weight	.507		.498	
Standard deviation	± .105		± .100	
Field weights [3]	1.014	2	1.992	4
Calculated weights [4]	65.403	129	32.868	66
Total	92.262	182	47.795	96
Combined total		140.057	278	
Estimated				
Weight of ice fishing and pre-census harvest [4]	13.689	27	6.474	13
Weight of late summer catch (post-census) [5]	-		-	
Weight of autumn angler harvest [4]	2.535	5	1.494	3
Total				
Annual weight of fish harvested	108.486	214	55.763	112
Combined total		164	326	

1 Based on total number fish not released.
2 Based on mean weight from summer census data.
3 Based on fisherman's weight estimations. Sex known.
4 Estimated weight of harvested fish counted without measurements, proportioned by sex ratio (1.9:1), using male and female mean weights of summer census.
5 Weights for this period included with actual total weight harvested from summer creel census May 16 to Sep. 10/81.

Table 17 Total annual weight (kg) of actual and estimated lake trout (sexes combined) harvested [1] by anglers, Kathleen Lake, Kluane National Park, Yukon.

	1980	n	1981	n
Actual				
Sum of fish weighed [2]	108.634	34	245.340	143
Mean weight	3.195		1.716	
Standard deviation	± 3.496		± 1.880	
Field weights [3]	104.788	41	294.144	158
Calculated weights [4]	40.643	27	24.155	20
Total	254.065	102	563.639	321
Median Weight	-	-	1.233	
Mean weight	-	-	1.756	
Standard deviation			± 1.828	
Estimated				
Weight of creel fish not sampled [5]	149.193	121	97.407	79
Weight of ice fishing & pre-census harvest [5]	160.290	130	283.590	230
Weight of late summer (post-census) harvest [5,6]	33.291	27	-[7]	
Weight of autumn angler harvest [5]	9,864	8	64.116	52
Total				
Annual weight of fish harvested	606.703	388	1,008.752	682

1 Based on total number of fish not released.
2 Based on mean weight from summer census data.
3 Taken from fisherman's estimation.
4 Calculated from measured lengths using L-W power curve of 1981 data.
5 Estimated weight of harvested fish counted without measurements, based on median of 1981 weights.
6 Creel census in 1980 terminated August 10th.
7 Weight included with actual total weight harvested from May 16 to Sep. 19/81.

Table Total weight (kg) of actual and estimated arctic grayling, (sexes combined) harvested [1] by anglers, Kathleen Lake, Kluane National Park, Yukon.

	1980-81	n		
Actual				
Sum of fish weighed [2]	5.243	7		
Mean fish weight	.749			
Standard deviation	± .259			

	1980	n	1981	n
Sum of actual weights [2]	1.031	2	4.222	5
Calculated weights [3]	181.248	242	80.143	107
Total harvested	182.279	244	84.365	112
Estimated				
Weight of ice fishing and pre-census harvest [3]	14.980	20	22.470	20
Weight of late summer harvest (post-census) [3,4]	15.729	21	- [5]	
Weight of autumn angler harvest [3]	6.741	9	-	0
Total				
Annual weight of fish harvested	220	294	107	142

1 Based on total number of fish not released.
2 Based on mean weight from summer census data.
3 Estimated weight of harvested fish counted without measurements, using mean weight.
4 Creel census in 1980 terminated Aug. 10th.
5 Weight included with actual total weight harvested from summer creel census May 16 - Sep. 10/81.

1(

Table Total harvest, actual and estimated, of all species by angling, Kathleen Lake, Kluane National Park, Yukon.

	1980		1981	
	kg	kg/ha/yr	kg	kg/ha/yr
arctic grayling	220	0.065	107	0.032
lake trout	608	0.180	1009	0.299
kokanee	73	0.022	164	0.049
Total weight	901		1280	
Total harvest by angling [1]		0.267		0.379
Estimated lake production by MEI [2]		1.68		1.73

1 Surface area of Kathleen Lake = 3376 ha

2 Production $Y = .966\sqrt{MEI}$ MEI(1980) = 3.027 MEI(1981) = 3.19 Table .

Sex Ratio and Maturity

Overall sex ratios of kokanee sampled from fishermen's creel were 1.2:1 males to females in 1980 while in 1981 it was found to shift further to 1.9:1 in favour of males (Table 20). Reasons for the dissimilarity were not apparent and could reflect an incomplete cross-section of sampling of fishermen's creel. The apparent selectivity towards males in both 1980 and 1981 may also be attributable to the pre-spawning development of male aggressive behaviour.

Most males and females caught in the early season, up to about mid July, were in advanced stages of ripening for spawning later in August. This condition was similar in both 1980 and in 1981. After about the mid part of July, there was a definite change in the maturity of the fish caught, with most being immature or of a stage of ripening precluding spawning that year. More of these were males, of age 3^+ or 4^+.

The reduction in number of kokanee caught, the lower stage of maturity, and the shift in age structure towards 3^+ males is a strong indication that the larger, older and more mature members of the population commence migration from Kathleen to Sockeye Lake in mid July, preparatory for spawning later in August.

Table Sex ratios of kokanee sampled from fisherman's creel, Kathleen Lake, Kluane National Park, Yukon.

	♂	♀	Ratio
1980	14	12	1.2:1
1981	56	30	1.9:1

Size Composition

Mean Length

Mean length of kokanee caught in the 1980 angler's creel was 372.1 ±63.3 mm (n=52) for male and female plus those of unknown sex, and in 1881 it decreased to 358.6 ±31.7 mm (n=93), a difference of 13.5 mm (Table). In both years, males caught were slightly longer than females, being 388.6 ±7.0 mm (n=14) compared to 362.0 ±68.6 mm (n=10), respectively, in 1980 and 362.5 ±30.3 mm (n=53) compared to 359.0 ±27.3 mm (n=29) in 1981 (Table).

The difference between means found for 1980 and 1981 indicates that variations between age classes occur for a fish with such a short and uniform life cycle and what would appear to be fairly uniform environmental conditions for growth.

Length-Frequency Distribution

Kokanee length-frequency distribution from fisherman's creel, Kathleen Lake, during 1980 and 1981 shows one principle peak, males and females combined and a second, smaller peak (Fig. 3 and 4). These peaks did not shift when analysed by sex. The length around which the strongest peak centred was 420 mm in 1980 and 370 in 1981, indicating that length of fish comprising the fisherman's creel dropped in 1981. ~~(Tables 2 & 3)~~. The age of fish of this size was 4^+, indicating that kokanee of this size class are the potential spawners later in the summer. This is also supported by a drop in number of kokanee caught in the weeks prior to spawning and further, of those caught during late summer, more 3^+ were caught than had been earlier.

Table Kokanee mean lengths (mm) and weights (gm), Kathleen Lake.

1980				
Length				
Male (n=14)	$\bar{x}$ = 388.6	± 7.0 *		
Female (n=10)	$\bar{x}$ = 362.0	± 68.6		
Combined (n=14+10+28)			$\bar{x}$ = 372.1	± 63.3
Weight	N.A.			
1981				
Length				
Male (n=53)	$\bar{x}$ = 362.5	± 30.3		
Female (n=29)	$\bar{x}$ = 359.0	± 27.3		
Combined (n=53+29+11)			$\bar{x}$ = 358.6	± 31.7
Weight				
Male (n=51)	$\bar{x}$ = 506.8	± 104.9		
Female (n=26)	$\bar{x}$ = 497.5	± 99.7		
Combined (n=51+26+7)			$\bar{x}$ = 491.5	± 112.2

* standard deviation

Fig.___. Kokanee length-frequency distribution
from fisherman's creel
Kathleen Lake, Yukon, 1980.

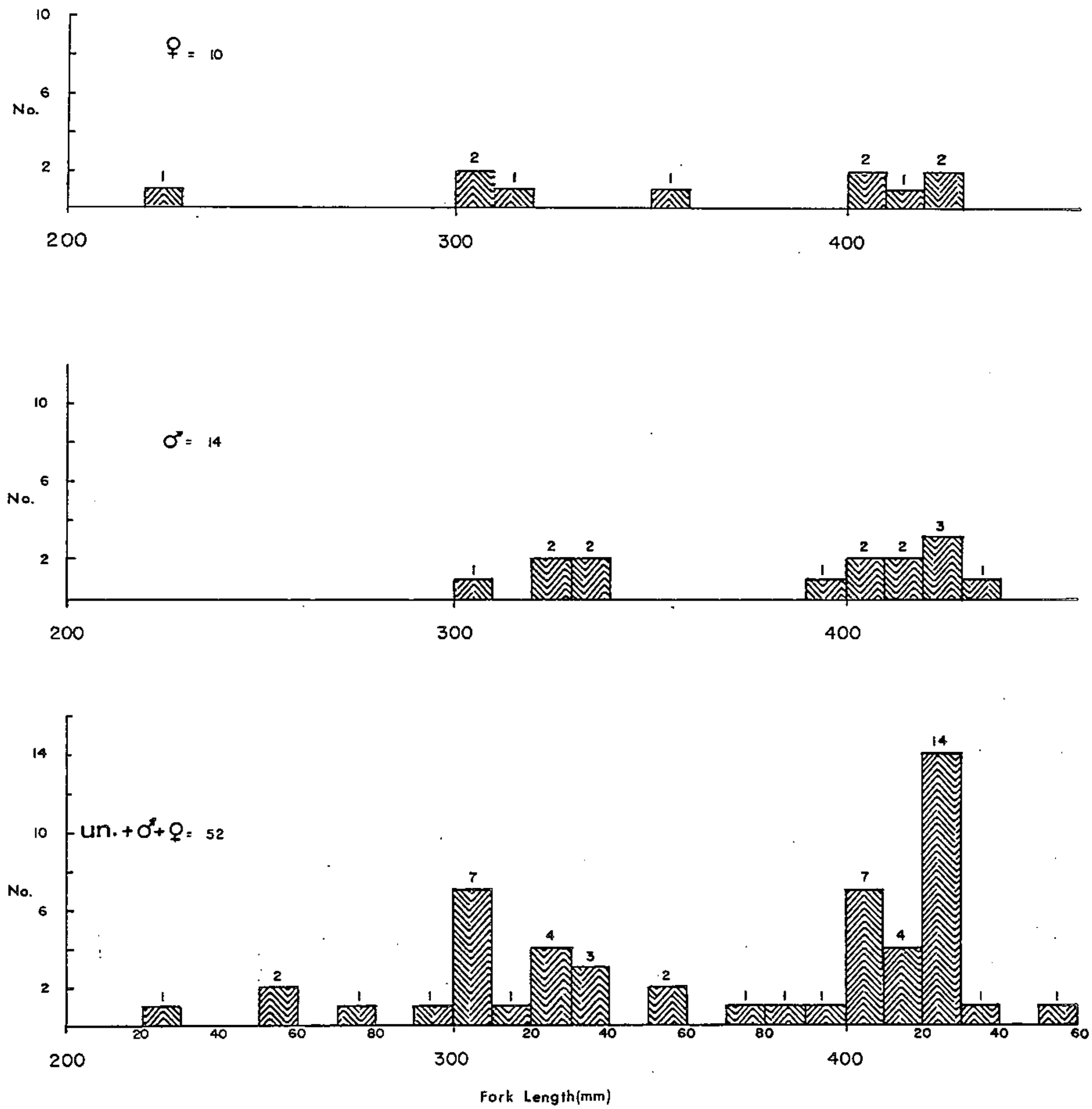


Fig.___. Kokanee length-frequency distribution from fisherman's creel Kathleen Lake, Yukon, 1981.

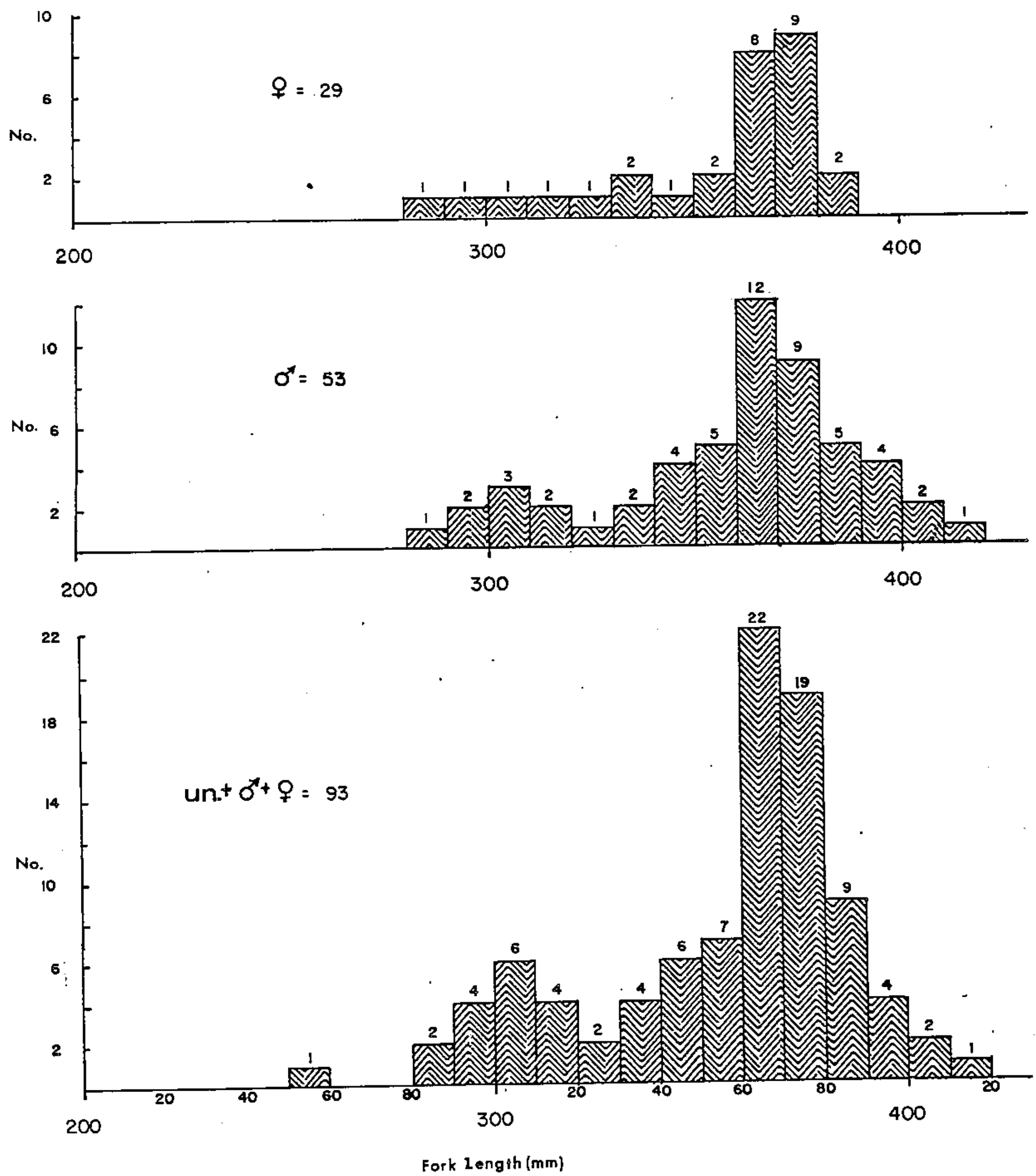
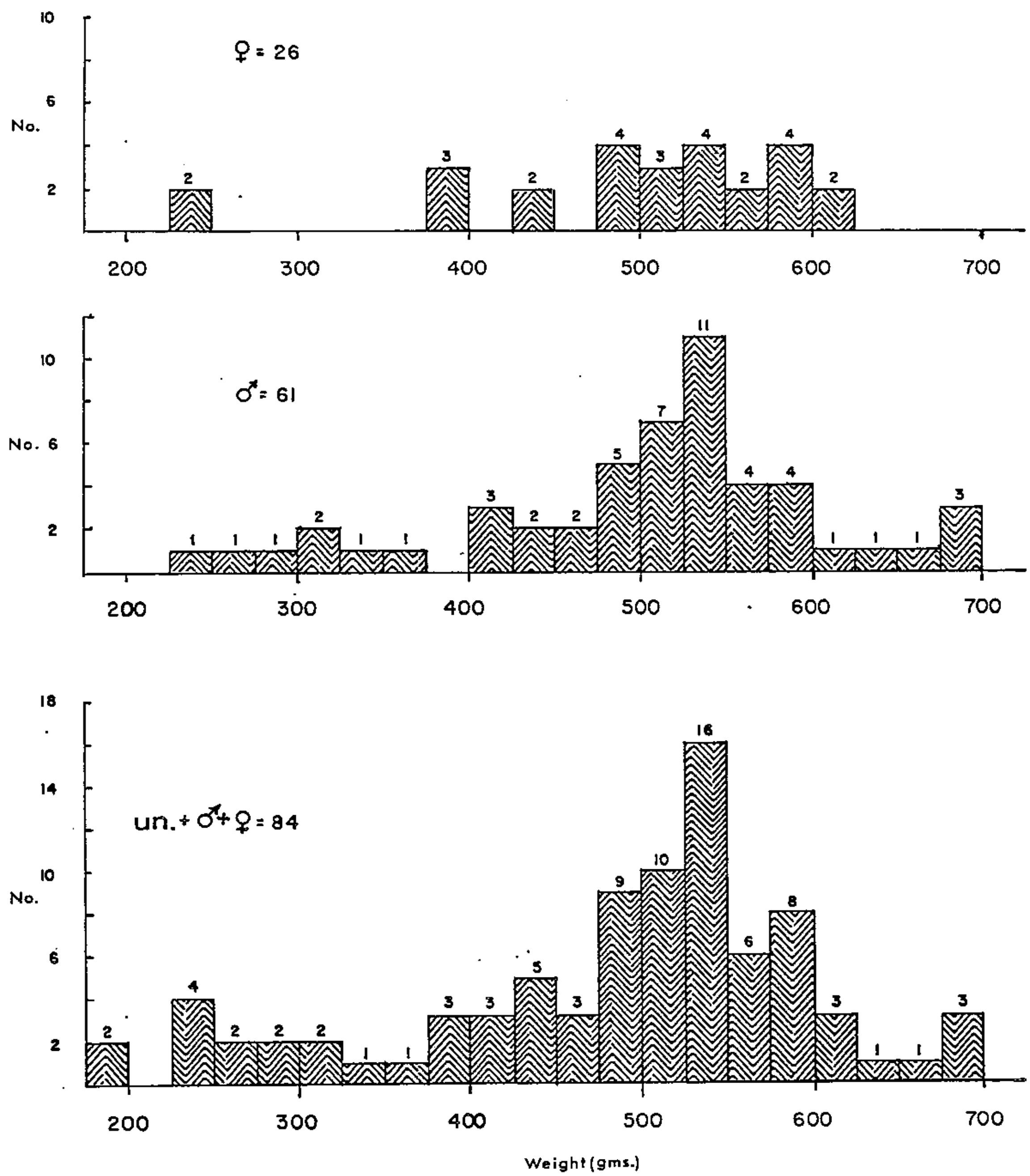


Fig. __ . Kokanee weight-frequency distribution
from fisherman's creel
Kathleen Lake, Yukon, 1981.



A second, weaker peak was centred around 310 mm in both 1980 and 1981. These were mostly 3^+ fish. Very few fish of smaller size were caught by anglers.

Mean Weight

Mean weight for kokanee in the angler's creel for males, females plus unknown sex was 491.5 ±112.2 g (n=84, in 1981, (Table).

In 1981, males were found to be slightly heavier than females, being 506.8 ±104.9 g (n=51), compared to 497.5 ±99.7 g (n=26) (Table). The standard deviation is larger than would have been expected for a population of such a short, uniform life cycle, lake distribution and apparently similar environmental conditions prevailing from year to year.

Data for weight on 1980 was not sufficient to calculate mean weights for that year, but because the mean length was smaller in 1981 than in 1980, it can be assumed that the average weight would also be less in 1981.

The reduction in mean size (length and presumably weight, as suggested above), could reflect the increased inter competion for food by the 1981 adults because their number is almost double from the 1980 adults.

Weight-frequency Distribution

Weight frequency distribution of kokanee in 1981 (~~Table~~ Fig.) shows a broad peak centre around 540 gms, sexes combined plus unknown , which did not shift when analysed by sex. These fish were mostly mature 4^+, with some 3^+. A very slight secondary peak centred around 300 gm was discernable, representing 3^+ fish.

CREEL CENSUS

Results and Discussion

Age Composition

Age-Frequency

Age-frequency distributions of kokanee from angler's creel are shown in Fig. - & -. In both 1980 and 1981, more 4^+ fish were caught then 3^+, although in 1981 the difference was very pronounced in favour of older fish. Although 2^+ fish were caught in 1980, none were taken in 1981. In both years only one 5^+ kokanee (♂) was caught.

Analysis by sex shows that slightly more males then females of age 4^+ and 3^+ were taken in both years. This may be related to early demonstration male pre-spawning aggressive behaviour.

Fig.____. Kokanee Age-frequency distribution from fisherman's creel Kathleen Lake, Yukon, 1980.

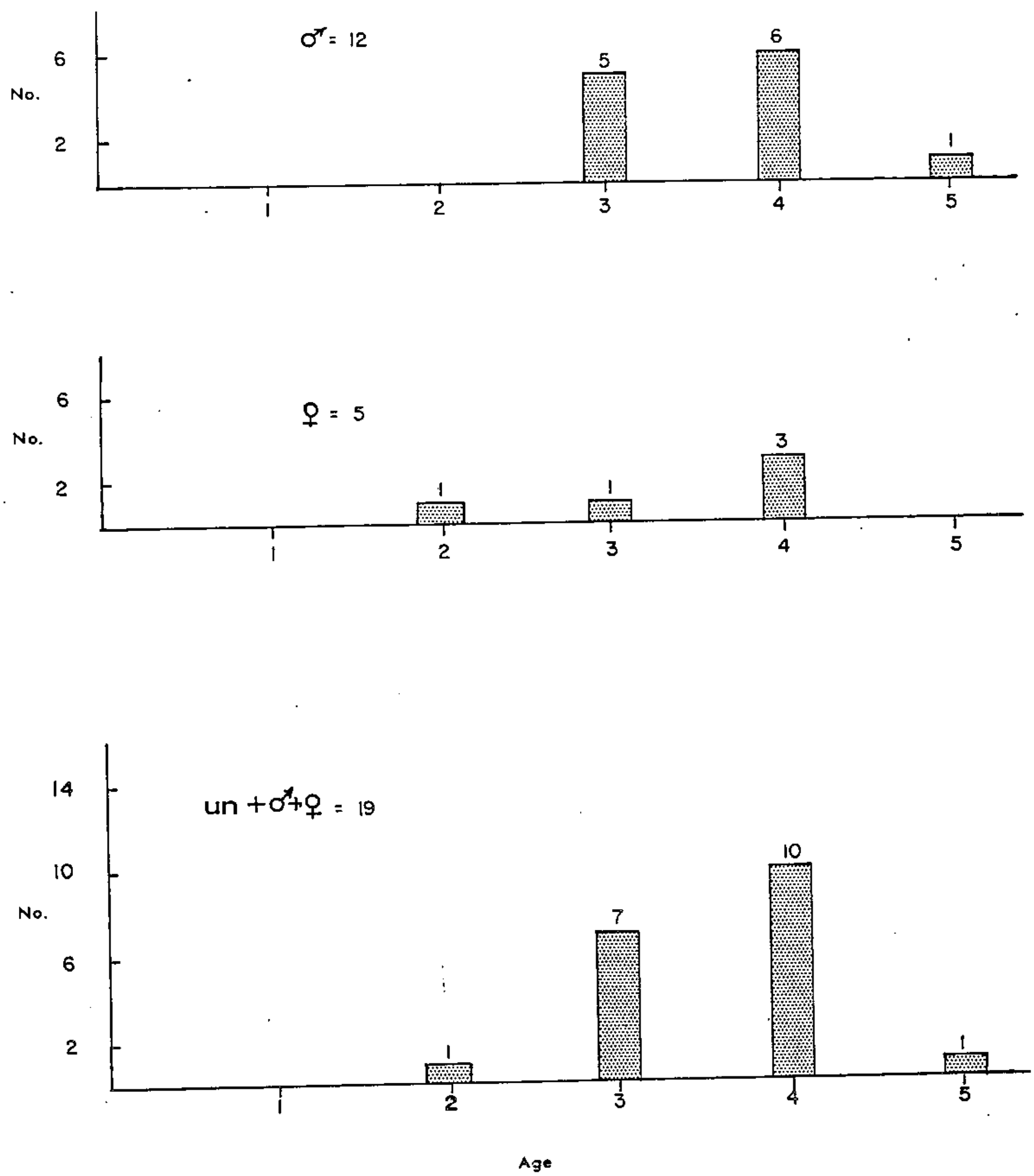
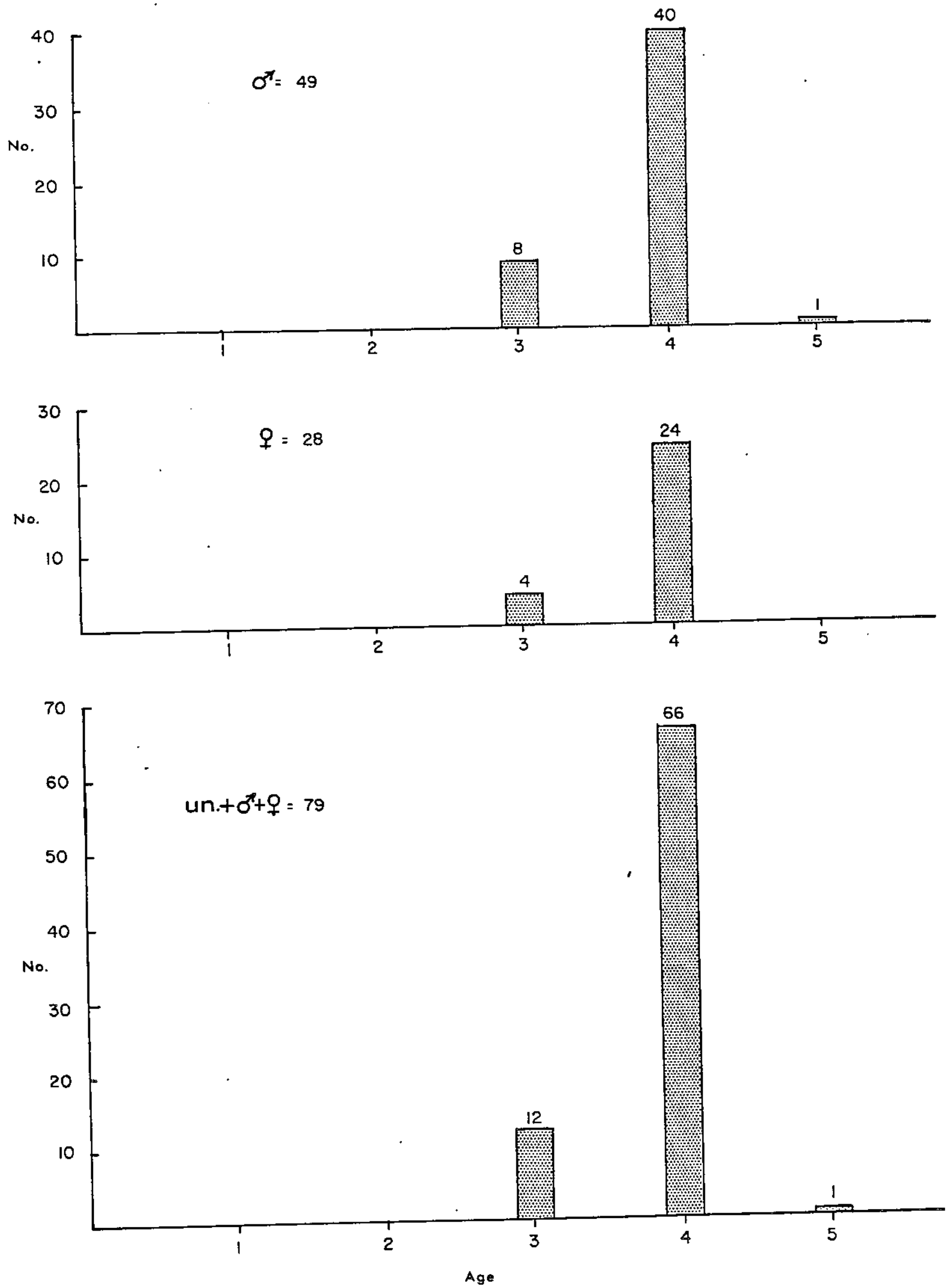


Fig. ___. Kokanee Age-frequency distribution
from fisherman's creel
Kathleen Lake, Yukon, 1981.



CREEL CENSUS

Results and Discussion

Growth
Length-Weight Relationship

Length-weight relationship for kokanee measured in the fishermen's creel are shown in Figs. [illegible], [illegible] & [illegible]. Power curve relationship are represented by $y=6.58453E-05x^{2.6867}$ for 1981 males, $y=1.02713E-05x^{3.0044}$ for females and $y=4.13480E-05x^{2.7736}$ for males plus females and unknowns, where y=weight and x=length. Weight data was too limited in 1980 to plot differences in coefficients between 1980 and 1981 components of the catch. From analysis of the mean lengths and weights, these measurements are shown to be very similar for males and females, therefore, length-weight curve and coefficients for the combined sexes plus unknowns can be considered a good approximation.

Growth

Growth calculation from creel data is limited because fishermen's catches were largely composed of only two age classes, 3^+ and 4^+. The mean length and weights for 3^+ males, females and ~~males, females~~ plus unknowns was calculated to be [illegible] mm and [illegible] gms, [illegible] mm and [illegible] gms and [illegible] mm and [illegible] gms respectively. Estimates of annual growth in length and weight made from this data (Table [illegible]) shows that the average annual increment in length from 3^+ to 4^+ was [illegible] mm and for weight, [illegible] gm.

The average length for 3^+ fish given by Scott and Crossman (1973) (4^+=5th year of life and is not given) is 215-275 mm for Nicola Lake, B.C., (Lorz and Northcote, 1965) 254-305 mm for Pond Oreille Lake, Idaho (Buss 1967) and 250 mm for Baulta Lake (Fallis, 1970).

Kokanee from Kathleen Lake, therefore, are larger at 3^+ than would be expected from a lake as potentially unproductive as Kathleen. This larger size may reflect an environment with considerably less competion for food than those fish noted in comparison.

Kokanee in the Kathleen lakes drainage usually live to 4^+, rather than the more normal 3^+ as in other areas, therefore, mature kokanee from this drainage are considered to be of an abnormally large size. By comparison, kokanee from Frederick Lake appear to spawn at 3^+ and reach 250-320 mm at maturity (~~Table~~).

*

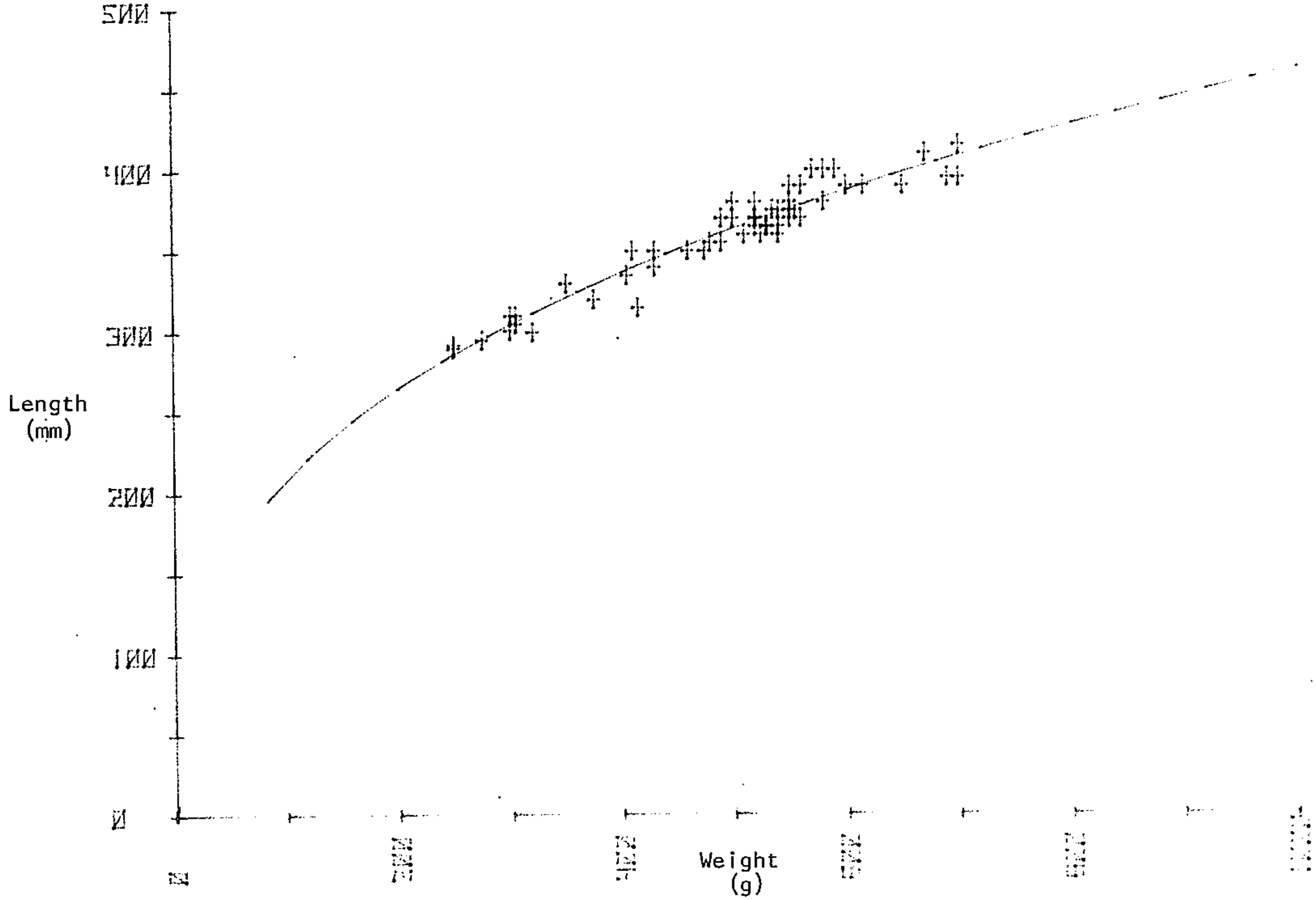


Fig.   . Length-weight relationship of kokanee males, from angler's creel, Kathleen Lake, 1981.

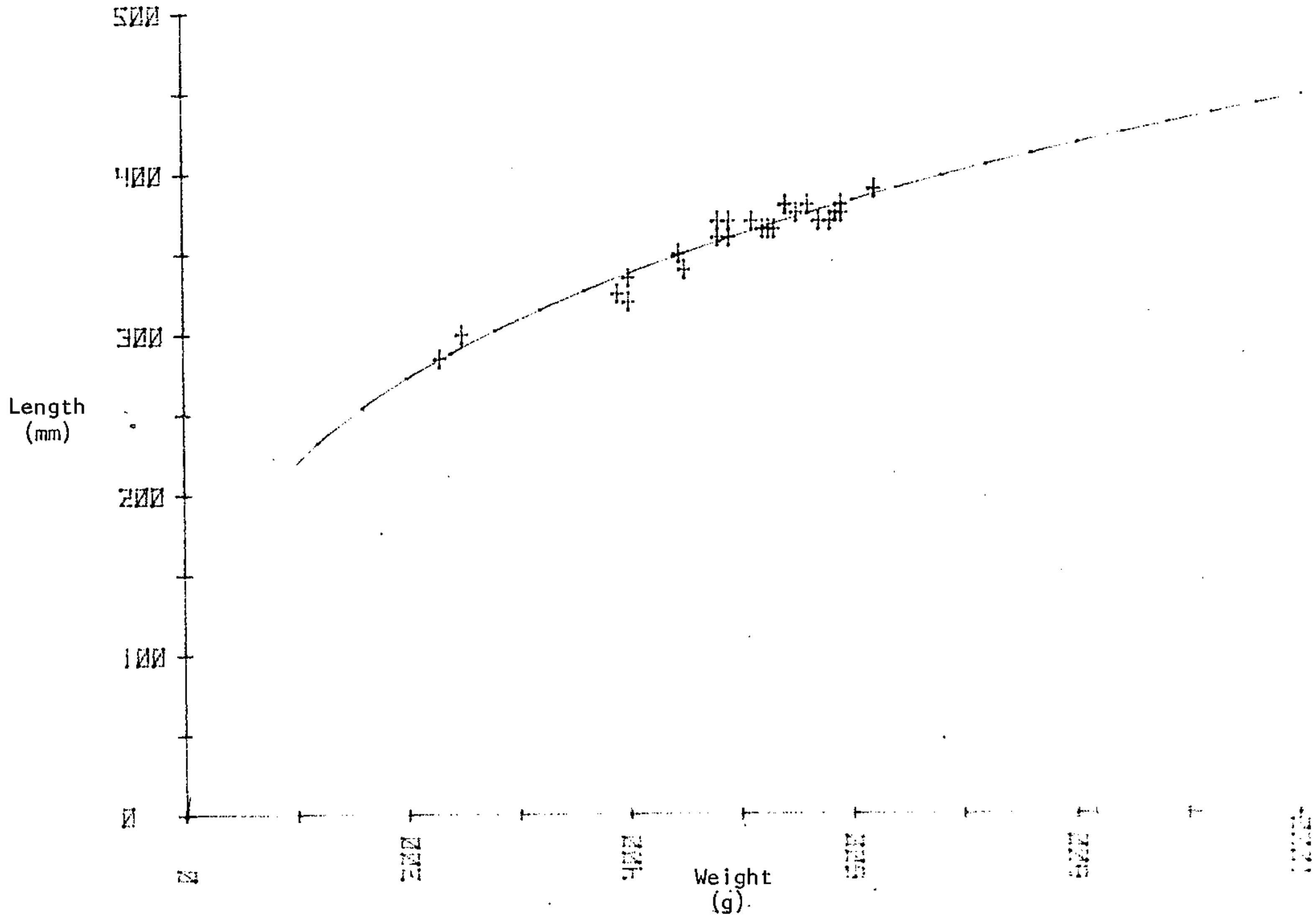


Fig. . Length-weight relationship of kokanee females, from angler's creel, Kathleen Lake, 1981.

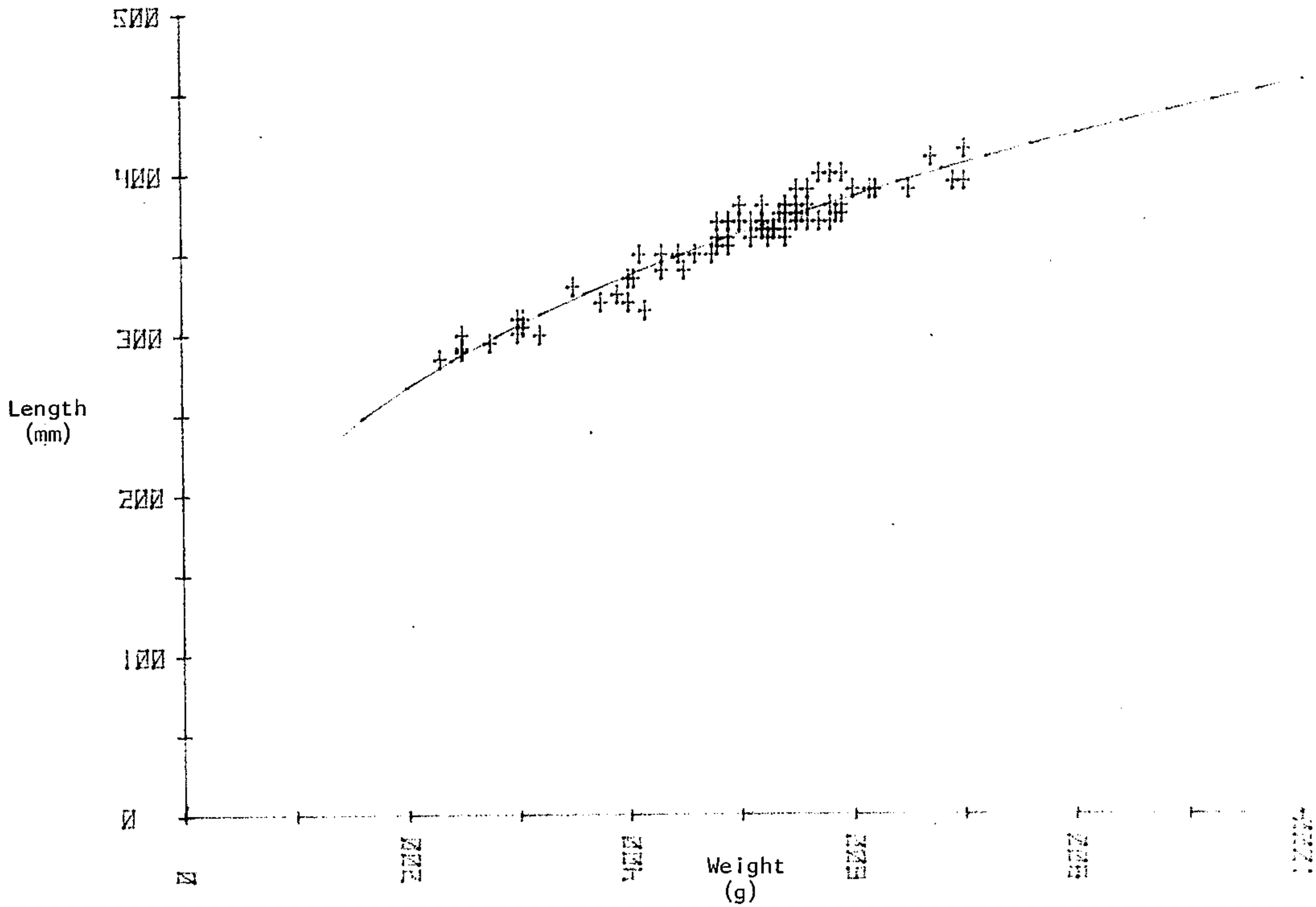


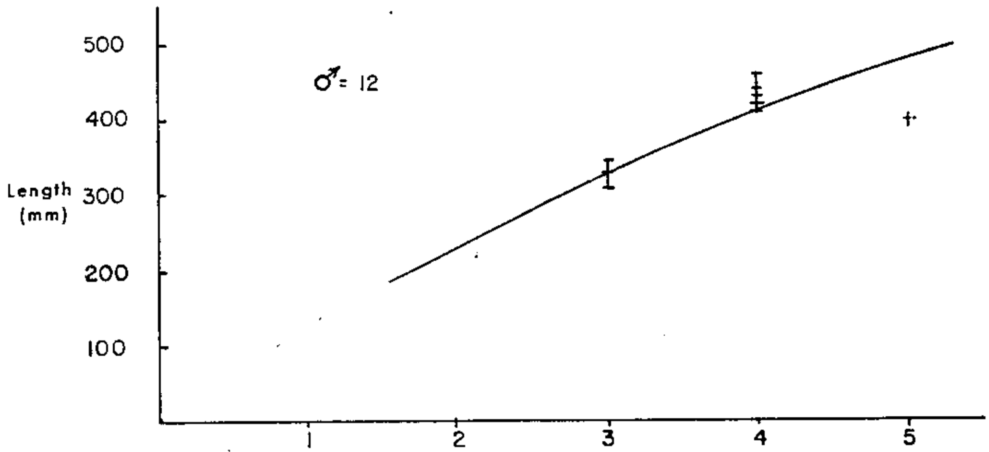
Fig. . Length-weight relationship of kokanee (sexes combined) from angler's creel, Kathleen Lake, 1981.

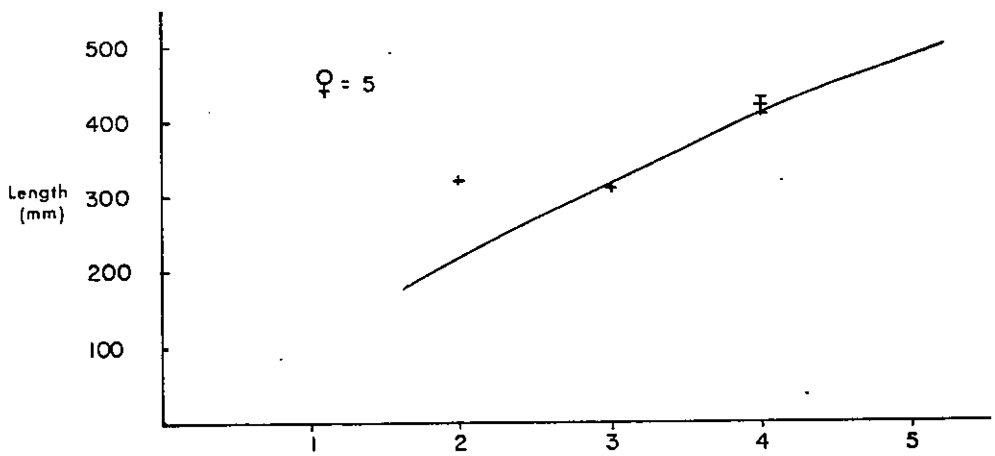
Table . Estimations of average calculated for length*, weight and growth increments at each age class, from fisherman's creel, 1981, Kathleen Lake.

	Age class					
	0^+	1^+	2^+	3^+	4^+	5^+
♂						
Length (mm)				(290-320) 305.8±10.7 (n=8)	(330-415) 373.4±18.7 (n=40)	395.0 (n=1)
Length Increment (mm)					67.6	21.6
Weight (gm)				(250-415) 313.8±54.4 (n=8)	(350-700) 537.7±70.3 (n=40)	700.0 (n=1)
Weight Increment					223.9	162.3
♀						
Length (mm)				(285-325) 307.5±18.5 (n=4)	(310-390) 366.3±17.5 (n-24)	
Length Increment (mm)					58.8	
Weight (gm)				(230-400) 317.5±90.0 (n=4)	(314-620) 520.5±69.4 (n=24)	
Weight Increment (gm)						
♂±♀± UN.						
Length (mm)				(285-325) 305.8±12.9 (n=12)	(310-415) 370.8±18.2 (n=66)	395.0 (n-1)
Length Increment (mm)					65.0	24.2
Weight (gm)				(230-415) 315.0±64.0 (n=12)	(314-700) 531.8±68.9 (n=66)	700.0 (n=1)
Weight Increment (gm)					216.8	168.2

* ± standard error.

Fig.___. Kokanee length-age curves
from fisherman's creel
Kathleen Lake, Yukon, 1980.





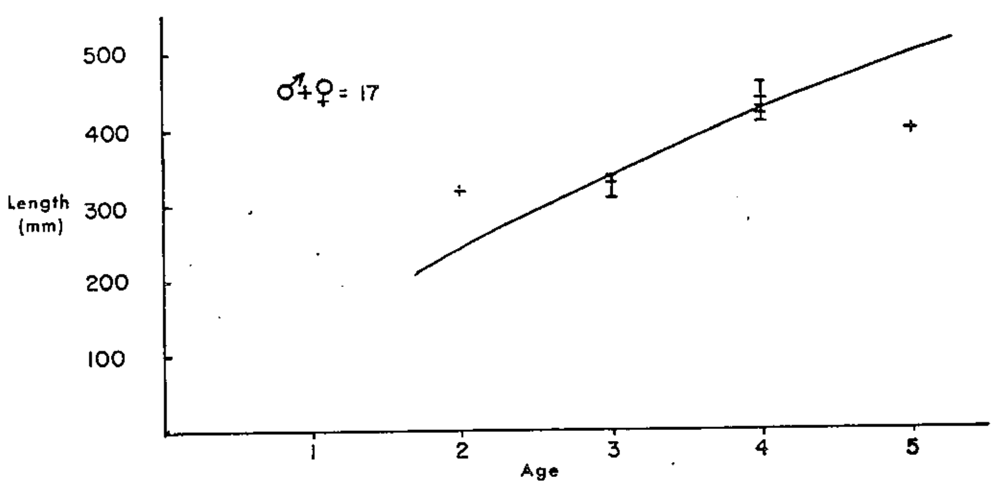


Fig.___. Kokanee length-age curves
from fisherman's creel
Kathleen Lake, Yukon, 1981.

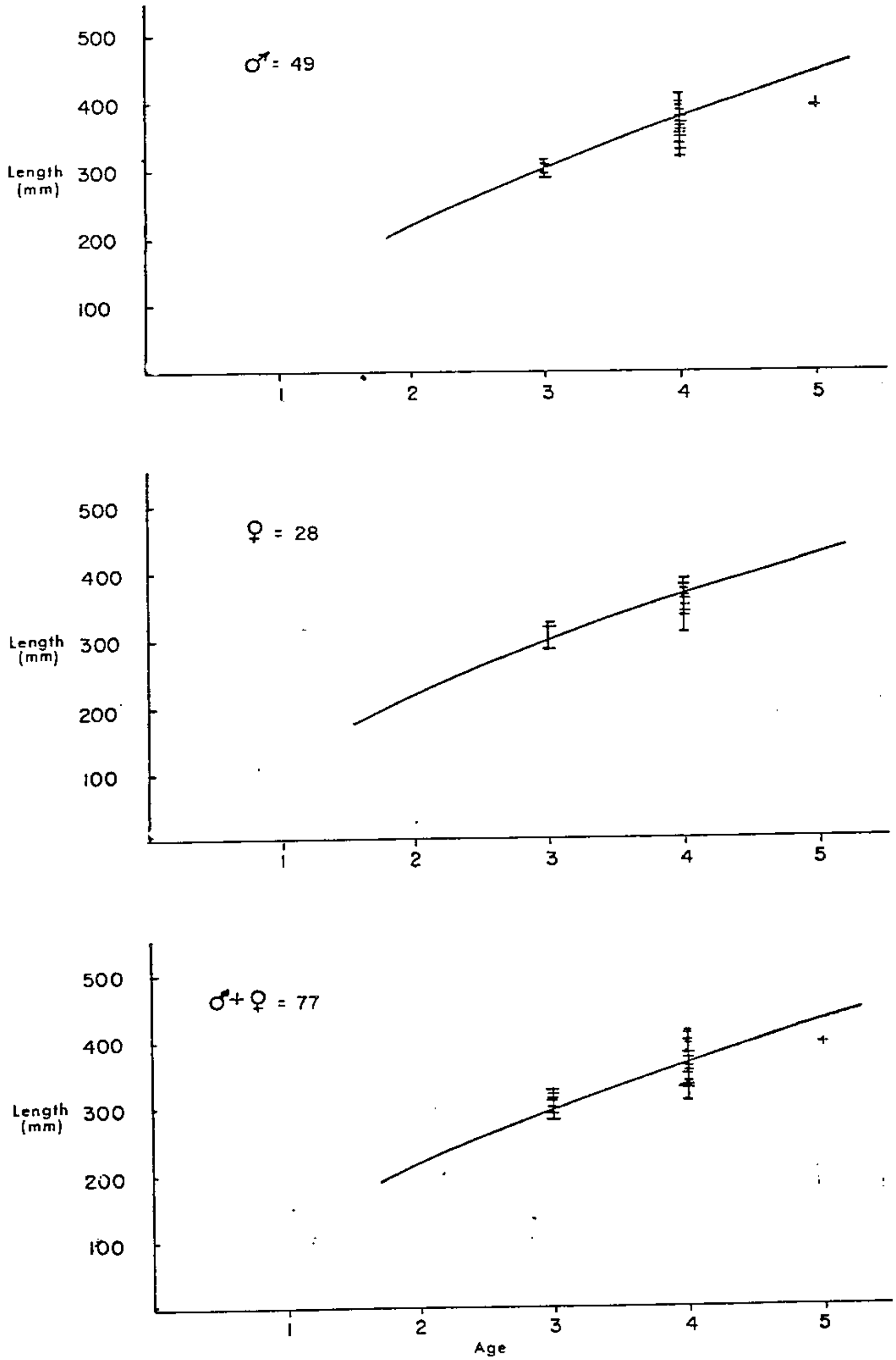
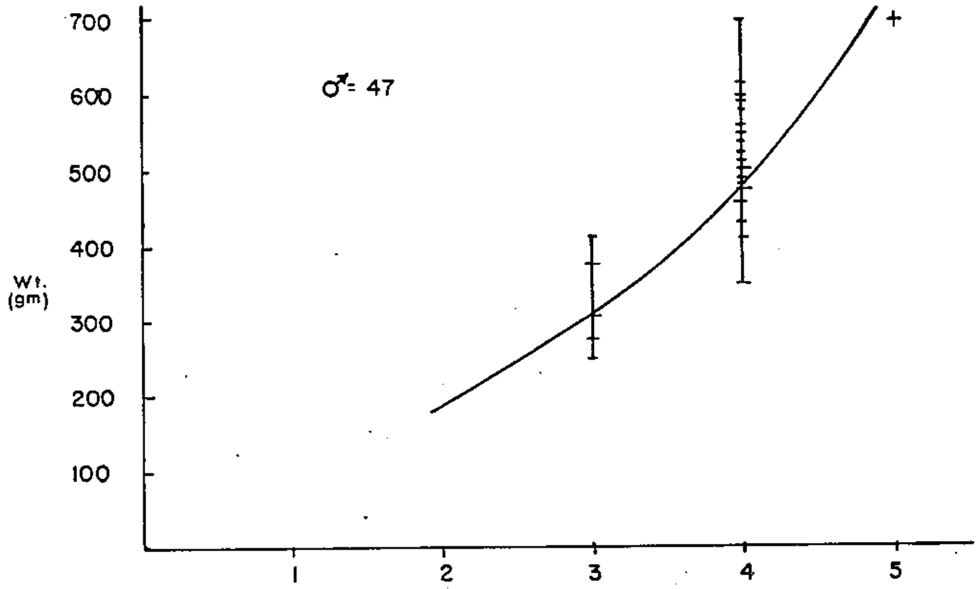
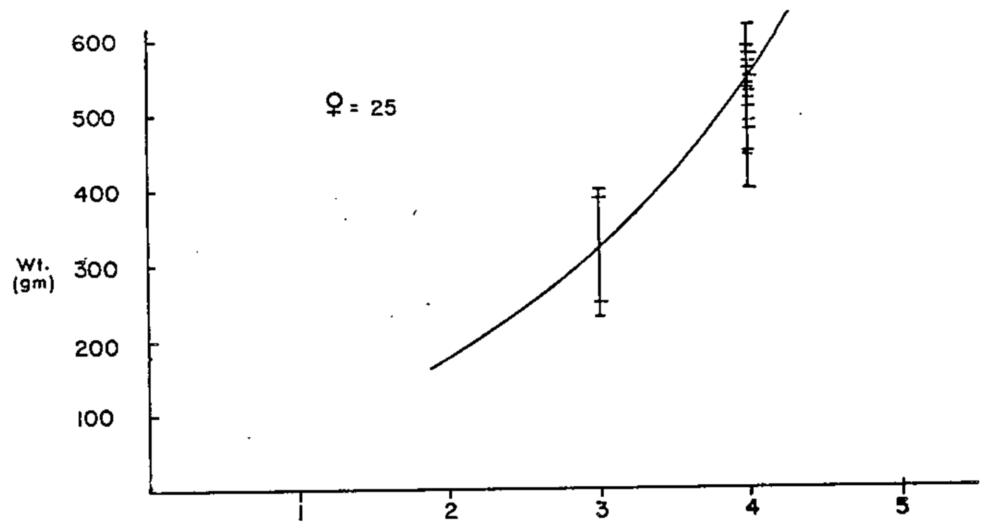
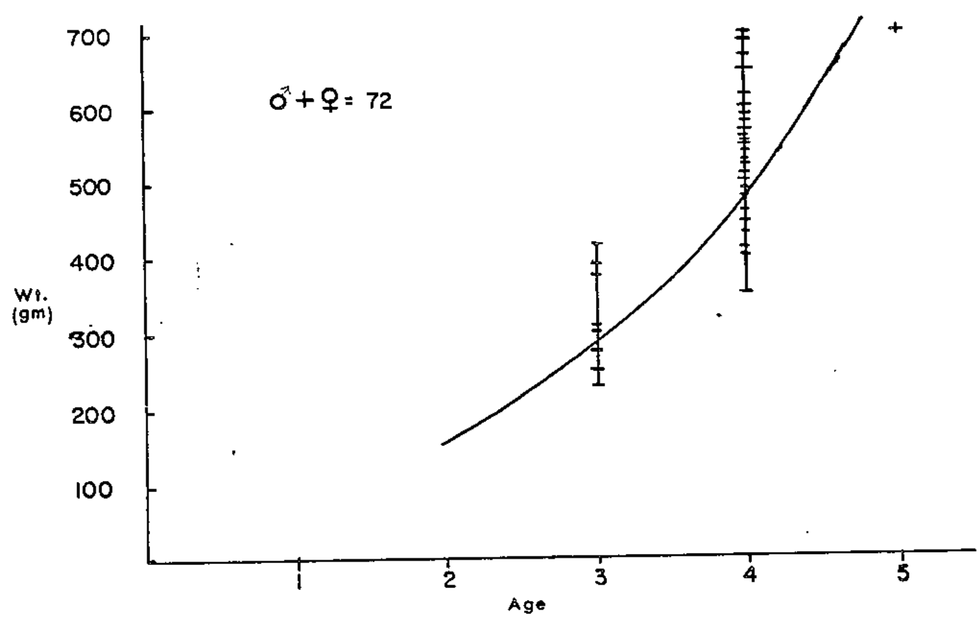


Fig.___: Kokanee weight-age curves from fisherman's creel Kathleen Lake, Yukon, 1981.







SPAWNING ENUMERATION

Introduction

Prior to 1975 little information was known about the extent or location of the spawning kokanee in the upper lake. Local reports were confusing about the various spawning places and relative numbers. With the drastic decline in 1975 of the relative abundance of the kokanee population (Wickstrom, 1977), a method was needed to estimate the actual size of the population. Reluctance to further netting of the already small population, dictated another approach. Fortuitous physical circumstances at the spawning grounds permitted a relatively easy solution for determing the abundance of the adult spawning population without interference. Kokanee spawn in the shallow outlet reaches immediately below Sockeye Lake and along the northern shore beaches of the lake, allowing direct observation when sunlight and wind are favourable.

Since noting the decrease in numbers in 1975, an attempt has been made over the past several years to enumerate kokanee on their spawning grounds. In 1975, the year the decline was first observed, only a limited estimate was recorded due to unfamiliarity of the spawning times and the peak of the spawning was missed. It was not realized until 1976 that spawning along the north shore of Sockeye Lake also took place. In 1977, the spawning population was not tallied since limnological field studies were not conducted in the Park that season. In 1979, members of the Park warden service conducted the enumerations and contributed their data to this study.

Methods

Enumeration of the spawning kokanee followed a relatively simple procedure whereby the observer commenced counting from a fixed point just downstream from the lowermost fish in the spawning area. Using a hand tally, the kokanee were counted as the observer walked along the south bank of the stream towards the lake. The spawning grounds were divided into areas as the natural pools, riffles, flats, chutes and runs suggest (Map &). Sub-totals for each area were recorded and then the overall total determined. Particular attention had to be given to counting the large numbers in several of the spawning areas. The upper half of the outlet stream and the lakeshore group of spawning locations had to be counted from a canoe, because the water at these places was either too wide or deep to permit observation from the shore. Canoe observations were continued consecutive with the lower stream counts. A complete count from the lowest point of the spawning area on the outlet stream to the furthest point of the beach spawners along the lakeshore took approximately one hour. The time of day giving the most satifactory light conditions was about 11:00 hours. Adverse cloud cover and surface winds detracted from the accuracy of the observations.

Results and Discussion

In 1975, a total of slightly more than 1000 kokanee were estimated to be on the spawning grounds. Because only one count was made on August 26th, during which, about 500 spawning adults were counted alont the spawning flats (Table) of Sockeye lake outlet (Map 7) the estimated total had to be calculated using proportions established over succeeding years. Since counts made at this time of the spawing period (August 26) reflect declining numbers (Fig. 11) an extrpolation along a projected curve at the same slope as found in succeeding years provided an estimate of the maximum probable number of kokanee spawned that season.

In 1976, the presence of the lake spawners was not discovered until August 24th, after which counts were made of the total population and have been repeated in succeeding years. The maximum number of spawning kokanee in this year was estimated to be 2,134, with the peak rising on August 24th (Table). The number of spawning kokanee dropped off rapidly during the first week in September.

In 1977, no enumerations were made since field work was not conducted that season. In 1978, 1979 and 1980 the total number of spawning kokanee were quite similar, with estimates being 3,872, 3,684 and 4,217 respectively (Tables , &). The pattern of kokanee numbers occurring on the spawning grounds was similar over these three years and compares to that of 1976, for which only partial data was collected for the early part of the period, and with that observed in 1981 (Table) where the total numbers were much greater.

The numerical pattern of kokanee on the spawning grounds commences with the first spawners appearing on the spawing flats about the first week in August and rises in number until about the third week in the month. Decline initially proceeds slowly and then rapidly in the first week of September (Fig.), so that by the second week in September very few kokanee are found on the spawning grounds.

In 1981, the pattern of spawning was similar as in previous years but the total numbers were considerably greater than any previous counts.

Difficulty was experienced at first in counting the crowded fish but with repeated trials a confident composite count was established. The kokanee were found to presist longer on the spawning grounds this year than in any other previous season. Greater numbers were found, not only in the spawning outlet, but also along the north shore of Sockeye Lake in the usual places where spawning kokanee were observed in previous years. As well as the general increase in number in kokanee in the usual places, kokanee were also oberved in other areas which were previously unused. These areas included locations along the east shore, adjacent to Cottonwood Creek outlet and along the west beach of the north shore.

From the low numbers which were estimated in 1975 to be slightly over 1,000, there has been a gradual increase over the succeeding year so that the present population is now about seven times what is was previously. This increase has not been steady, but has shown fluctuations as shown in Fig. . In 1979, the total count dropped slightly, from 3,872 the previous year to 3,684, then rose again in 1980 to 4,217. The reasons for these fluctuations are not clear and could stem from many factors. Poor spawning success during the years previous to Park administration when the spawning process could have been subjected to outside disturbances which would not be apparent in the spawning population until five years later. Other physical and biological factors which may have affected the size of the previous spawning populations may have been water levels or severe winters, which may have caused a high mortality on the eggs along the lake shore and outlet stream.

Whether the kokanee population continues to rise as a result of spawning protection commencing in 1975 and showing up in the population 5 years later or whether it will level off is difficult to forecast at present. So far the population is continuing to rise, although saturation of the best spawning grounds appears to be setting in. Continued spawning enumeration is essential for the ensuring years.

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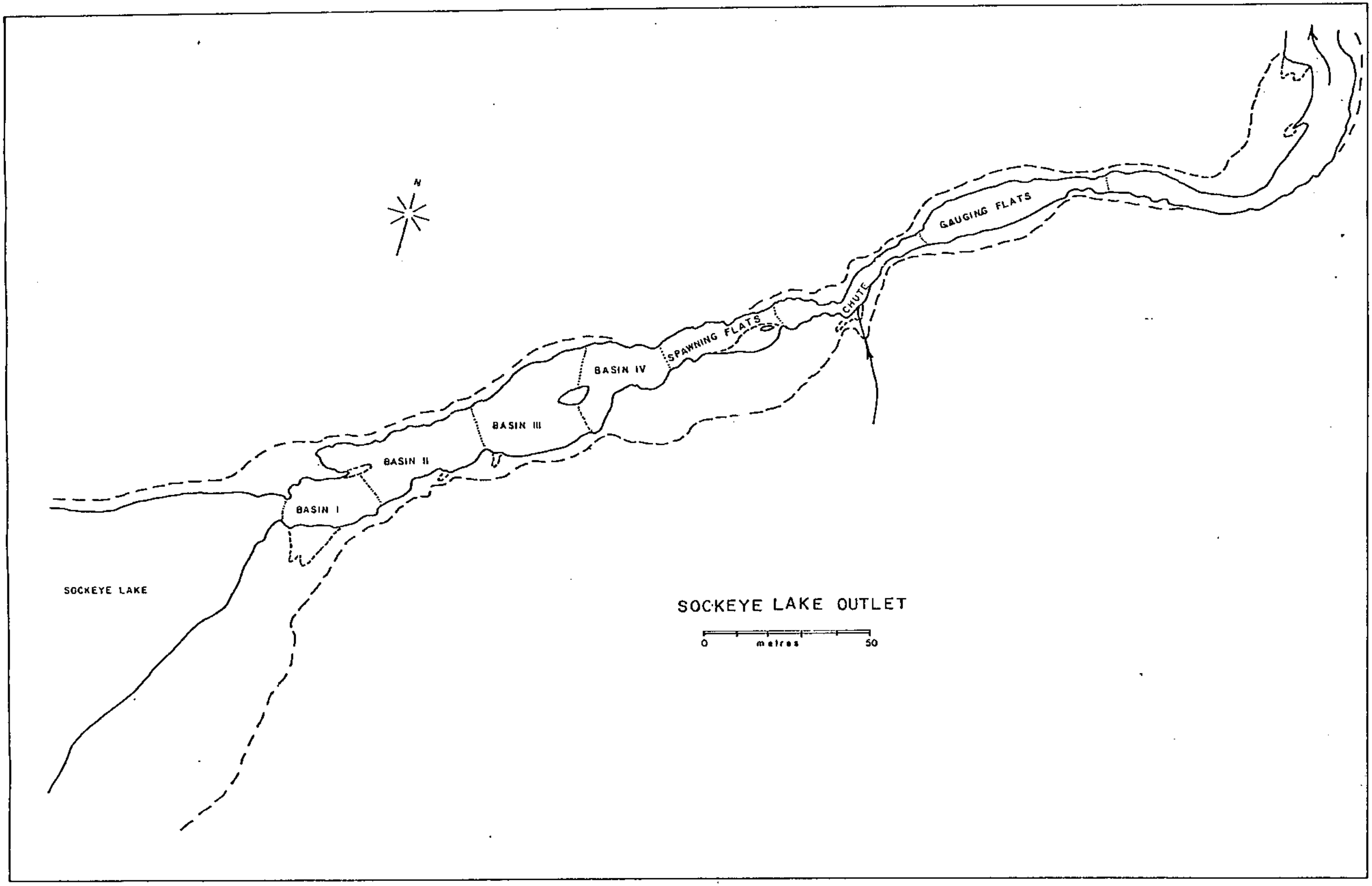

Map Outlet stream from Sockeye Lake showing area delineations used in enumeration of spawning kokanee.

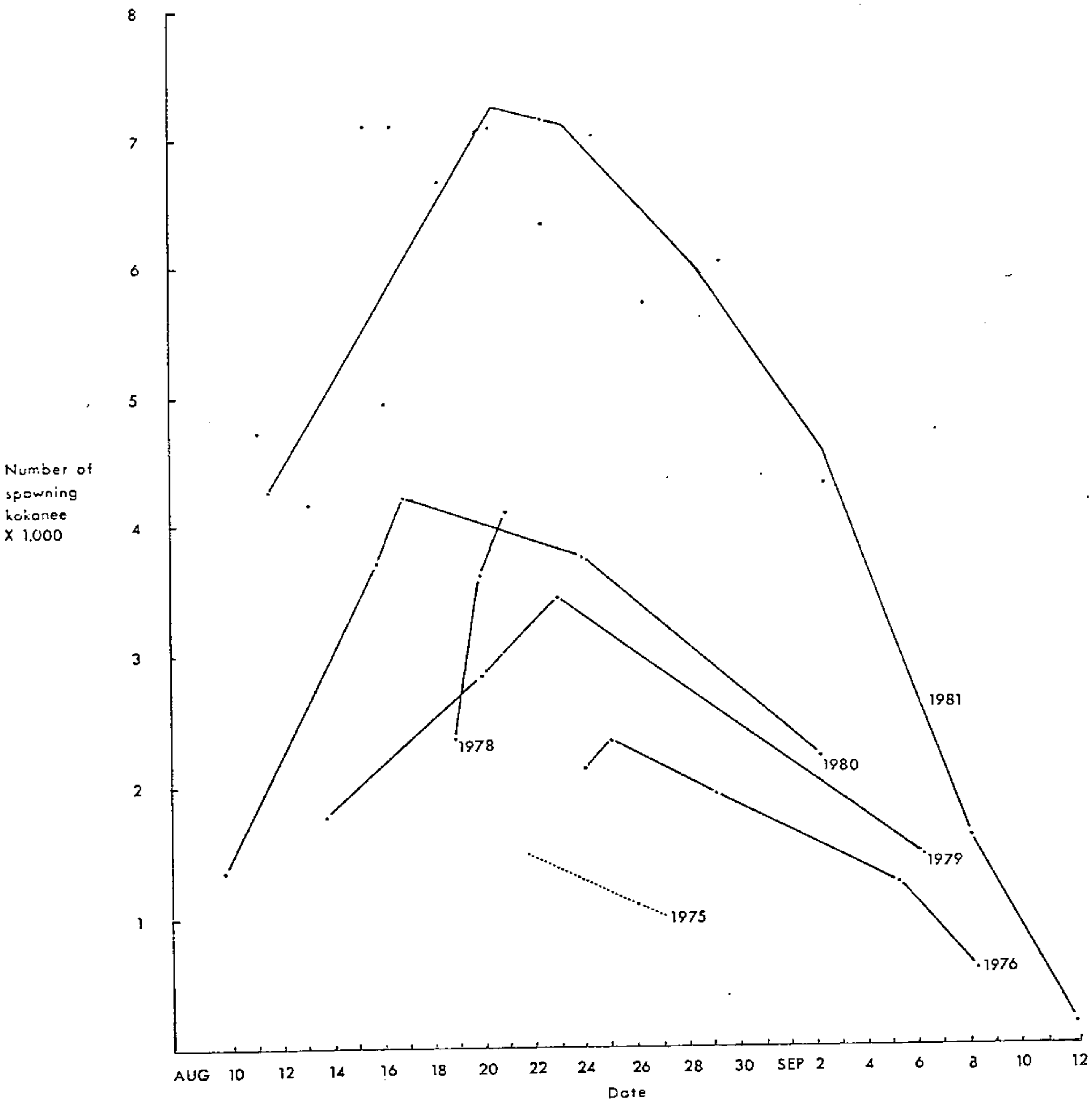

Fig. 11. Total number of spawning kokanee in Sockeye Lake and outlet stream

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1975[1].

Location[2]	August 26/75		
	Trial 1 (RKB)	2 (RDW)	3 (RF)
Spawning Flats	400	500	700

1 Enumeration made without hand tally; kokanee present at Spawning Flats only.

2 Location shown in Map .

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1976.

Location *	August								September			
	6	8	12	15	18	24	25	29	1	5	9	14
Gauging Flats	0	0	0	9	6	0	0	2	1	1	22	2
Chute	0	0	0	10	3	57	67	78	39	27	66	3
Spawning Flats	0	0	10	192	456	610	576	543	589	339	172	3
Basin IV	0	0	0	118	168	282	217	189	203	134	27	0
III	-	-	-	-	-	225	380	245	374	239	120	0
II	-	-	-	P	-	86	80	45	38	12	10	0
I	-	-	-	P	-	-	114	102	119	30	11	0
Lake Narrows	-	-	-	-	-	409	381	298	218	196	76	0
Boulder Beach	-	-	-	-	-	0	4	2	-	2	3	0
Beaver Beach	-	-	-	-	-	20	24	0	-	3	1	0
Sandcliff Beach	-	-	-	-	-	120	129	122	-	66	27	0
Spawning Point	-	-	-	-	-	321	367	319	-	197	45	0
Tenting Beach	-	-	-	-	-	4	21	0	-	0	0	0
Totals	-	-	-	-	-	2134	2360	1945	-	1246	580	8

* Locations shown in map

P= Present

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1978.

Location *	August 19 16:30	August 19 17:30	August 20 11:00	August 20 12:30	August 21 10:30
Gauging Flats	260	250	281	259	306
Chute	60	65	52	55	53
Spawing Flats	795	837	1346	867	1101
Basin IV	220	280	470	523	512
III	172	665	675	675	700
II	417	30	60	60	48
I	106	85	109	109	125
Lake Narrows	0	440	312	312	550
Boulder Beach	0	0	0	0	16
Beaver Beach	88	88	82	82	136
Sandcliff Beach	285	285	240	240	283
Spawning Point	178	178	245	245	283
Tenting Beach	0	0	0	0	0
Totals	2581	3203	3872	3427	4113

* Location shown on Map

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1979 [1].

Location	August 14	August 23	September 6
Gauging Flats Chute	38	341	65
Spawning Flats	377	1283 [2]	965
Basin IV III II I	772	1617	
Lake Narrows Boulder Beach Beaver Beach Sandcliff Beach Spawning Point Tenting Beach	600	443	436
Totals	1787	3684	1466

1 Enumeration made by Park wardens L. Freese and R. Staley.

2 Note that count shown includes Basin IV with Spawning Flats. Number on Spawning Flat estimated to be 200 less.

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1980.

Location	Aug 10	Aug 13	Aug 16	Aug 17	Aug 20	Aug 24	Sep 2
Gauging Flats	0	12	17	34	76	90	75
Chute	9	0	8	37	35	60	57
Spawing Flats	355	720	1650	1331	1223	1417	1040
Basin 1V	0	75	140	135	100	180	70
111	} 1000		500	548	360	440	316
11			30	300	24	80	0
1			642	400	96	434	11
Lake Narrows			388	900	512	490	242
Boulder Beach			0	0	0	18	15
Beaver Beach			4	130	25	52	29
Sandcliff Beach			10	30	67	174	152
Spawning Point			320	270	301	333	198
Tenting Beach			0	2	0	0	0
Totals	1355	–	3709	4217	2820	3768	2205

Table Enumeration of spawning kokanee in outlet stream and along north shore of Sockeye Lake, 1981.

Location	August 4	11	13	16	18	20	22	24	26	29	September 2	8	12
Gauging Flats	0	0	26	137	241	378	373	403	361	316	210	24	2
Chute	0	5	22	84	209	301	311	322	302	268	160	60	37
Spawning Flats	0	704	1255	172	} 1800	2253	1954	2172	2004	2054	1182	340	28
Basin IV	P	600	1450	1725	} 300	175	190	221	115	214	154	40	0
III	P	600	250	} 125	1420	1700	1450	1383	1172	1082	917	330	10
II	P	450	250	}	225	150	220	269	134	168	85	30	0
I	P	1320	} 850	295	1150	350	381	602	367	286	180	70	0
Lake Narrows	P	650	}	750	850	850	605	702	329	698	290	222	18
Boulder Beach	0	75	2	55	38	60	60	91	94	108	86	66	0
Beaver Beach	0	25	0	} 40	1	18	64	78	106	110	86	34	18
Sandcliff Beach	0	5	25	}	23	250	260	280	327	227	280	105	4
Spawning Point	0	300	44	150	424	575	480	503	382	418	425	177	47
Tenting Beach	0	2	2	0	31	50	27	8	44	78	70	66	29
Totals	-	4736	4176	4981	6692	7110	6375	7034	5737	6027	4125	1564	193

P= Present

Plate Outlet of Sockeye Lake. Preferred kokanee spawning grounds are located along expanded reach shown in foreground.

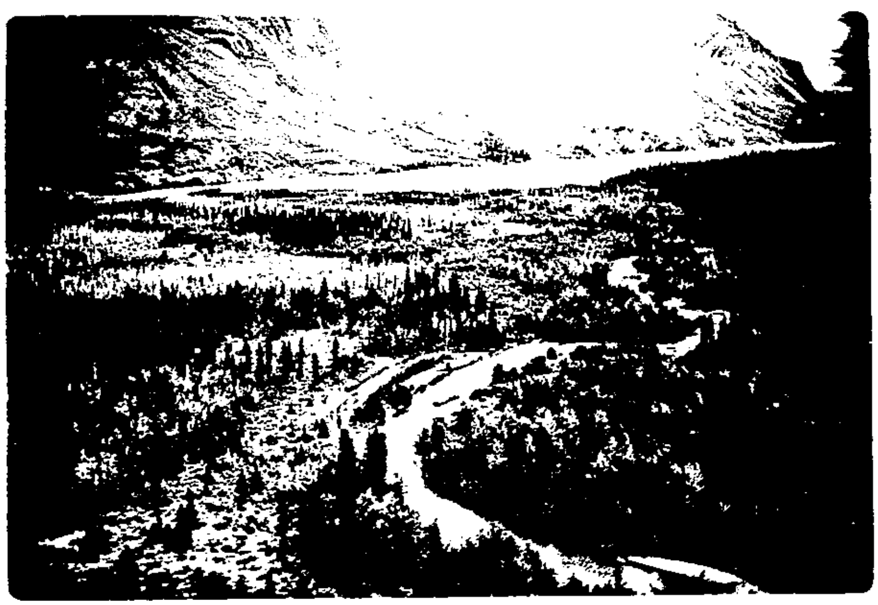

Plate Lower reaches of Sockeye River just above Louise Lake. The shallow stream is non-navigable by boat traffic.

Plate 1. Spawning area of Sockeye Lake outlet stream.

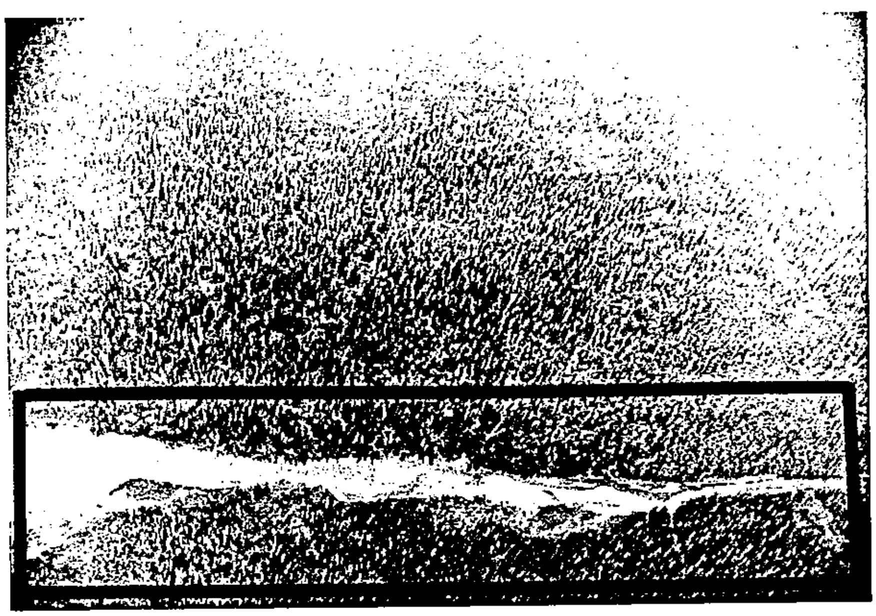

Plate 2. Spawning area of Sockeye Lake outlet stream. Delineated area shown in Fig. 2.

GENERAL DISCUSSION

The kokanee in Kluane Park are distributed throught the three lakes in the Kathleen Lake drainage, all migrating to spawn in one area. The general characteristics of kokanee in the Kathleen lakes drainage are similar to those of populations from other areas. The Frederick Lake population, which is thought to be of the same origin, appears to differ slightly from those in the Kathleen lakes drainage. Those in Frederick Lake do not reach the same size at maturity (300 : 375mm) and appear to spawn one year younger (3^+ rather than 4^+) and at an earlier time (early August-late August). These differences, which require further elucidation, may be related to warmer, more productive waters of Frederick Lake.

Since monitoring the kokanee population in Kluane Park commence~~ment~~d in 1975, a seven-fold increase in population numbers has been observed. Rising from a low of just over 1,000 adult spawners in 1975, a total of 7,100 were counted in August, 1981. As the results of the spawning enumeration show, the increase has not been steady, but levelled off in 1978 through 1980 at around 3,600 to 4,000 and then in 1981 almost doubled. This significant increase in the adult population ~~this past year~~ in 1981 was apparent earlier in the ~~1981~~ season from creel census results where greater numbers of kokanee were caught for similar numbers of anglers and time spent fishing as in 1980.

Reasons for the overall increase are not entirely certain and may result from several factors.

Foremost among these is the interim management measures which were effected commencing with the 1976 season, restricting areas and reducing limits. The exclusion of the upper waters from all fishing is considered to have been effective in protecting the spawning grounds from disturbance more importantly than preventing anglers from catching pre-spawning or spawning fish. Spawning adults do not feed and attempt to drive fishermen's lures away, often becoming snagged in the process. Disturbance on the spawning grounds is more detrimental than angling and results from fishermen wading into the shallow spawning beds and disrupting spawning activity, displacing spawning pairs and most important, physical disturbance of the redds and egg deposits by churning up the bottom, allowing the current to sweep eggs onto poor substrate and to carry silt onto eggs. Physical disturbance, if extensive for only a short period, could be very detrimental to egg survival, resulting in a poor year class.

The reduction of angling limits from 10 to 2, with a possession of two, imposed by the interim management measures, was also considered to have been effective in aiding the population increase. Creel census results show that anglers harvest 4^+ kokanee in the early to late summer which are potential spawners. Therefore, the magnitude of harvest has a direct effect on the number of potential spawners later in August that year.

Creel census results show that at present limits, the angling pressure (number of anglers and total time spent angling) did not increase significantly in 1981. However, the early summer anglers are predominantly local residents who exert annual pressure on the kokanee each spring. The present level of exploitation does not appear to be detrimental to the spawning stock and appears to be effective in satisfying anglers.

Another possible factor for the increase in kokanee may relate (or be coincidental) to the increasing angling pressure on lake trout. Although creel records were not kept for years previous to 1980, it is generally accepted that the extent of angling, on Kathleen Lake in particular, has increased since the early 1970's. Most important is the continuing increase of spring ice-fishing. This growing harvest of lake trout (in

1980, 0.180 kg/ha and in 1981, 0.299 kg/ha) can be considered heavy, if not an over-harvest for this lake at present (Wickstrom 1982, in prep.). Lake trout are the only predator of larger kokanee and its reduction would relieve considerable pressure on the kokanee population. Lake trout, however, require a much longer time to recover. Periodic assessment of the angler pressure and harvest is recommended.

The increasing kokanee population is not expected to continue rising, but to level off, with fluctuations as the capacity of the spawning area is exceeded. Results from the spawning enumeration indicate the best spawning grounds may be saturating at present. Ricker (1968) notes that the success of eggs from a heavy spawning run are less than from a moderate one.

Cyclical years of peak spawning runs are known to occur in sockeye salmon populations (Ricker 1968) and may in fact account for the unexpected increase in spawning kokanee in 1981. Local reports from long term residents appear to concur with this, observing in previous years that the population rose and fell noticably.

For this reason, it would be of value to continue the spawning observations and enumerations to extend 8 to 10 years beyond the first population records made in 1975. Since population enumerations were not made in 1977, it is particularly important to tally the population in 1982 when the progeny of spawners from that year will be returning to repeat the cycle. Enumerations in 1983 will be the eighth since 1975, and may add important information for future adjustment of management regulations. The overall method of assessing the status of the population by means of passive observation and enumeration can be considered very effective and should be continued annually by Park staff to monitor the kokanee population.

RECOMMENDATIONS

1. The interim management measures which were initiated in 1975 appear to have proven effective in augmenting a rise in the kokanee population and should remain in effect for a further five-year period, at the end of which time management should be reviewed with consideration of the other sport species, fishing pressure, and Park use.

2. Allow present regulations to remain in effect, permitting catch and possession of two kokanee per day, and the continued closure of all fishing above Louise Lake for another five years.

3. Annual assessment of the status of the kokanee population by means of passive observation and enumeration at the spawning grounds has proved effective and should become a part of the Park's annual resource management program, carried out by warden staff.

4. Because the enumeration results must be comparable with previous years, the method used by observers must be standardized. This will require the need for a designated person assigned to the annual job who will receive background instruction and field training. Information gathered in the succeeding years will be useful for possible future needs of management adjustments.

5. Spawning usually peaks about the third week in August, therefore, spawning enumerations should be conducted August 18, 20 and 22 each year as a minimum number of observations required to determine the peak number of kokanee spawning. If poor weather conditions are encountered, then

attempts should be made on the following day. Enumeration attempts ~~prior~~ before to August 18 would be desireable because numbers would be lower, making familiarization and practice easier prior to encountering peak numbers.

6. An update of the creel census should be undertaken in four years (1985) to update the extent of angler harvest at that time and provide data for comparison with present information. This census should coincide with further study on the lake trout population. Information on the production and harvest of lake trout would be of use in the continued managing of kokanee as well as an aid for the proper management of the prime sport fish species.

7. Continued efforts should be made to record the extent of spring and autumn angler pressure and harvest, particularly the spring ice-fishing periods. Warden staff could be effective in gathering this information from their daily patrols. Record cards and data sheets for weekly, monthly and annual compilations should be prepared.

8. Future aquatic studies in Kathleen Lake and its upper drainages should include further aspects of kokanee biology. In particular, more information on migration, its timing, and the possible use of discreet spawning areas in the outlet and shores of Sockeye Lake by kokanee from the two lower and one upper lake. It would be of interest and of management value to determine whether the resident kokanee population in Sockeye Lake spawns along the north shores of Sockeye Lake or shares the outlet stream with those from the lower lakes.

Knowing where kokanee from each lake prefer to spawn may be an aid to more precise management. The use of tagging and particularly radio tagging, may be useful for this purpose. Radio tagging of fish is a method currently being perfected and should be reliable for field use in the very near future.

9. Consideration should be given to the desired extent to which angling harvest should be allowed for two preferred sport species; kokanee and lake trout. Different management strategies are required to accentuate kokanee and lake trout. The extent of lake trout harvest should be considered also: whether to encourage greater production of smaller fish for greater angler use, or attempt a more normal distribution. This consideration should be made by Park representatives from regional and Park levels together with fisheries advisory personnel.