SKEENA SALMON MANAGEMENT COMMITTEE

ANNUAL REPORT 1962

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W.R. Hourston

A.W.H. Needler

IN CHARGE OF INVESTIGATIONS

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ADVISORY BOARD MEMBERS

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Biological Station
Nanaimo, B. C.
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Terms of Reference

The Skeena Salmon Management Committee was established by the Minister of Fisheries in 1954 to investigate the condition of Skeena River salmon stocks, to improve management of the runs, and to increase the yields if possible. Rehabilitation of the Babine Lake sockeye run, which had been seriously depressed by the 1951-52 Babine River rock slide, was considered paramount.

The Committee was directed to use the administrative and research staffs of the Department of Fisheries to achieve its objectives. Staffs of both the Protection and Conservation Branch of the Department and the Fisheries Research Board of Canada had worked extensively on Skeena salmon prior to 1954; the Committee was directed to co-ordinate and, where necessary, extend these activities.

Present members of the Committee are Mr. W. R. Hourston, Director, Pacific Area, Department of Fisheries and Dr. A.W.H. Needler, Director of the Biological Station of the Fisheries Research Board of Canada at Nanaimo.

Upon establishing the Committee, the Minister appointed an Advisory Board representing the various sections of the industry concerned with the Skeena salmon fishery. The Committee meets with its Advisory Board several times each year to discuss investigations and the basis for regulation of the fishery. Advisory Board members for the year 1962 are listed on the front page of this report.

Record of Meetings

The Committee met at Vancouver on December 12, 1961, to examine the evidence concerning the likely abundance of the 1962 Skeena sockeye and pink runs and to discuss and formulate appropriate regulation.

It was noted that the 1962 sockeye run would be composed mainly of 4_2 and 5_2 fish from the 1957 and 1958 spawnings. Available evidence indicated that the return of fish of both ages would most likely provide a total run of between 1,000,000 and 3,000,000 sockeye. The Committee, for the purpose of proposing regulations in advance of the season, took the most probable size of the run to be 2,200,000.

On the basis of past average production, the 1962 pink run was expected to amount to approximately 800,000 fish. This number was less than the optimum escapement alone. Because of the problems associated with protecting pinks while providing for a proper catch of sockeye, the Committee felt that protection of the 1962 pink run would best be effected by weekly adjustment of fishing times and areas when the abundance and migration route of the pink run became known.

On the basis of the above, the Committee released on December 19, 1961,

a statement containing proposals for regulation of the 1962 fishery for consideration by the Advisory Board and the industry generally. The proposed regulations for the Skeena Gill-net Area and adjacent waters were as follows:

(a) That the upriver commercial fishing boundary be maintained at the Mowitch-Veitch Point line.

(b) That prior to 6:00 p.m., Sunday, June 17, 1962, only gillnets having mesh not less than 8" linen, or 8-1/2" nylon, stretched measure, be permitted and that prior to this date, a 72-hour weekly closed period from 6:00 p.m., Thursday, until 6:00 p.m. Sunday, be maintained.

(c) That fishing for salmon with gillnets of any mesh size be permitted after 6:00 p.m., Sunday, June 17, 1962, until the end of the fishing season, as follows:

(i) From June 17 to August 26 - 96-hour weekly closed time 6:00 p.m., Wednesday to 6:00 p.m., Sunday;

(ii) From August 26 to the end of the fishing season - 72-hour weekly closed time 6:00 p.m., Thursday to 6:00 p.m., Sunday.

(d) The Committee also proposes to make recommendations as follows for adjacent fishing areas in order to extend similar protective measures for Skeena-bound sockeye and pink salmon whilst passing through those areas:

Area 3, Nass River - Sub Areas 3X and 3Y only

(i) Same weekly closed times as in (c) above from July 8, 1962, to August 19, 1962.

Salmon Purse Seine Area No. 5 - Beaver Passage and Ogden Channel only

(i) Same weekly closed times as in (c) above from July 22, 1962, to August 19, 1962.

(e) Provisos:

(i) That the weekly closed times outlined above shall be extended in the event that for any week or series of weeks during the progress of the fishing season the proposed weekly closures, in the opinion of the Committee, are deemed insufficient to provide adequate escapement of salmon for reproduction purposes,

(ii) That extra fishing time would be granted, if, in the opinion of the Committee in the light of development of sockeye and pink runs at the time, such might safely be permitted consistent with attaining adequate escapements for reproduction.

The Committee met with its Advisory Board at Prince Rupert on January 24, 1962, and held a public meeting in Prince Rupert on January 25, 1962. A further public meeting of the Committee and its Advisory Board was held on February 1, 1962, in Vancouver. The 1961 Skeena salmon runs and the results of investigations carried out under the direction of the Committee were reviewed at these meetings. Available information bearing on the expected numbers of sockeye and pinks in 1962 was presented and the regulations proposed in the Committee's release of December 19, 1961, were discussed.

Advisory Board members present at the Prince Rupert meetings were S. Oddsun, J. Daniels and R. Nelson. Messrs. R. Bell-Irving, E. MacMillan, R. Hager and K. F. Fraser were represented by Messrs. O. W. Philippson, H. Robbins, D. F. Miller and A. Currie respectively. At Vancouver, Advisory Board members A. E. MacMillan, R. Hager, R. Nelson and K. F. Fraser were present.

Several alternate proposals for regulation of the 1962 runs were received from Advisory Board members, individuals and organizations. These proposals mainly involved extension to weekly fishing times so that a larger catch could be provided. One proposal called for a reduction in the number of boats allowed to fish in the Skeena area. It was also proposed that a uniform opening date for sockeye fishing be established for the northern areas 3, 4 and 5.

Following the meetings with the industry, the Committee examined all proposals received regarding 1962 regulations. The Committee concluded that having regard for the rehabilitation and maintenance of the stocks that no change in the regulations as originally proposed was warranted at that time. It pointed out, however, that because of the large range in the forecasted abundance of the 1962 runs and the difficulty of predicting the number of boats fishing these runs, the regulations recommended must be considered even more tentative than usual. Changes in regulation would probably be necessary during the season as the patterns of the runs and the fishery became apparent.

A further meeting of the Committee with its Advisory Board was held in Prince Rupert on July 27, 1962. The purpose of this meeting was to advise Board members on the progress of the 1962 runs and to discuss appropriate regulations for the remainder of the season.

At the conclusion of the 1962 fishing season the Committee met in Vancouver (December 10) to examine the 1962 Skeena runs and the effect of the regulations recommended by the Committee. The pertinent information is presented in the following section.

The 1962 Skeena Salmon Catch and Escapement

The weekly catches by gill-net for all species in the 1961 season, as reported in the British Columbia Catch Statistics of the Department of Fisheries for Statistical Area 4, are given in Table I.

The 1962 sockeye run was smaller than anticipated and was very close to the minimum of the predicted range in size. This low return (1,097,000) was due

Table I. Area 4 gillnet catch by weeks; 1962.

Week ending		Sockeye	Pink	Coho	Chum	Spring
May	12					6
	19					13
	26					42
June	2	1	3			55
	9	17			2	237
	16	187				545
	23	17,078	595	646	195	1,029
	30	28,051	3,246	1,959	624	1,996
July	7	32,479	11,206	2,419	1,161	1,462
	14	65,047	5,578	1,784	820	2,292
	21	76,818	13,056	3,790	935	2,729
	28	85,851	17,682	2,117	511	951
August	4	114,872	123,885	10,388	3,206	1,567
	11	52,549	118,900	9,212	2,744	474
	18	6,255	91,143	9,076	1,993	82
	25	3,743	123,082	15,452	4,805	113
September	1	1,028	47,416	7,417	3,261	44
	8	131	9,798	3,489	732	36
	15	34	2,148	3,231	477	49
Totals		484,141	567,738	70,980	21,466	13,722

to smaller-than-expected numbers of both 4- and 5-year-old sockeye. The 5_2's from the 1957 spawning amounted to 631,000 fish; the return of 4_2's from the 1958 spawning was 372,000. The remainder of the run was made up largely of 5_3 sockeye.

Figure 1 shows, for the Skeena Gill-net Area, the numbers of days fishing recommended by the Committee prior to the season, the actual number of days fishing allowed each week, the estimated weekly rates of exploitation for pink and sockeye, and the estimated weekly total abundance (catch plus escapement) of pink and sockeye.

In the first two weeks after fishing began, 3 days per week fishing was provided. Although the number of salmon landed in this period was small, the catch was a moderate one for early season. Escapement, on the other hand, was less than adequate due to the high rate of removal (56% to 83%) by the fleet. Fishing time was reduced to 2 days per week in the first three weeks of July to provide additional spawners. By July 22, it was apparent that the sockeye run was only moderate in size. At this time the total run amounted to about 370,000 fish. The catch amounted to 220,000 pieces while the escapement of 150,000 was much below the optimum of the early runs.

The moderate size of the run, together with the high rate of fishing

SKEENA RIVER, 1962

	17 June	24	1 July	8	15	22	29	5 Aug.	12	19	26	2 Sept.	9
DAYS FISHING RECOMMENDED	3	3	3	3	3	3	3	3	3	3	4	4	
DAYS FISHED	3	3	2	2	2	1	3	0/3	0/3	4	4	4	
ESTIMATED RATES OF EXPLOITATION (%)													
PINK					68	18	47	35	26	56	52	68	
SOCKEYE	56	83	46	68	67	26	62	34	23	49	39		

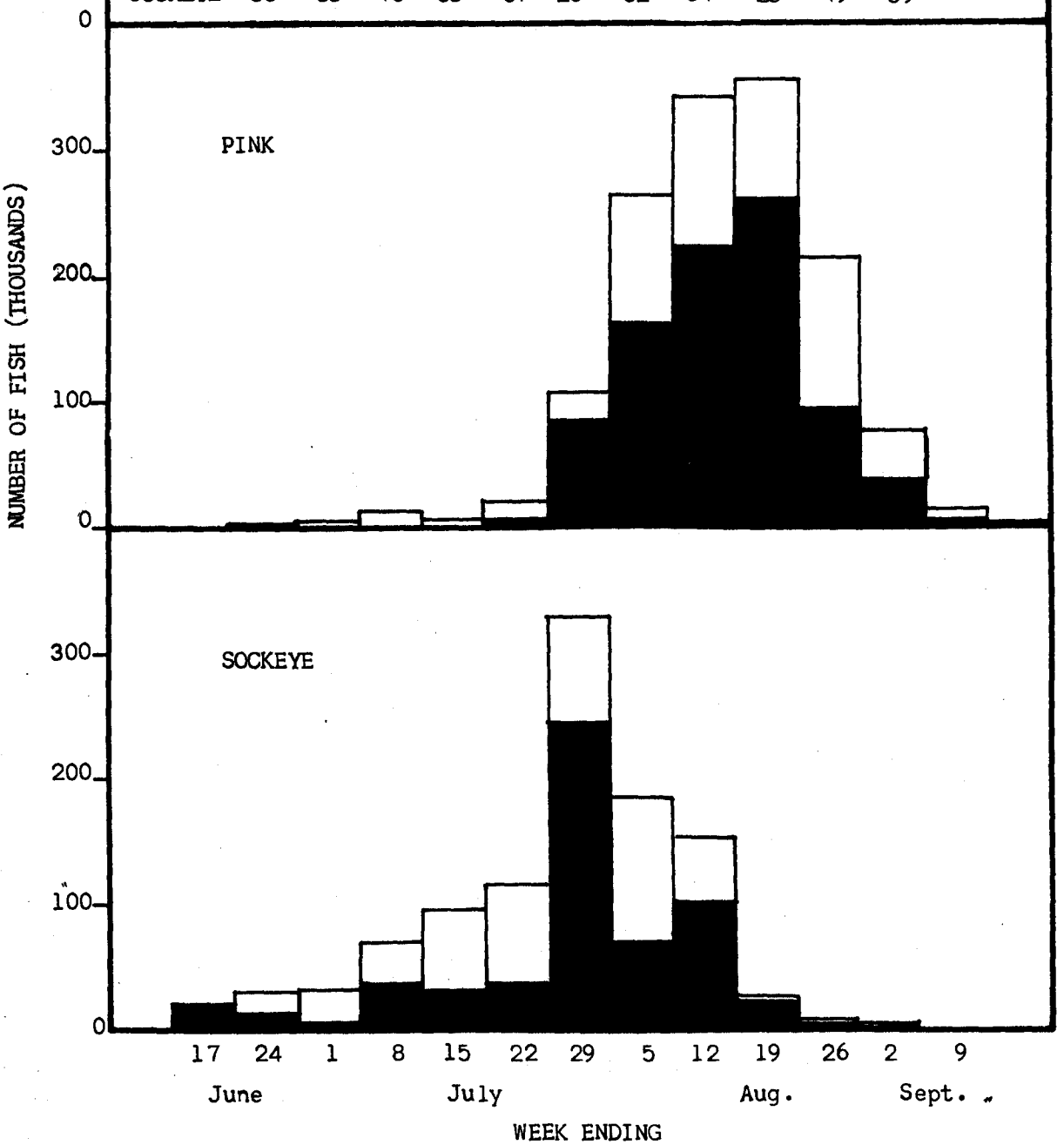


Figure 1

observed thus far, indicated that further restriction of fishing would be necessary to ensure an adequate escapement to the important Fulton and Babine Rivers. The Committee therefore recommended that fishing be reduced to one day during the last week of July. This action resulted in an estimated escapement of 250,000 for the week; a substantial proportion of total escapement for the season as a whole. Fishing continued on a 3-day-per-week basis in the week ending August 5. Although the run showed a decline in abundance at this time, a catch of over 100,000 was provided during this week. The abundance of sockeye continued to decline rapidly in the following two weeks and for all practical purposes the run terminated by August 19. During the last two weeks of sockeye fishing, 3 days fishing per week was provided in the "outside" portion of the Skeena Gill-net Area.

The total catch of sockeye in the Skeena area for the season was 484,000. The effective escapement (total escapement less Indian food fishery catch) of 582,000 was considerably less than optimum. As usual most of the escapement was to the Babine Lake system where 548,000 sockeye were counted. The number of spawners observed in other areas was generally small.

The 1962 pink run, which amounted to about 1,700,000 fish, was larger than anticipated but within the predicted range. This number represents an excellent return from the parent spawning. The catch of pinks in the Skeena Gill-net Area was 580,000. In addition, up to 140,000 Skeena-bound pinks were taken in Ogden Channel. Figure 1 illustrates the weekly abundance of pinks in the Skeena Gill-net Area, and the division of the stock by week into catch and remaining escapement upriver. Pinks did not appear in the area in numbers until the last week in July when the fishing time had been reduced to one day to provide additional protection of sockeye. During this week 20,000 pinks were caught and an estimated 87,000 escaped. In the first week of August when 3 days fishing were permitted an escapement of 138,000 was estimated while 124,000 pinks were caught in the Skeena Gill-net Area and up to an additional 117,000 Skeena-bound pinks were taken in the adjoining Ogden Channel fishery.

At this point it was evident that the pink run would not prove to be unusually large. It was also apparent from the distribution of catches throughout the area that a considerable proportion of the pink run was entering the Skeena area through Ogden Channel and thereby being subjected to additional fishing pressure. Special regulatory action was therefore considered necessary to offset this heavy fishing pressure so that escapement requirements could be better met. Accordingly the Committee recommended that the inside portion (river) of the Skeena area be closed together with the Ogden Channel portion of adjoining area 5, during the weeks ending August 12 and 19. This action achieved the desired result. A relatively low rate of exploitation followed. Escapement provided in the two weeks was estimated at 483,000; the catch amounted to 213,000.

During the fourth week of August the fishing time was extended from 3 to 4 days to harvest the late pink run. Observations on the spawning grounds at this time indicated that the run was now composed almost entirely of fish proceeding to the Lakelse River and that a substantial escapement to this area was already evident.

The escapement of pink salmon, which was estimated to be 1,000,000, was larger than the stock in the parent year but much smaller than that needed to

bring the run to its former abundance. Some 835,000 spawned in tributaries of the Skeena River or in the river itself, while 165,000 spawned in coastal streams adjacent to the Skeena Gill-net Area. The abundance of the pink runs to the different spawning areas differed considerably from those in the cycle year 1960. Escapements to the Kispiox and the Kitwanga Rivers, both of them "early-run" streams, were respectively two-thirds and twice those in the cycle year 1960. The escapement to the Babine River in 1962 was 5 times the size of the 1960 run. The major portion of the 1962 pink escapement was to the Lakelse River where an estimated 635,000 pinks spawned, an increase of 5 times the number spawning there in the cycle year. The spawning in the main stem of the Skeena River was over 3 times heavier in 1962 than in 1960.

The Skeena gill-net catch of spring salmon was about 13,700, the third lowest catch since the present system of catch statistics was begun in 1950. The escapements of spring salmon were reported by Departmental officers to be moderate to the Ecstall, Kitsumgallum and Bear Rivers and light to the Morice River. The count of spring salmon at the Babine fence was low and 79% of the run was "jacks".

The gill-net catch of coho salmon in the Skeena Gill-net Area was approximately 71,000, slightly above the 1950-1961 average. The escapements to the Lakelse, Kitsumgallum, Bulkley and Morice Rivers were reported to be medium and to the Bear River to be light.

The 1962 gill-net catch of chums in the Skeena area, which numbered about 21,000 pieces, was the lowest recorded since the present system of catch statistics was begun. Escapements generally were reported as light.

The annual catches of sockeye and pink salmon since 1912 and 1903 respectively are shown in Figures 2 and 3. The annual catches of spring, coho and chum salmon for the period 1950 to 1962 are shown in Figure 4.

Investigations and Fish Cultural Projects

Most attention is being directed toward sockeye and pink salmon. These species contribute most to the Skeena fishery in terms of both numbers and value. For about 30 years, the abundance of sockeye and pinks, and consequently their contribution to the fishery, has remained at a considerably lower level than that sustained previously. More recently in 1951 the sockeye run was further depressed as a result of a rock-slide on the Babine River. This slide seriously reduced the size and effectiveness of the escapement to the important Babine system in both 1951 and 1952. There followed a corresponding reduction in the size of the returning runs beginning in 1955.

The immediate objective of the Management Committee was to restore the Babine run to at least its pre-slide level by providing escapements comparable in size to those observed in the pre-slide years. The long-term objective is to establish a sound basis for management of the Skeena stocks so that the largest sustainable catch can be achieved.

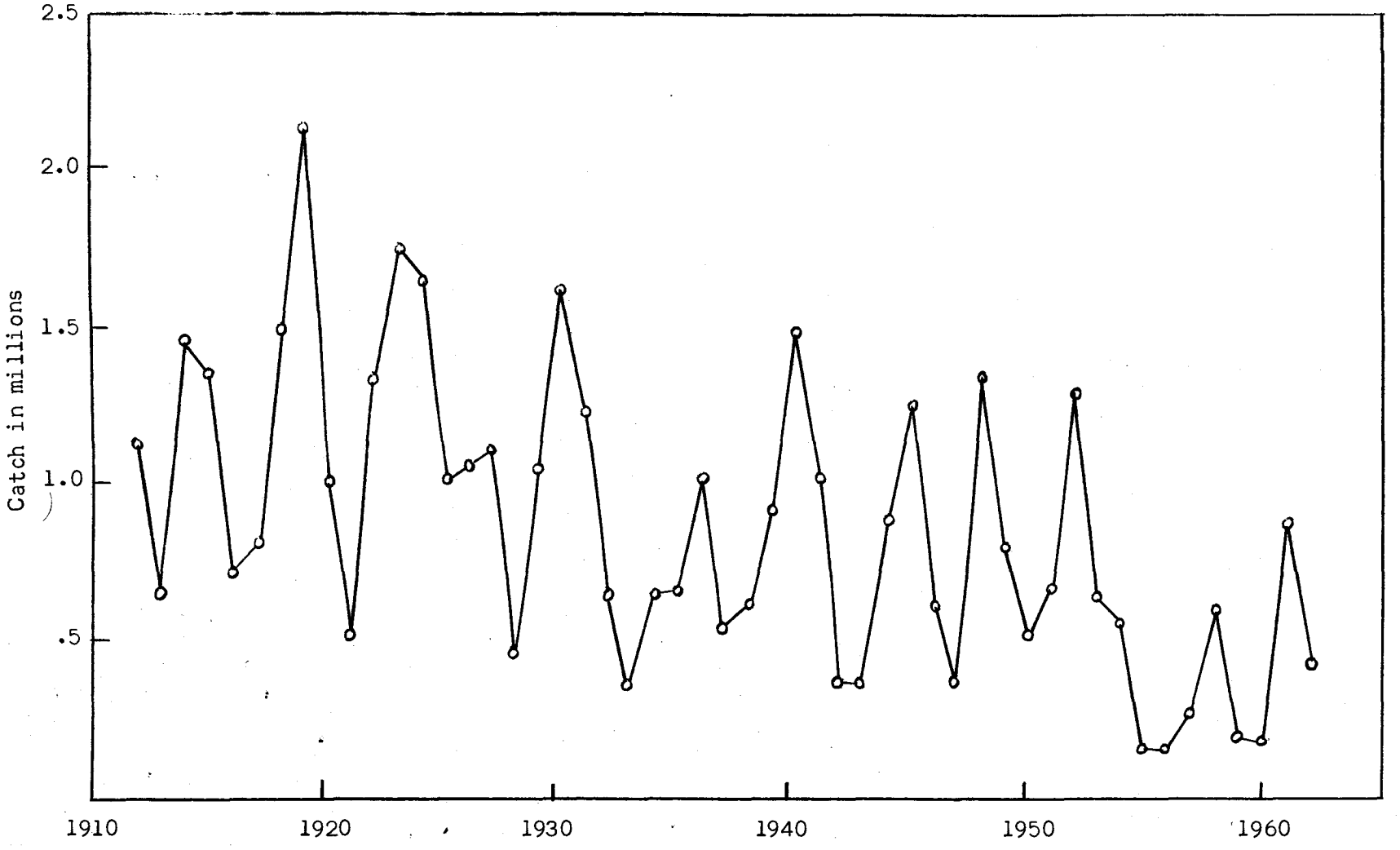


Fig. 2. Annual catch of sockeye in the Skeena Gill-net Area (from British Columbia Catch Statistics of the Department of Fisheries, 1950-1962, and from pack and sampling data, 1912-1949).

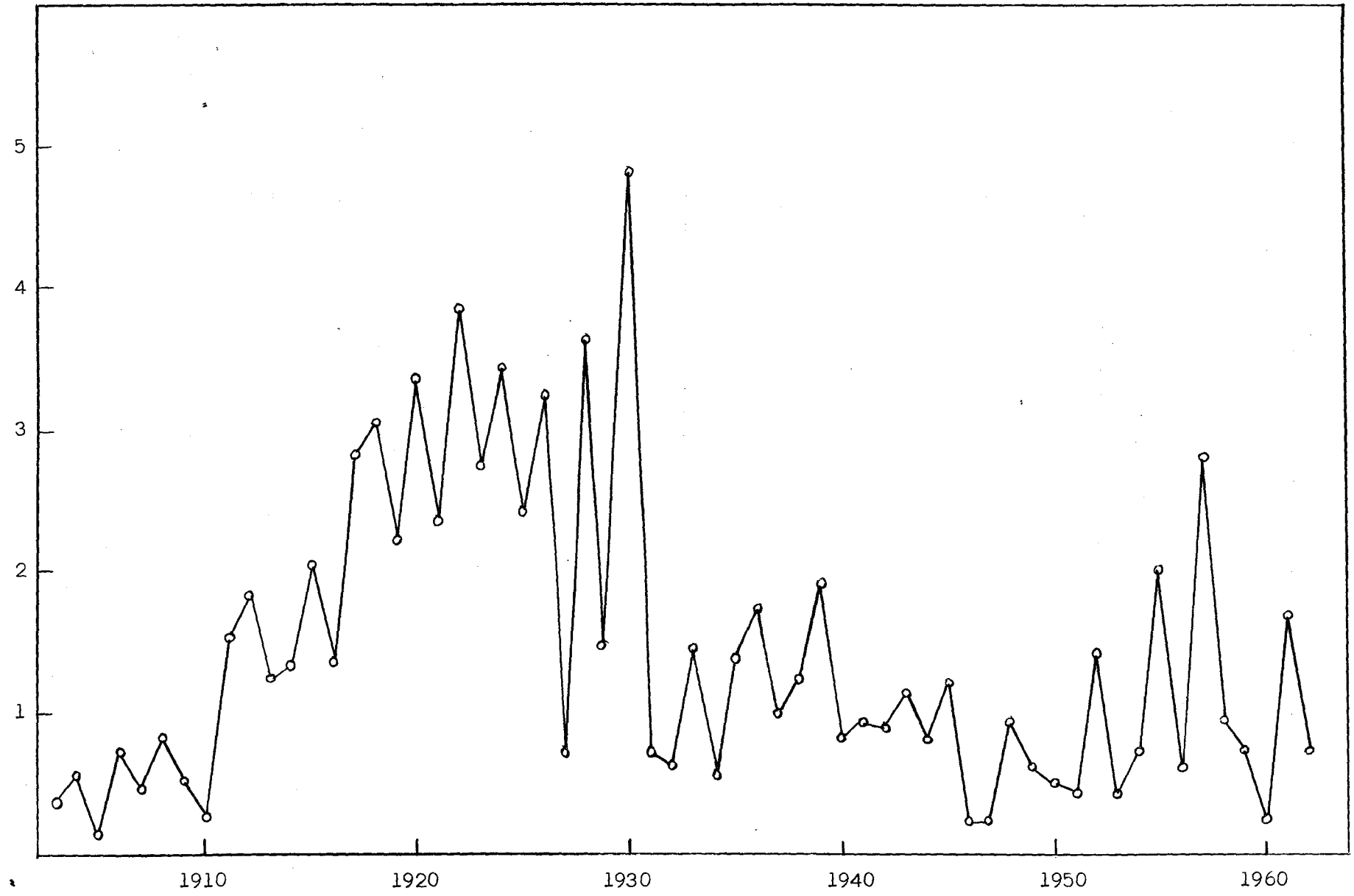


Fig. 3. Estimated annual catch of Skeena River pink salmon (1903-1949, using pack figures and available information of annual average fish per case; 1951-1961, from British Columbia catch statistics of the Department of Fisheries). In years 1955-1962 the estimated catches of Skeena fish caught in adjoining statistical areas 3 and 5 are included.

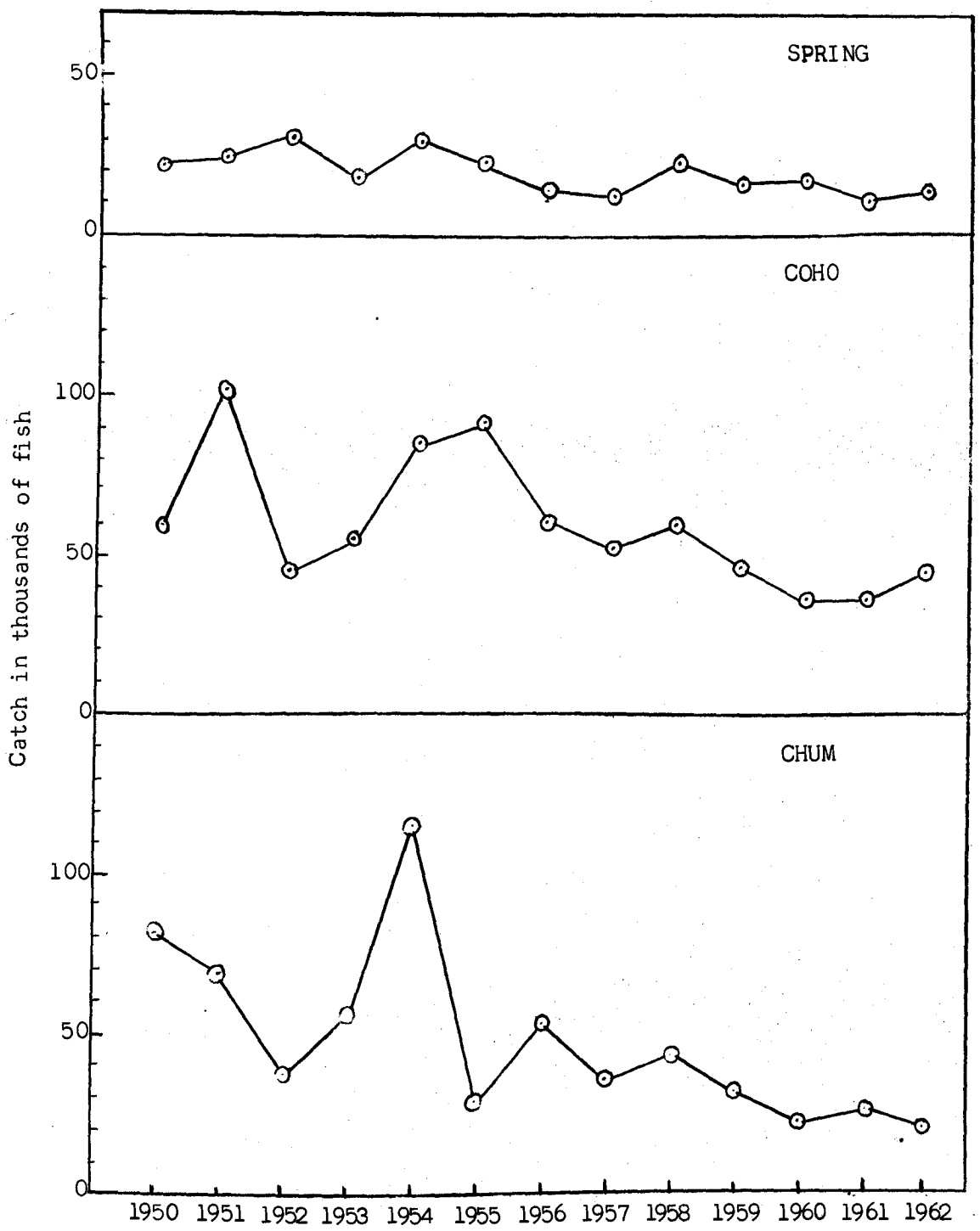


Fig. 4. Annual gill-net catches of spring, coho and chum salmon in the Skeena Gill-net Area (from British Columbia Catch Statistics of the Department of Fisheries).

Rehabilitation of Babine sockeye

The Babine run is the most important single sockeye run to the Skeena system. Past records reveal that these fish have made up 80% or more of the annual Skeena total.

In 1951, a rock-slide on the Babine River partially obstructed the migration of spawners to the Babine spawning grounds. Although temporary remedial action was taken, the 1952 escapement was similarly affected. Removal of the slide was completed in time to provide the 1953 escapement with ready access to the spawning grounds.

In 1951 and 1952, both the number and effectiveness of the spawners reaching Babine Lake were seriously reduced. The number of effective spawners in these years has been estimated as 141,000 and 158,000. These escapements were about one-third the average size of escapements observed in 5 years preceding the slide.

Because Babine sockeye return mainly as 4- and 5-year-old fish, the effects of the slide were expected to occur first as a reduction in the stock returning in 1955, and would continue through to 1956 and 1957. Very small runs were therefore anticipated in those years. Accordingly, very stringent fishing regulations were recommended in 1955, 1956 and 1957 to restore, as far as possible, the escapements to their pre-slide level.

As was anticipated, the runs of 1955, 1956 and 1957 were small. Despite the special regulatory measures taken in 1955, no improvement in escapement size over the slide years was provided from the extremely small run. In 1956 and 1957, however, escapements comparable to many recorded before the slide were achieved (361,000 and 448,000, respectively).

With the return of 5-year-olds in 1962, it is now possible to examine the effects of the escapements provided from 1955 to 1957. The following table gives the number of 4- and 5-year-old fish returning from the three escapements in question and the level of production (return per spawner) which occurred.

Brood year	No. of spawners	No. returning		Total	No. returning per spawner
	(4_2 and 5_2 fish)	4-yr-old (4_2)	5-yr-old (5_2)		
1955	100,000	245,000	141,000	386,000	3.9
1956	361,000	266,000	330,000	596,000	1.6
1957	448,000	1,460,000	631,000	2,091,000	4.7

This level of production may be compared to that estimated for previous years. The returns from annual escapements from 1930 to 1954 ranged from 0.8

per spawner to a high of 5.3 per spawner and averaged 2.6 per spawner. Production from the 1955, 1956 and 1957 broods was therefore within the observed past range. Two spawnings (1955 and 1957) resulted in an above-average return, while the return from the 1956 spawning was below average. It is evident that the additional spawners provided by the special regulatory measures taken from 1955 to 1957 provided an increase in the number of returning fish.

Changes in the annual abundance of sockeye from 1946 to 1962 are shown in Figure 5 to indicate the immediate effects of the slide on escapements and the returning runs, and progress made to restore the runs to the pre-slide level. Only 4_2 and 5_2 sockeye are accounted for in the totals shown. Since Babine sockeye are almost invariably sub-2 fish, the runs shown in the figure mostly reflect the abundance of Babine sockeye.

In the years shown prior to 1955, runs ranging in size from 750,000 fish to nearly 2,500,000 fish were recorded. In two years (1948 and 1952) the runs approached 2,500,000. Runs of the order of 1,000,000 fish occurred in the remaining seven years. Relatively small runs occurred in 1955, 1956 and 1957 as a direct result of the slide on the 1951 and 1952 escapements. Since 1957 the runs, with only one exception, have been comparable in size to most pre-slide years. Although the 1948 and 1952 levels have not been achieved, the runs of 1958, 1959, 1961 and 1962 ranged from nearly 1,000,000 to 2,000,000 fish and compare favourably with seven of the nine pre-slide runs shown.

The effect of the slide on the second generation is reflected in the small size of the 1960 run. The small escapement provided in this year will affect the runs returning in 1964 and 1965. It is evident, however, that, for the most part, the effects of the slide have largely been eliminated and a general level of abundance comparable to the pre-slide level has been achieved.

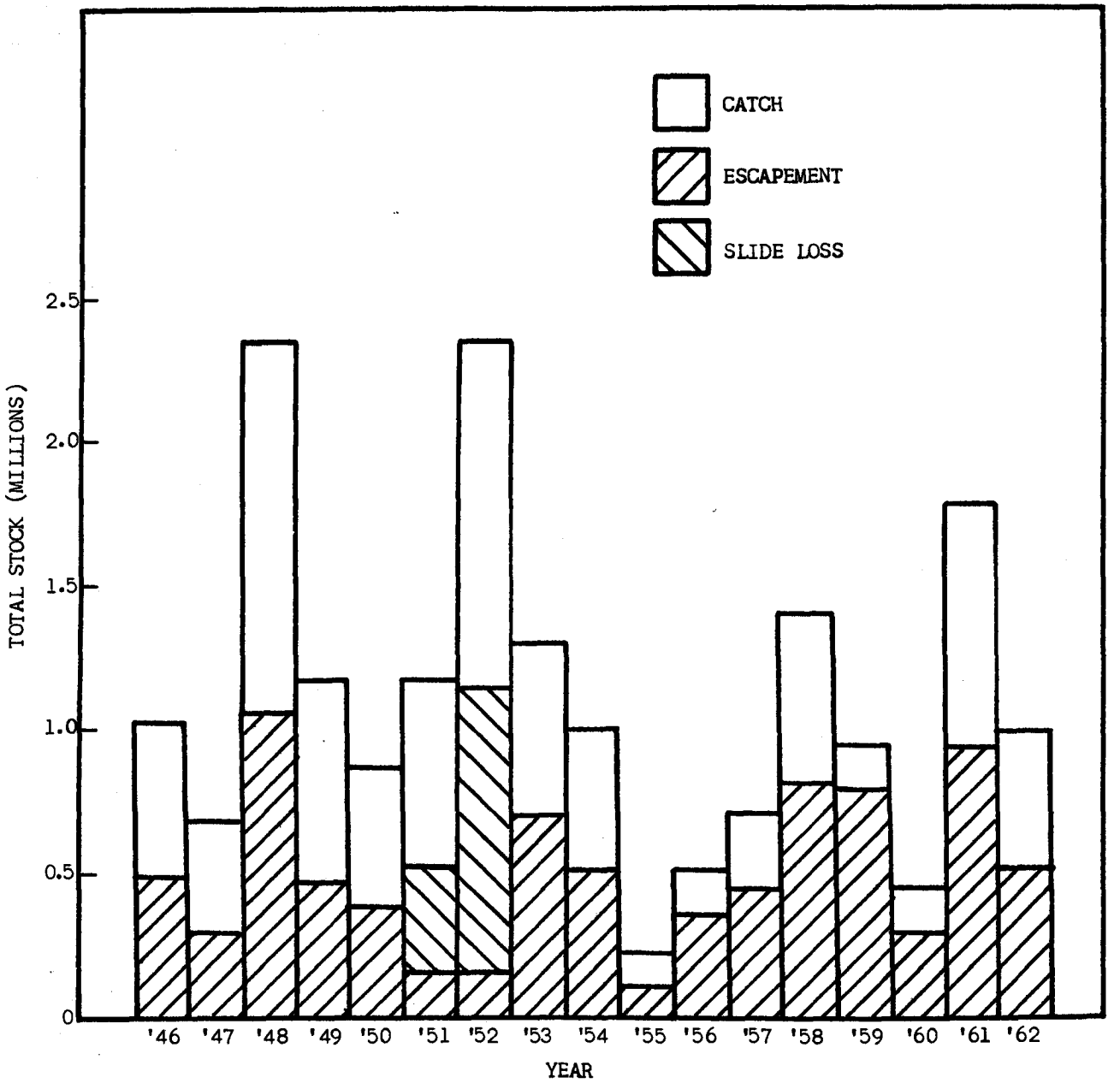
Basis for management of Skeena stocks

Essentially two questions must be answered: What escapement size and distribution is needed to result in the largest sustained catch? How can the fishery be regulated so that the necessary escapement can be provided?

Sockeye. Analysis of available records of the number of sockeye returning from escapements of known size to the Skeena has revealed that, on the average, the best return has resulted from spawnings of from 800,000 to 1,000,000 fish. On the basis of the observed ratio of spawners to Babine and to the Skeena as a whole, an optimum of about 800,000 sockeye is indicated for Babine.

Intensive studies are being carried out at Babine to provide a better understanding of the escapement requirements of this important and complex sockeye producer. Essentially these studies have involved: (a) estimation of escapement size and distribution, (b) assessment of the abundance, distribution, and growth of the resulting young in relation to the capacity of the lake nursery areas available, and (c) estimation of the number, size and age composition of resulting smolts.

Results to date have clearly demonstrated that the Babine run is made up of a number of individual stocks each of which depends upon a different spawning



SKEENA RIVER: CATCH AND ESCAPEMENT OF 4_2 AND 5_2 SOCKEYE, 1946 TO 1962.

Figure 5. Skeena River: Catch and escapement of 4_2 and 5_2 sockeye, 1946 to 1962.

area and, to a considerable extent, a different lake nursery area for reproduction purposes. These stocks have been identified as well on their relative time of migration through the fishery, time of entry into the lake, and time of spawning. Once the number of spawners required to use each spawning ground and lake nursery area most effectively is known, then appropriate regulation of the fishery will be possible.

Babine studies were intensified in 1962 to provide the additional information needed to determine the relationship between the number of parents and the resulting production for individual stocks. The fence count of spawners entering the system was followed by stream surveys, tag and recovery programs, and a special study of the incidence of lake spawning, in order to obtain better estimates of individual escapements. The use of otoliths to determine the age of spawning fish provides, for the first time at Babine, means of comparing the number and age composition of the parents to the number and age composition of returning adults for individual stocks. The reading of otoliths sampled in 1962 revealed wide differences in the age composition of spawners from one part of the spawning area to another.

In 1962, as in previous years, an estimate of the smolt output was made. The number of smolts resulting from the small 1960 escapement was estimated to be 13,000,000. This number indicates that an average survival occurred from the 1960 spawning. Additional studies were carried out to evaluate the present method of estimating smolt abundance and to develop a new method involving photoelectric devices.

Pinks. Intensive study of Skeena pink salmon stocks began in 1956. At this time, little was known of the escapements to the major spawning grounds or the contribution of individual runs to the fishery. Extensive tagging and surveys have since provided sufficient knowledge to meet the most immediate requirements for management.

Analysis of past catch statistics revealed that spawnings in years of abundance more often resulted in large returns than did spawnings in years of scarcity. It was also evident that the existing stock level was far below that which produced the large catches prior to 1931.

Measurements of the fry output from several major spawning areas were made from 1956 to 1961, and confirmed the above view. Fry outputs were roughly proportional to the abundance of parent spawners, suggesting that recent escapements have been below the capacity of the spawning grounds to produce pinks.

Work on pink salmon was reduced in scope in 1962. Estimates of the fry output from the moderate 1961 escapement of 325,000 spawners to the Lakelse River revealed a very low survival to the fry stage (4% as compared to 18 to 19% from the two previous spawnings). The output of fry from the much smaller 1961 Babine spawning, however, appeared to be good. A survival from egg to fry of 36% was indicated.

Observations of the fry output from Shames Slough, a side channel of the Skeena River, were made as an initial step to determine the effectiveness of the considerable amount of main stem spawning observed in some recent years. The

very few fry observed indicated almost a complete lack of young from the substantial number of pinks (about 35,000) which spawned in the slough in 1961.

Evaluation of present methods of estimating escapement size and the development of new methods continued in 1962. Comparison of estimates derived from tag and recovery programs to actual counts of the number of spawners was concluded on the Lakelse River. In three tests, tag and recovery procedures have provided estimates of 127%, 130% and 142% of the number counted through the fence.

The problem of obtaining objective information of the number and distribution of Skeena main stem spawners was also examined. Carcass counts and gill-net drifts on a representative number of river bars may provide a comparative measure of annual escapement size.

Regulation of the fishery

Knowledge of the strength of the runs as they develop and of the effect of commercial fishing on them is required to formulate regulations which will result in the desired division of catch and escapement. Specific projects carried out to provide essential information have included:

(a) Tagging of adult fish in the fishing area. Recovery of tags in the fishery and on the spawning grounds has provided information on the period of time each stock is available to commercial fishing.

(b) Collection and analysis of preliminary catch and escapement records. Available records of the daily and weekly salmon landings are used together with estimates of escapement to indicate the abundance of fish present in the fishing area and the rate of exploitation of them.

(c) Test fishing above the commercial fishing boundary. Daily catches made by standard gill-net drifts are used to estimate the numbers escaping the fishery throughout the season.

(d) Sampling of the commercial catch and the escapement. Samples are used to determine the age, sex and size composition of the runs so that the contribution of each brood year is known.

With the exception of tagging and recovery programs, the above projects are now carried out each year on a routine basis. The information these projects provided in 1962 continued to meet the present minimum requirements for regulation of the Skeena stocks.

Fish culture and development

In 1962, problems posed by expansion or proposed expansion of industry in the Skeena area continued to be examined. Particular attention was given to studies required to assess the possible effects on salmon production of proposed hydro-electric developments at Moricetown Falls on the Bulkley River, a major

salmon producing tributary of the Skeena, and on the Fulton River and Pinkut Creek - both important sockeye spawning streams tributary to Babine Lake.

In addition, operation of the Nanika River hatchery by the Department of Fisheries began on a full-scale basis in an attempt to rebuild the once substantial sockeye run to Morice Lake.

Further biological and engineering studies were carried out to examine the feasibility for developing, by the use of modern fish cultural techniques, the potential of Babine Lake as a sockeye producer.

Reports of progress in investigations and fish culture and development projects carried out in the Skeena area in 1962 follow this section.

Reports of Progress in Investigations and Fish Culture Projects, 1962

(1) The 1962 Babine escapement

The Babine Lake system comprises the largest sockeye salmon producing area in the Skeena system, having supported approximately 80% of the total Skeena escapement in past years. A count of the Babine escapement has been made annually since 1946 by the operation of a fence on the Babine River.

Babine fence counts and sampling are made (1) to show the effect of commercial fishing on the age, size and other features of the greatest part of the Skeena sockeye run, and (2) to provide a statistical record of characteristics of the escapement needed for assessing the year-by-year production of the Babine system.

The counts of the 5 species of salmon in the years 1946-62 (excepting 1948, when the fence was inoperative) are shown in Table II.

The 1962 fence operations began on July 11. The sockeye escapement was, as usual, bimodal in regard to time of entry to the lake. The first mode of 12,345 large[1] sockeye occurred on August 2. The second mode of 27,808 occurred on August 18. After the second mode, the daily counts showed a fairly steady decline and had dropped to 245 by September 22 when operations were discontinued. The first mode of abundance is of fish bound for the smaller streams, largely at the south end of Babine Lake. The second mode is composed of fish which spawn

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[1] The sockeye runs include fish 3, 4, 5 and 6 years of age. The number of 6-year-olds is negligible. Three-year-olds are all "jacks" or precocious males of small size and questionable value in production. For most statistical treatments, only "large" fish are considered.

Table II. Counts of salmon passing the Babine fence.

Year	Sockeye		Spring	Pink	Coho	Chum
	Large	Jack				
1946	444,551	31,154	10,528	28,161	12,489	18
1947	261,460	261,101	15,614	55,421	10,252	7
1948*	650,000					
1949	461,139	47,993	7,433	13,663	11,938	5
1950	364,356	179,302	6,838	38,728	11,654	7
1951	141,415	11,042	2,778	50	2,122	0
1952	349,011	27,936	5,915	2,706	10,554	1
1953	686,586	28,028	8,353	1,108	7,648	17
1954	493,677	9,745	5,925	4,604	3,094	66
1955	71,352	30,624	3,528	2,151	8,947	3
1956	355,345	18,164	4,345	2,691	9,250	3
1957	433,149	50,162	7,509	25,865	4,421	15
1958	812,043	30,769	8,274	6,600	7,606	8
1959	782,868	31,920	9,597	56,766	10,947	20
1960	262,719	49,396	2,855	4,876	6,794	6
1961	941,711	27,853	2,921	70,044	10,024	4
1962	548,000	46,200	3,030	37,500	11,000	23

*Total sockeye estimated from comparison with stream surveys and fence counts of other years.

for the most part in the Fulton, a major down-lake tributary, and in the Upper and Lower Babine Rivers. On the average about 95% of the run passes through the fence between July 10 and September 15. The mid-point is usually reached about August 20.

The 1962 escapement of 3,030 spring salmon was below average. A separate count of jack springs and large springs was made. Of the total, 2,400 or 79%, were jacks, and 630 or 21% were large. Prior to this year all springs were lumped in a single count so no exact division is possible for runs prior to 1962. However, the ratio of jacks to large springs in 1962 appeared similar to those observed in former years. Spring salmon spawn below as well as above the fence. The count, therefore, represents only a part of the total escapement.

The pink salmon escapement of 37,500 counted through the fence showed a very good return of spawners from a relatively small brood year escapement (4,876 in 1960). An additional 2,500 pinks are estimated to have spawned below the fence in 1962, to give a Babine River total of 40,000.

The coho count of 11,000 may well reflect the largest escapement since operations began in 1946. The final count in three other years was slightly higher than in 1962, but this year operations were terminated earlier than in the past. Several hundred coho were still passing daily when counts were discontinued on September 22.

To determine the characteristics of the 1962 Babine sockeye run, about 1% of the fence count was sampled daily for length, age, and size composition. The long-term average for sex ratio (1946-1961) and size (1949-1961) is compared with the 1962 measurements in the following table.

	Sex ratio		Length in cm.		
	Percent males	Percent females	Large males	Jacks	Females
Long-term average	45.5	54.5	55.7	37.9	58.6
1962	39.8	60.2	62.7	36.4	60.3

The average egg content of 1962 females was estimated to be 3,335. A total of 321,571 females are estimated to have escaped the Indian fishery above the fence leaving a potential egg deposition of 1,072,000,000.

(2) Babine River spawning ground studies

Estimates of numbers of spawners in a stream of known spawning area are made more precise if (1) their average spawning density during the season, and (2) their rate of turnover, or replacement from within the spawning population, are known. In addition, some insight into the probable success of spawning is provided by knowledge of the extent to which successive pairs of spawners superimpose their redds. If estimates are to be made on the basis of measurements such as these, some additional check on the real population size is needed. Estimates from tag and recovery data may be helpful, and aerial photography can in many instances show the size of the spawning population at a given time.

Measurements of density, rate of turnover and superimposition are particularly needed for sockeye on the Upper and Lower Babine Rivers because annual escapements to these areas are especially large and difficult to count directly. (The average total population on these two rivers above and below Nilkitkwa Lake in the last 5 years has been estimated at 250,000 sockeye.) In 1962 an

observation platform or "tower" was placed on a 30-foot high aluminum scaffolding and erected in the middle of the lower river spawning area. A grid of twine was stretched above the surface of the water to delineate 3,700 square feet of spawning gravel (37 squares each 10 × 10 feet). An observer spent 6 to 8 hours on the tower each day from September 13 through October 18 plotting and describing the movements of salmon over the gridded area. It was hoped that these measurements could be shown to be representative of the river as a whole.

The observed density of spawning sockeye appears in Figure 6. An average of 1 fish per 26 square feet occurred on October 1 and was the greatest density observed. Possibly a few fish contributing to the estimate were transients but their numbers are considered non-significant for the purpose of this analysis.

During the entire period of observation about 245 sockeye used the gridded area for spawning thus giving a season-long concentration of 1 fish per 15 square feet. The best estimate of rate of turn-over is therefore the greatest density observed, divided by the season-long density, i.e. $\frac{26}{15} = 1.73$ fish. The useful spawning area in the lower river was measured and found to be 120,000 square yards. At a density of 1 fish per 26 square feet, an estimate of the spawning population at the peak would be 41,538, and the total for the season 1.73 times this figure, or 71,900 sockeye.

There was very little evidence of superimposition of sockeye redds. Some overlapping occurred at the edges of excavations, but so far as could be seen it did not result in displacement of eggs. However, the 1962 run to the lower river was considered smaller than usual and further studies will be required to observe the effect of changes of spawning density which will occur with larger escapements. Superimposition may be more frequent when there are greater concentrations of fish on the grounds.

Estimates of both the Upper and Lower Babine River spawning populations were made by tag and recovery in 1962. Tagging was deferred until all uplake populations had passed through the two rivers and most fish were seined from pools of resting fish so it is considered unlikely that any significant number of tags were carried out of the area. Pertinent data for the estimates are as follows:

River	No. tagged	No. inspected	No. tags recovered	Population
Upper	1,450	53,027	392	196,146
Lower	1,032	28,673	465	63,635

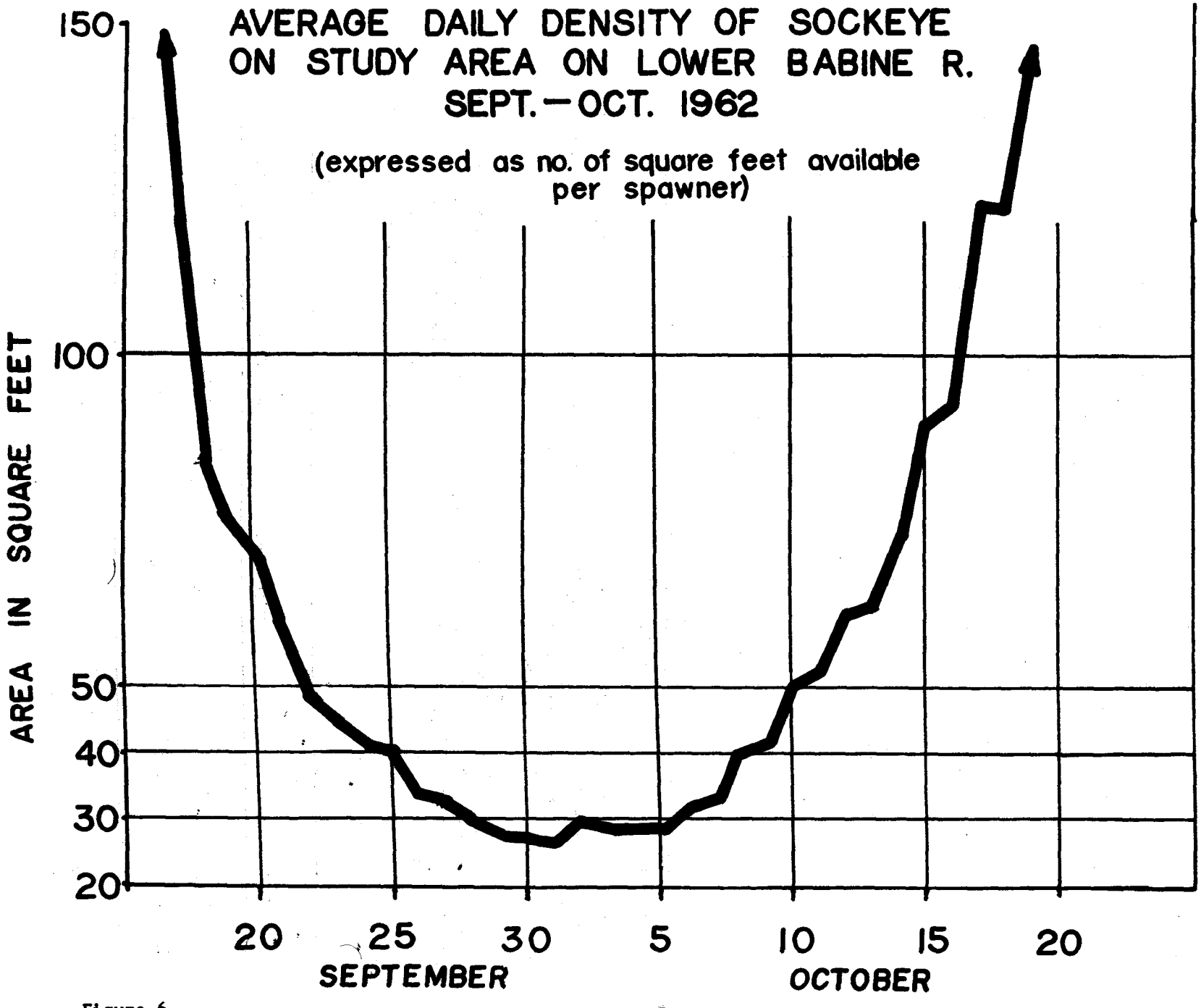

AVERAGE DAILY DENSITY OF SOCKEYE
ON STUDY AREA ON LOWER BABINE R.
SEPT.—OCT. 1962
(expressed as no. of square feet available per spawner)
AREA IN SQUARE FEET
150
100
50
40
30
20
20
25
30
5
10
15
20
SEPTEMBER
OCTOBER

Figure 6.

In view of the tendency for tag and recovery data to provide an overestimate of spawning populations (see Babine fence tagging section of this report) some downward adjustment of these figures is in order. Tagging at the fence in 1962 was not specifically designed to estimate the Babine population, but nevertheless suggested a population about 20% larger than the fence count. The greater time at liberty of tagged fish and, therefore, the tag loss and accumulation of factors contributing to the overestimate by the fence tags, was substantially greater than would be expected when using the river tags alone. A downward adjustment of 10% is considered most reasonable until further data are available. The corrected total is 176,500 for the upper, and 57,300 for the lower river. The latter figure is 14,600 smaller than that calculated for the lower river from the tower observation data.

There is a possibility that the observations from the tower were not representative of spawning density and rate of turnover throughout the lower river. However, aerial photographs of the entire lower river near the time of peak spawning suggest that the density, at least, was similar throughout the river. No further resolution of the differences can be suggested at this time. Either or both methods may be at fault. Either would probably have provided a better estimate than could have been obtained by a direct count.

(3) The migration times and spawning distribution of Babine sockeye sub-stocks.

The Babine sockeye stock is composed of a number of individual runs or sub-stocks which proceed to spawn at somewhat different times and in different spawning areas. Management of the stock as a whole can be improved considerably if the spawning requirements of the sub-stocks can be determined and appropriate fishing regulations formulated.

Better definition of these sub-stocks has resulted from taggings carried out in the commercial fishing area and at the Babine fence. The recovery of tags in the fishery, at the Babine fence, and on the spawning grounds has provided much needed information on the timing and spawning distribution of these fish.

Since 1946, four tagging programs have been carried out at the Babine fence. Details of the taggings and recoveries are as follows:

Year	Fence count of large sockeye	Tagging rate[1]		Recovery rate[2]	
		Number	% of fence count	Number	Per cent
1946	477,705	9,417	2.0	1,623	17.2
1947	522,561	5,225	1.0	803	15.4
1958	842,812	7,870	0.9	610	7.8
1962	594,200	6,200	1.0	1,548	25.0

[1] In each year a fixed percentage of the daily escapement was tagged.

[2] 1946 and 1947 figures include tags sighted but not actually recovered.

These taggings have demonstrated that the Babine escapement can be divided into four parts on the basis of migration time. These are:

(a) The "early" run which includes fish bound for about 10 streams - mainly in the southern half of the lake. About 90% of these enter before August 12.

(b) A combination of fish bound for Morrison River and 15-Mile Creek. Of these 90% enter between August 1 and 18, but they overlap the following group considerably.

(c) A large run to the Fulton River. Over 90% of these pass between August 5 and August 30 but overlap both the preceding and following groups substantially.

(d) The runs to the Upper and Lower Babine Rivers. These constitute about 50% of the entire escapement on the average. Over 90% of these enter after August 15 in 1962.

The timing of these four groups of spawners at the Babine fence is shown in Figure 7.

Repeated tagging of these sub-populations will demonstrate the variability in their timing from year to year. If this variability is small it may be possible to apportion them to the grounds by assessing their most probable contribution to the stock at any time in the fishery and regulating accordingly.

Apart from the value of tagging to show the timing of components of the escapement, considerable interest has prevailed in the degree of accuracy which might result from a Babine population estimate by tag and recovery methods. Pertinent information from the four years of data are as follows:

Year	Percent of run tagged	Percent of tags recovered	Percent error in estimate
1946	2.0	1.05	+90%
1947	1.0	0.71	+41%
1958	0.93	0.47	+98%
1962	1.13*	0.94	+20%

*Only large sockeye considered in 1962 experiment.

The high variance associated with these four experiments is discouraging. By comparison, tagging of pink salmon for population estimates by Board personnel has erred from 27 to 42% in recent years.

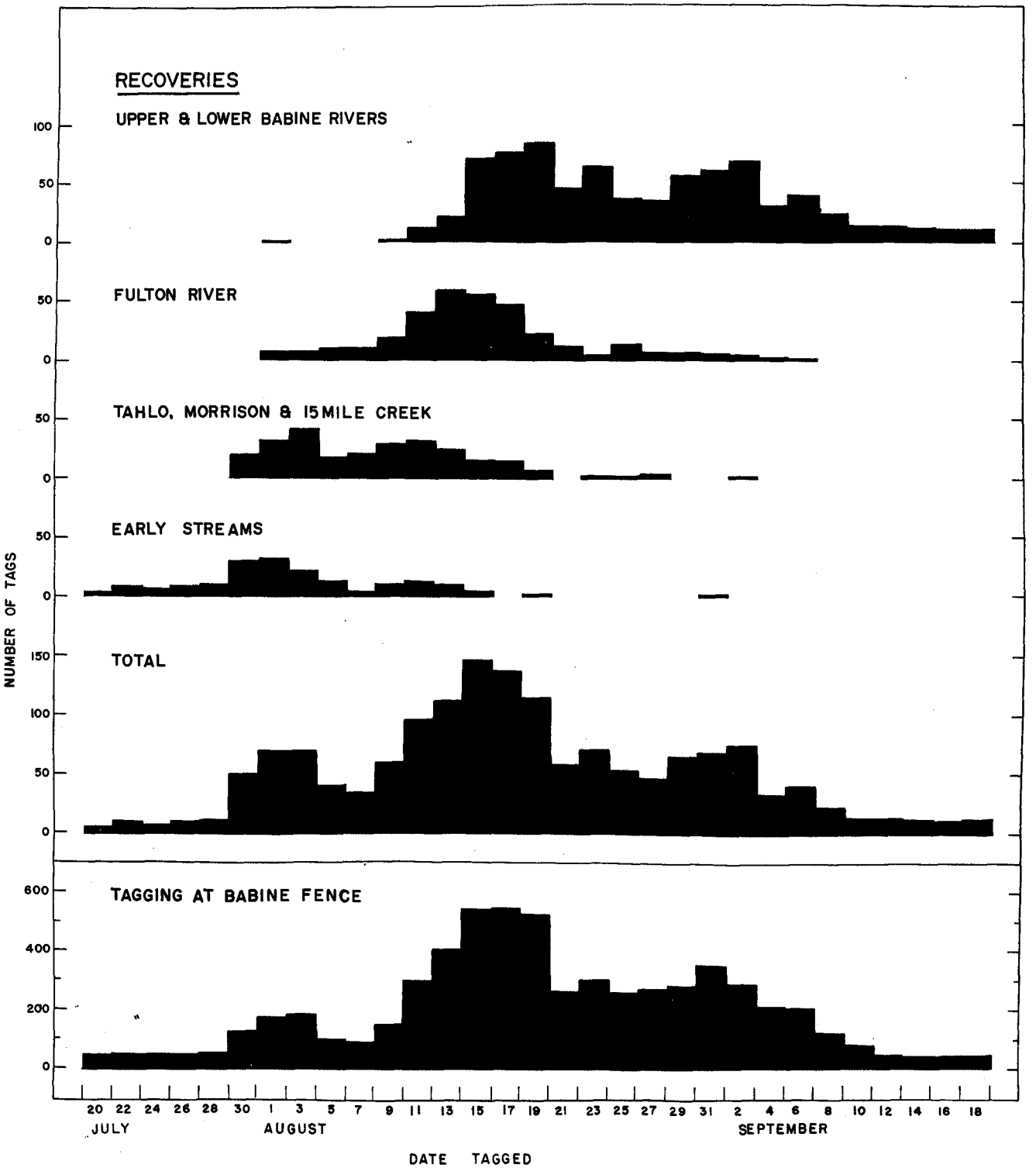


Figure 7. Recoveries of sockeye tags by spawning area and tagging date, Babine Fence tagging, 1962.

(4) Age and length composition of Babine sockeye

Understanding of the dynamics of the Babine sockeye stock may be greatly improved when sub-populations are recognized and studied independently. Size and age of return may serve to differentiate certain of these sub-populations and thereby simplify the study.

The age and size composition of fish in the annual escapements to Babine have been determined since 1946 from samples taken at the counting fence. In 1958, and to a greater extent in 1962, these statistics have also been obtained from sub-samples taken periodically on the spawning grounds.

In the past, attempts to determine the age of Babine sockeye, from examination of scales were unsuccessful because the margins of salmon scales are resorbed as the fish matures. Otoliths - calcareous growths resting in the semi-circular canals of fishes - develop growth bands and may be read in much the same manner as scales. In 1962, more than 1,800 otoliths were obtained from dead salmon on the spawning grounds. In addition a sample of otoliths and scales were taken at the test fishing site where scales are readily legible, and these provided a 70 to 80% agreement in age determination. Errors in both scale and otolith reading probably contributed to the discrepancy.

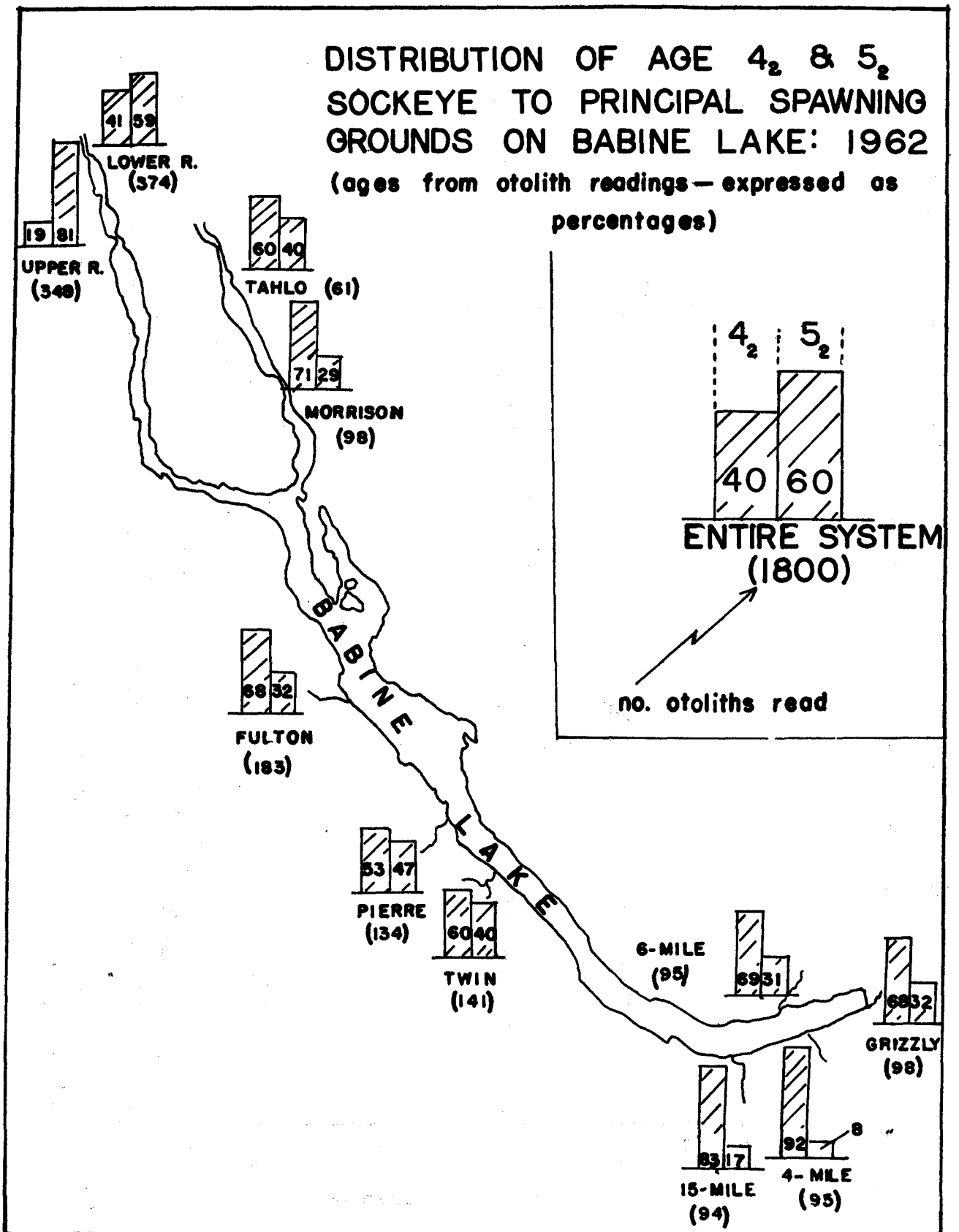
Otoliths showed that the age composition of Babine sub-populations differed substantially. The division into 4- and 5-year-old fish, as indicated by the samples, appears in Figure 8. A few additional 6-year-olds have not been included.

Figure 8 shows that 4-year-old fish predominated among the early, south-end fish, while those which entered the system late and spawned largely in the Upper and Lower Babine Rivers were predominantly 5-year-olds. It is also noteworthy that these river spawning populations passed through the fence together and completely intermixed (see Babine fence tagging section) yet the upper river fish included 81% 5-year-olds whereas the lower river included only 59% 5-year-olds.

Confidence in the overall sampling for age is provided by the samples at the fence. These showed that 40% of the large adults were 4-year-olds. Spawning ground samples weighted to abundance suggested the same proportion.

Age at return may often be determined by inspection of total length. At Babine most smolts go to sea after one year in the lake, and increase their length with each year out. In general the 1962 length frequencies were bi-modal and reflected the two age groups accurately. A sample of 200 sockeye of each sex from the Lower Babine River have been measured and aged to illustrate this in Figure 9.

Analysis is underway to determine the significance of measured differences in size. Further work will be necessary to determine the degree of variability which may occur spacially and temporally within streams - a prerequisite to confidence in samples taken periodically through the season.


DISTRIBUTION OF AGE 4₂ & 5₂ SOCKEYE TO PRINCIPAL SPAWNING GROUNDS ON BABINE LAKE: 1962
(ages from otolith readings — expressed as percentages)
4₂
5₂
40 60
ENTIRE SYSTEM (1800)
no. otoliths read
BABINE LAKE
41 59
LOWER R. (374)
19 81
UPPER R. (348)
60 40
TAHLO (61)
71 29
MORRISON (98)
68 32
FULTON (183)
53 47
PIERRE (134)
60 40
TWIN (141)
6-MILE (95)
69 31
68 32
GRIZZLY (98)
83 17
15-MILE (94)
92 8
4-MILE (95)

AGE-LENGTH RELATIONSHIP OF 400 SOCKEYE FROM LOWER BABINE RIVER IN 1962

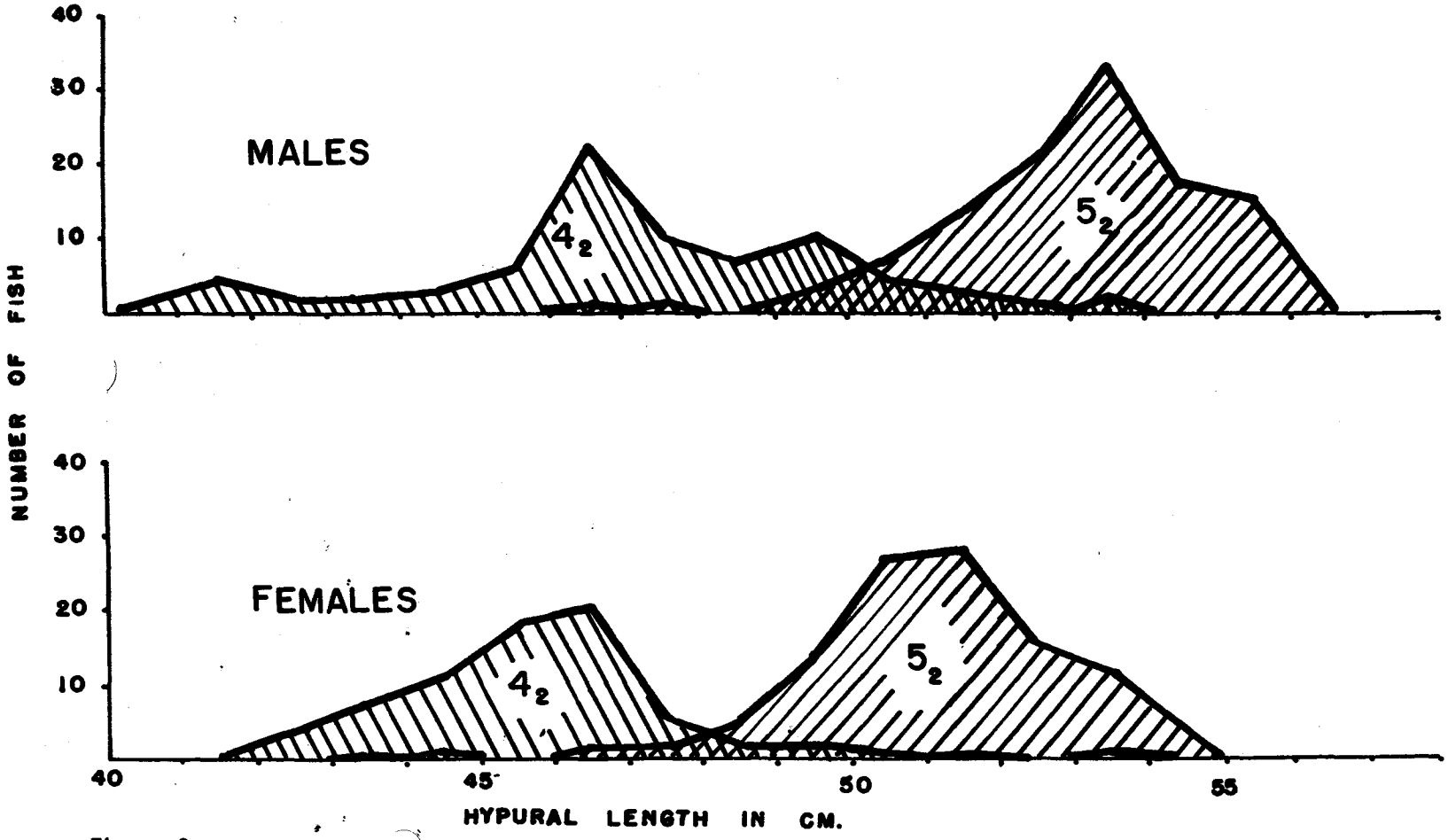


Figure 9.

(5) Babine Lake spawning surveys

In order to assess the spawning requirements of Babine sockeye, a series of accurate measurements of escapement size and distribution is required. In many past years, comparison of the fence count with estimates of the number of fish observed on the various spawning grounds revealed that a considerable number of sockeye which entered the system could not be accounted for on the streams. The possibility of lake spawning is therefore being examined.

Some preliminary surveys for lake spawning populations were conducted in 1958 and 1961. A more intensive program was initiated in 1962. Standard gillnets of 5-1/4-inch mesh and 100 feet long were used to fish each of 26 sites around the main lake basin in the period October 21 to 28. Each set was accompanied by sonic readings of the depth of the set and the general topography in the vicinity. The total catch was only 41 salmon - about 1.6 per set on the average. This compares with about 10 fish per set during a similar period in 1961, and suggests that the population in the lake during October, 1962, was less than in October, 1961. The largest catches in 1962 were at Red Bluff, just north of Topley, and in an area just north of Pendleton Bay (Fig. 10).

From October 22 through to October 25, a team of four scuba divers investigated the lake spawning possibilities - primarily in the areas where productive gillnet sets had been made in 1961 and 1962. In all, 22 separate locations were inspected. Some were chosen because successful gillnet sets had been made in the vicinity; others chosen were taken to be generally representative of the range of conditions prevailing around the main lake basins. The usual plan was to have a 2-man team dive to the limit of good visibility (about 80 feet) while the other two separated and followed the shoreline for 100 yards or so in either direction at a depth of 15 to 25 feet. The bottom characteristics and the apparent suitability for spawning were noted after each dive.

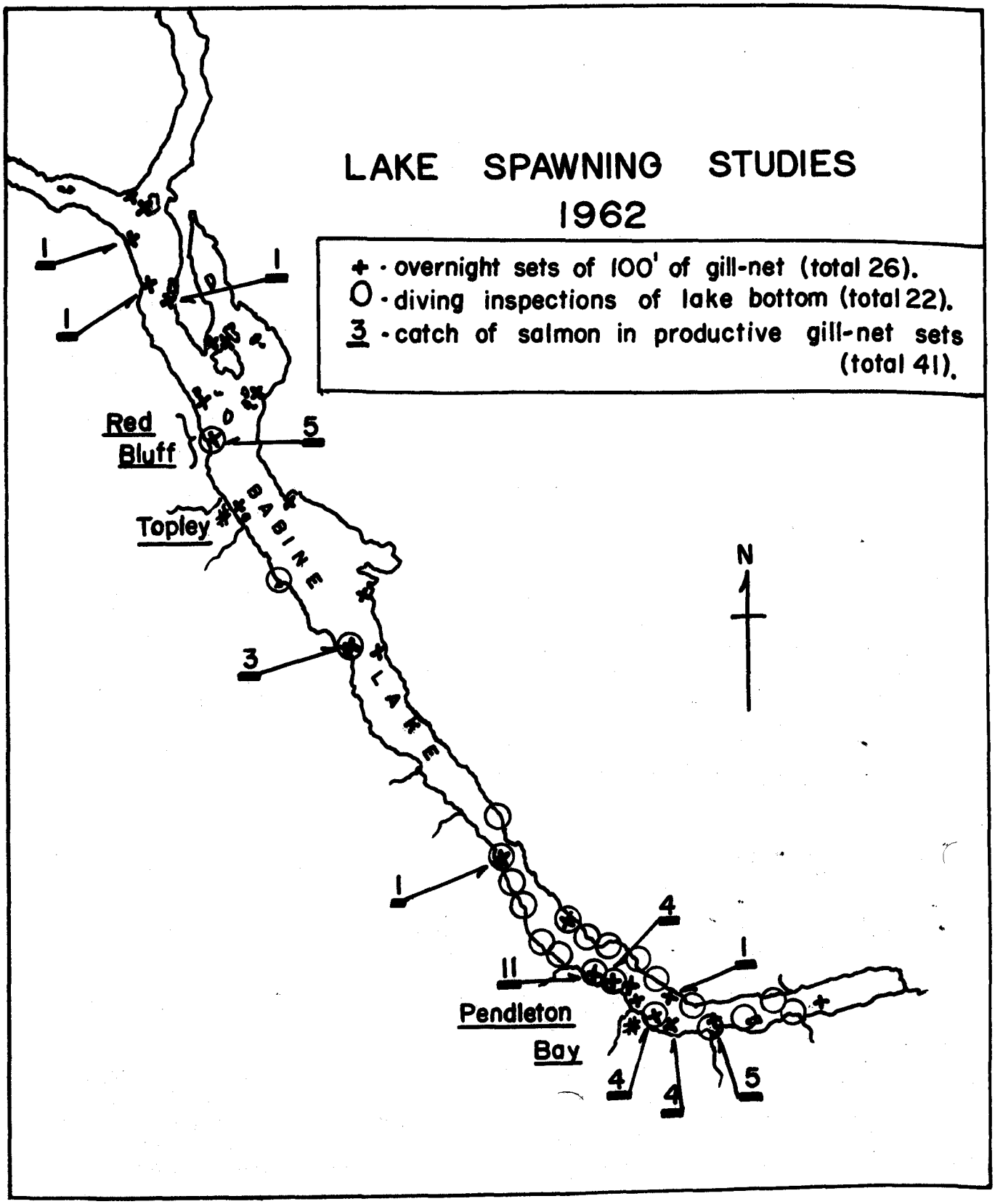
There were very few places where suitable spawning gravel was found, though the bottom contours and composition varied considerably. The most frequently encountered conditions can be described according to three zones as follows:

Zone 1 (0- to 5- or 6-ft. level). Little slope with coarse boulders. (Probably coincides with lowest lake level.)

Zone 2 (5- to 20-feet). Gradually sloping shelf of coarse gravel and frequently with some mud and aquatic vegetation.

Zone 3 (20- to 70-feet or more). Steeply sloping bottom of mud and silt to the limit of visibility.

Fifteen of the 22 inspections were in sites where spawning was judged impossible, four were in marginal areas, and three were in areas considered highly suitable. One of the suitable areas was at Red Bluff, where, on October 25, there were 60 to 70 salmon at depths of from 30 feet at least as far as the limit of visibility. Most of these fish appeared to have finished spawning.


LAKE SPAWNING STUDIES
1962
+ - overnight sets of 100' of gill-net (total 26).
O - diving inspections of lake bottom (total 22).
3 - catch of salmon in productive gill-net sets (total 41).
Red Bluff
Topley
BABINE LAKE
Pendleton Bay
N
1
1
1
5
3
1
4
11
1
4
4
5

They were observed over a steep slope of pea-sized gravel where several well-defined redds were attended by live females. The shoreline for several miles north of Pendleton Bay was also judged very suitable. Successful gillnet sets were made there but no live fish were found by the divers.

The discovery of lake spawners introduces new problems in evaluating Babine sockeye production. About 130,000 or 24% of the known escapement of 548,000 large sockeye were not accounted for on the spawning grounds in 1962; 230,000 or 24.5% of 940,000 were not accounted for in 1961. An unknown number of these doubtless spawned in the lake in both years. The question which will have to be answered in future is: How many, and with what spawning success?

(6) The Babine smolt output in 1962

The number of smolts migrating from Babine Lake each year provides a measure of the success of parent spawning two years before. Coupled with age and size of fish comprising the run, numbers may be used to assist in predicting the likely numbers of returning adults.

The smolt migration occurs in two runs, usually well separated in time. Uplake marking of smolts has demonstrated that the first or "early run" originates in the north (outlet) end of the system - largely in Nilkitkwa Lake and the north arm of Babine Lake. The second or "late run" originates in the main lake basins. From 1951 to 1957 only the late run was recognized and estimated. From 1958 until the present both runs have been enumerated. Details have been reported in the annual reports of this Station.

Figure 11 illustrates the typical daily migration pattern of smolts. Emigration from the lake becomes most active at dark and for one or two hours thereafter. A relatively small number of migrants is observed during the daylight hours. The proportion of the smolts emigrating during daylight, however, may become relatively less when small numbers of smolts are migrating and relatively more when large numbers are observed.

In 1962, for the third consecutive year, the number of smolt migrants was estimated by a tag and recovery program. In addition to tagging for enumeration purposes, a number of experimental tag releases were made to evaluate the method used.

For estimating purposes 75,000 smolts were marked and 3,790 or 5.1% of these were recovered. Unfortunately during the period May 11 to 19 the water levels were so low that only small numbers of smolts entered the trap designed to capture them at the outlet of Nilkitkwa Lake (Fig. 12). The estimate during this low-water period was, therefore, based in part upon catches made in a fyke net hung off the adult counting fence. The number of migrants during the low-water period is estimated at less than one million. The entire early run totalled 4.2 million, the late run 8.8 million to give a total 1962 smolt output of 13 million.

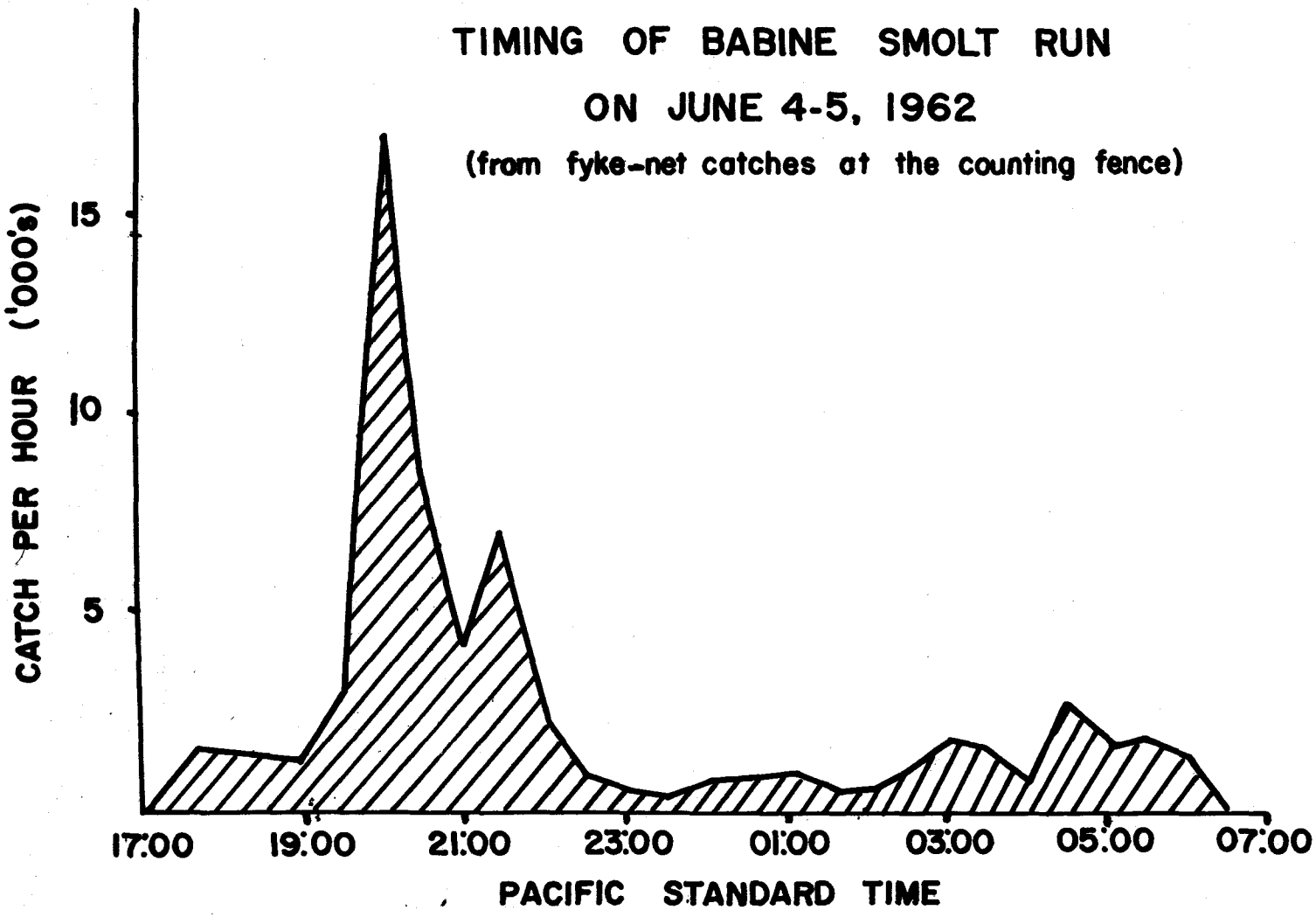
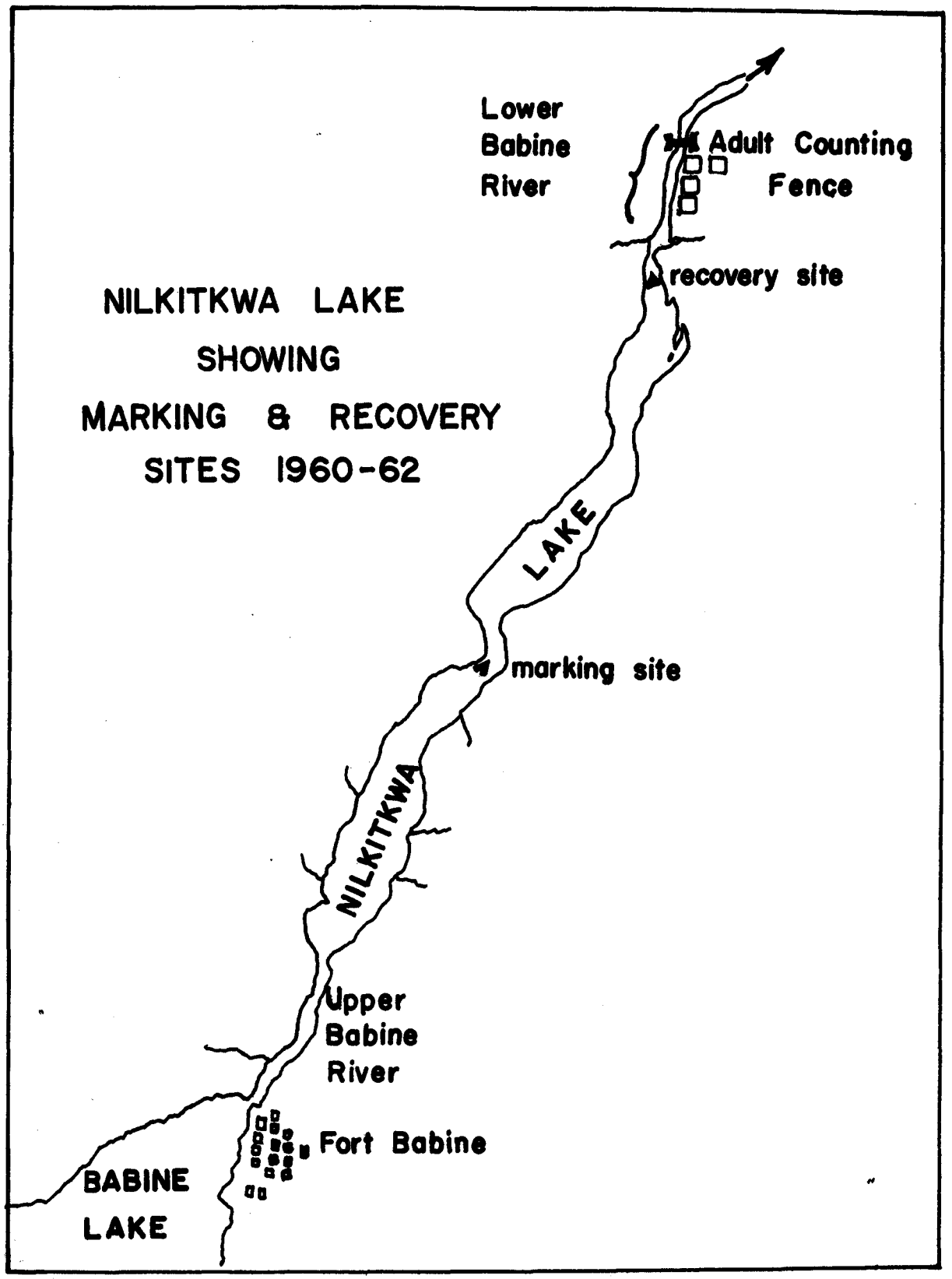

TIMING OF BABINE SMOLT RUN
ON JUNE 4-5, 1962
(from fyke-net catches at the counting fence)
CATCH PER HOUR ('000's)
15
10
5
17:00
19:00
21:00
23:00
01:00
03:00
05:00
07:00
PACIFIC STANDARD TIME

Figure 11.


NILKITKWA LAKE
SHOWING
MARKING & RECOVERY
SITES 1960-62
Lower
Babine
River
Adult Counting
Fence
recovery site
LAKE
marking site
NILKITKWA
Upper
Babine
River
Fort Babine
BABINE
LAKE

The best estimates of survival from egg to smolt for the brood years 1956 to 1960 are presented in Table III. Survival is also shown for smolt to adult and egg to adult for the 1956 and 1957 brood years. Returns from the 1958 brood year are not yet complete, but the 372,000 4-year-olds in 1962 suggest that the survival from it may be very poor. The survival of the 1960 year-class from egg to smolt was 3.2% which is about average for the Babine system.

Table III. Preliminary survival estimates for Babine smolts from brood years 1956-1962.

Brood year	Fence count	Egg potential ($\times 10^6$)	Smolts produced ($\times 10^3$)	Return of 4_2 and 5_2 ($\times 10^3$)[a]	% survival		
					Egg-smolt	Smolt-adult	Egg-adult
1956	355,345	523	22,200	596	4.24	2.68	1.14
1957	433,149	653	34,300	2,091	5.25	6.15	3.21
1958	812,043	1,547	45,000	372[b]	2.91	..	..
1959	782,868	1,554	16,000	..	1.03	..	..
1960	262,719	403	13,000	..	3.23	..	..
1961	941,700	1,511	..	..	..	..	..
1962	548,000	1,072	..	..	..	..	..

[a]This includes a small number of adults destined for Skeena spawning grounds other than Babine.

[b] 4_2 returns only.

The mean length of early-run smolts in 1962 was 81 mm - the largest recorded in the five years of data available from 1958 to 1962. It compares with a mean of about 76 mm for the 5-year period. At present there is insufficient evidence to show what effect this will have on survival of Babine smolts, though large size at time of migration is generally considered to be beneficial.

During the season several tests were made to evaluate the dependability of the tag and recovery procedure and to arrive at the estimated smolt output. Both release and recovery procedures were examined. To study release procedures, experimental tag releases were made upstream of the recovery site at a number of different places and times. The number and distribution (in time) of the recoveries were then compared to similar data obtained from the standard tag releases made for estimating purposes. Recovery procedures were examined by dividing recoveries into pre-midnight and post-midnight periods and determining if the proportion of tagged fish remained constant from one period to the next.

From May 19 to June 7, 30,000 smolts were tagged and released to test release and recovery techniques. The tests showed the following:

(1) That changes in time and place of release changed the rate of recovery. This is illustrated in Table IV where two of several experiments are summarized. In experiment 1, a release at the trapping site at 1600 hours, June 4, produced a tagged-to-untagged ratio twice as large as from any of the other three releases. In experiment 2, 3,055 tags spread below the trap produced a ratio in the recoveries which was about twice that of the tags in the control release.

(2) That the tag recovery ratios were not constant throughout the night. Table V shows the number of tagged fish among catches made (a) before and (b) after midnight in the period June 5 through 15. The table shows that pre-midnight tag ratios varied from about three times (June 5-6) to one-third (June 14-15) the post-midnight ratios. For the 10-day period an estimate of the population based upon the pre-midnight recoveries would have been about 80% of that based upon post-midnight recoveries.

It appears that some improvement in release procedures can be made, but unquestionably sampling effort must be applied throughout the period that fish run. Failure to sample throughout each night's run could result in grave errors in the estimates for each night, and for the season.

Table IV. Showing recovery rates of tags in experimental and control releases in two experiments at Babine in 1962.

Release data	Experiment Number 1 (June 4) (Releases in time)				Experiment Number 2 (June 5) (Releases in space)	
	A	B	C	Control	A	Control
Place	All at upper trap				Spread below upper trap	Upper trap
Time	10:00	16:00	22:00	After 22:00	22:00	After 22:00
No. tags	1,012	1,017	1,071	2,066	3,055	2,967
No. recovered	17	36	19	27	195	112
% recovered	1.7	3.5	1.8	1.3	6.4	3.8

Table V. Number of tags recovered, and ratios of tagged to untagged smolts in pre- and post-midnight periods, June 5-15, 1962.

Date	Pre-midnight catches			Post-midnight catches		
	No. caught	No. tags	Ratio	No. caught	No. tags	Ratio
June 5-6	15,000	8	1:1875	18,400	27	1:681
6-7	6,500	30	1:217	11,500	53	1:217
7-8	12,800	86	1:149	1,000	13	1:77
8-9	4,200	21	1:200	6,600	37	1:178
9-10	3,800	31	1:123	1,200	19	1:63
10-11	3,900	68	1:57	3,300	27	1:122
11-12	6,800	44	1:155	3,200	51	1:63
12-13	8,900	106	1:84	3,000	19	1:158
13-14	6,800	65	1:105	1,000	6	1:167
14-15	10,000	25	1:40	5,000	36	1:139
Totals	78,700	484	1:163	54,200	278	1:195

(7) Pink salmon escapements in 1962

Pink salmon spawn throughout most of the Skeena River system. Estimates of the number and distribution of these spawners are made annually in co-operation with Department of Fisheries personnel. The information obtained, together with catch statistics, provides knowledge of the size of the runs and the effect of the fishery on them. Accurate information of escapement size also serves as a basis for determining the relationship between parent and resulting progeny (fry and returning adult), knowledge of which is an essential basis for good long-term management.

1962 estimates of escapement size were obtained by a variety of methods. Considerable effort was placed into evaluating present techniques and developing new ones.

(a) Methods. 1962 estimates were made from aerial surveys, ground and boat surveys and counting fence operations. In addition to obtaining simple counts of salmon, particular emphasis was placed upon describing the runs in terms of timing and distribution over the grounds. Prior knowledge of the character of each run is essential if good estimates of population size are to be obtained.

Special efforts were made to describe the characters of the Lakelse River, and Skeena main-stem runs. On the Lakelse River a counting fence was maintained for the third consecutive year so that counts could be compared with estimates derived from a tag and recovery program. The results of the comparisons in the three years were as follows:

Year	Fence count	Tag and recovery estimate					Percent error
		Number tagged	Percent tagged	Number inspected	Number recovered	Estimate	
1960	111,936	3,332	3.0	22,435	472	158,376	41.5
1961	305,675	6,043	2.0	39,348	614	387,264	26.7
1962	625,000	6,429	1.0	64,505	509	814,740	30.4

A rather similar degree of error resulted from each year's tagging despite different levels of tagging and recovery effort. The data obtained in these three years of comparative estimates should now permit us to simulate a wide range of escapement sizes and tagging rates, and to predict the degree of accuracy to be expected at any anticipated population size or acceptable tagging rates in the future.

It should be noted that each of these tag and recovery estimates is drawn from the sum of recoveries on the stream and on the counting fence. The fence recoveries tend to include proportionally more tags than do the stream recoveries, so the error resulting from the use of stream recoveries alone is higher - by about 15% in past years.

Further understanding of the Lakelse run is provided through the distribution of tag recoveries each year. Tags attached to the fish in the first half of the run were recovered primarily in the upper part of the river; those in the second half of the run, primarily in the lower half of the river. This phenomenon prevailed in all three years as illustrated in Figure 13.

Enumeration on the Skeena mainstem is particularly difficult. Live fish are generally not visible in the silty waters and dead counts are difficult to interpret in terms of the size of the population from which they are derived. Furthermore, there is obviously a mixture of mainstem and "upriver" subpopulations on the grounds during much of the season and it is difficult to assess the former independently. At present the main effort is in establishing the timing and distribution of the spawners, and in lieu of direct counts, in developing a simple index of abundance. Some success can be reported in these efforts.

Runs in the past three years have demonstrated a consistency in distribution and time of spawning. Major spawning areas and relative intensity of spawning is shown in Figure 14. Greatest densities were noted between the Lakelse and Exstew Rivers each year. Peak of spawning is considered to have occurred in the second week of September each year. An index to population size has been attempted by relating numbers of salmon caught in standardized gillnet and seine catches on the river to numbers of dead observed at selected sites later in the season. In 1962, estimates of the spawning population were made independently from (1) carcass counts and (2) average gillnet catches per unit-of-area expanded for the entire productive part of the river. These estimates

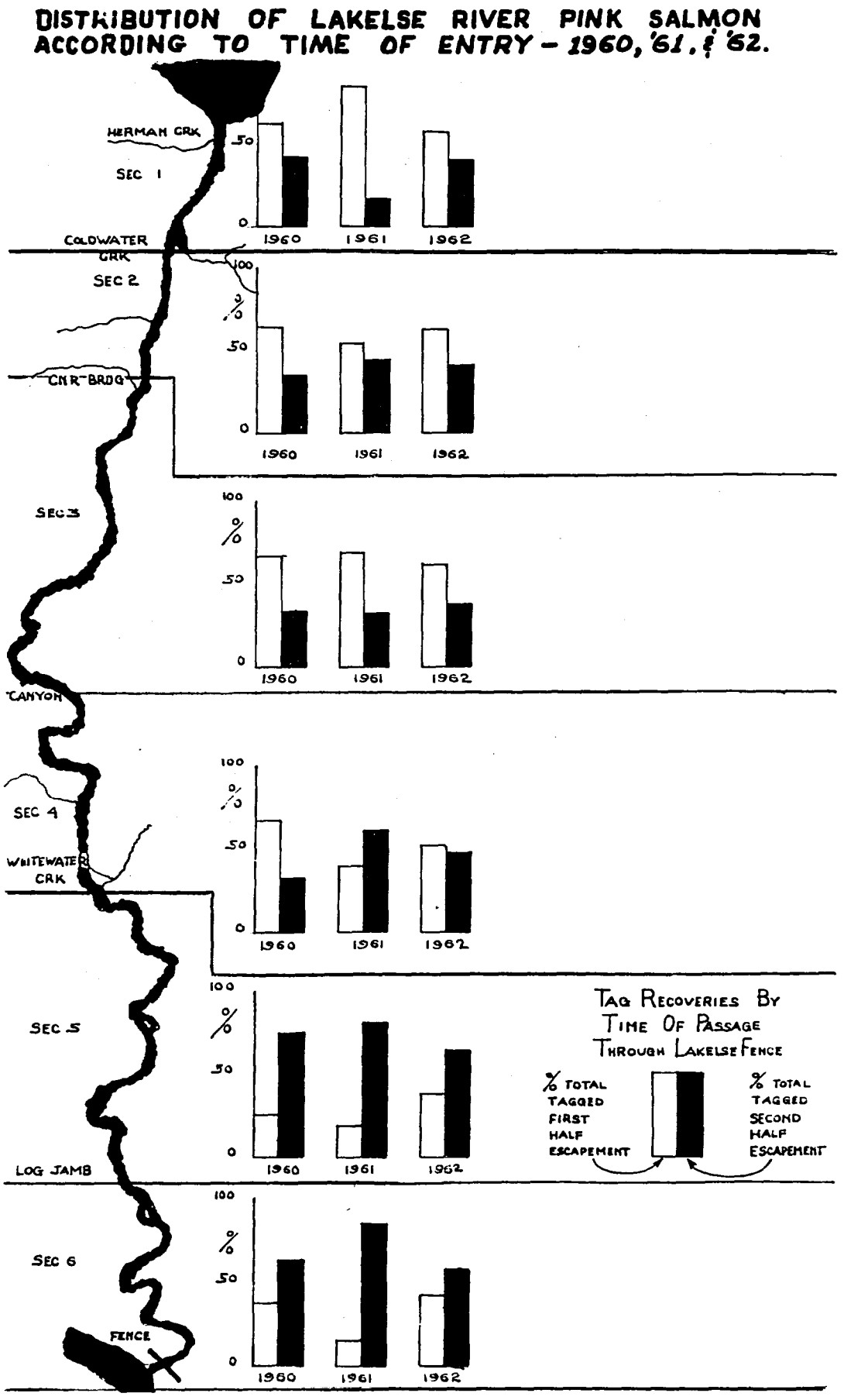
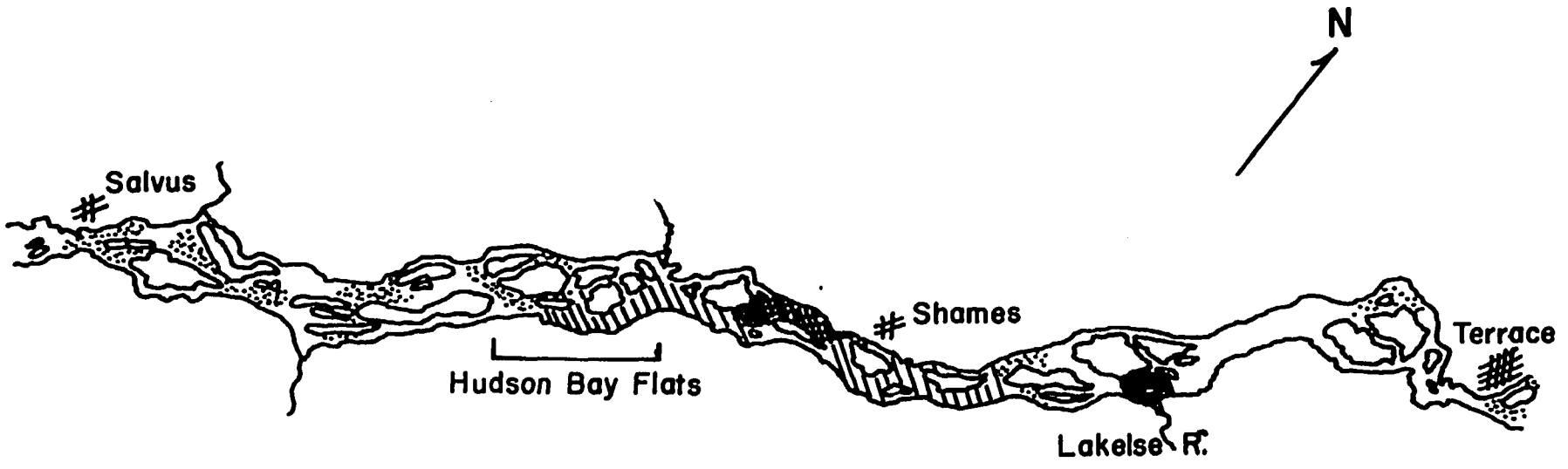
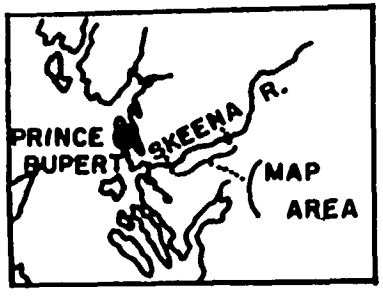

DISTRIBUTION OF LAKELSE RIVER PINK SALMON ACCORDING TO TIME OF ENTRY - 1960, '61, & '62.
HERMAN CRK
SEC 1
COLDWATER CRK
SEC 2
CNR BRDG
SEC 3
CANYON
SEC 4
WHITEWATER CRK
SEC 5
LOG JAMB
SEC 6
FENCE
100
%
50
0
1960
1961
1962
TAG RECOVERIES BY TIME OF PASSAGE THROUGH LAKELSE FENCE
% TOTAL TAGGED FIRST HALF ESCAPEMENT
% TOTAL TAGGED SECOND HALF ESCAPEMENT

Figure 13.

SKEENA MAINSTEM SHOWING DISTRIBUTION OF PINK SALMON SPAWNERS: SEPT. 1962.





SPAWNING DENSITY
HEAVY -
MEDIUM -
LIGHT -
SCALE
1 2 3 4 5 MILES (river width expanded to permit detail)

Figure 14.

yielded 35,000 and 39,000 pinks respectively. This is perhaps a closer agreement than could be expected over the long term, but suggests that these two approaches could be used interchangeably. At this point there is no guarantee that they provide the true population size.

(b) Estimated escapement. The escapement of Skeena pink salmon to major spawning grounds in the years 1955 to 1962 were as follows:

Estimated escapement of Skeena pink salmon, 1955 to 1962.
(thousands)

Place	1955	1956	1957	1958	1959	1960	1961	1962
Kispiox River	540	75	360	66	650	45	280	50
Kitwanga River	125	35	160	158	250	27	100	65
Lakelse River	175	75	140	262	185	122	325	635
Babine River	5	3	27	10	77	7	75	40
Bear River	6	Nil	15	Nil	20	Nil	5	Nil
Skeena River	10	5	50	50	150	10	450	37
Others	119	10	113	10	54	5	100	8
Coastal Rivers	78	75	105	116	95	45	99	165
Total	1,058	278	970	672	1,478	261	1,434	1,000
Total upstream of test-fishing site	987	202	868	558	1,383	215	1,335	835

The 1962 pink escapement to the Skeena system was the largest in an even- or "off"-year cycle since 1954, but about 75% of the escapement above the test fishing site spawned in the Lakelse River. The Babine, mainstem and the several important streams flowing into tidewater below the test fishing site also showed marked increases over the brood year escapements. The usual low level of even-year productivity was maintained in the Kispiox and Kitwanga Rivers.

A run of several thousand pinks was counted in streams tributary to the Bulkley above Moricetown falls. The possibility that a significant run may now develop on the Bulkley is viewed with great interest.

(8) Freshwater survival of Skeena River pinks

Estimates of the abundance of spawners and resulting fry have been obtained from several large spawning areas tributary to the Skeena River from 1956 through 1961. These estimates were made to determine the effectiveness of escapements of various sizes, and to assist in developing means of predicting the number of adults which will return from escapements and fry outputs of known size.

Comprehensive measurements of fry abundance were restricted in 1962 to a single stream, the Lakelse River near Terrace. Some additional information on fry output was obtained from the Babine River, and from Shames Slough, a side channel of the Skeena River about 15 miles below Terrace, B. C.

Work on the improvement and evaluation of fry trapping techniques was continued. This study involved both the testing of new gear and further examination of the behaviour of the fry migrants as it is related to the efficiency of the trapping devices.

(a) Egg to fry survival. The average survival rate from egg to fry on the Lakelse River has been determined for the brood years 1959, 1960 and 1961. (1956-1958 fry migrations were indexed but a total output was not obtained). In 1959 and 1960 the average survival was 18.5%. This was similar to the rates observed in other British Columbia streams for those years but was considerably above the long-term average. In 1962 the best estimate was about 4%. Spring water levels and stream velocities were particularly low in 1962 and there is a possibility that some fry avoided the nets. The 4% survival is therefore considered minimal.

In the Babine Lake system, pink salmon spawn almost exclusively in the Lower Babine River. Fry survival at Babine is of particular interest because the spawning area is comparatively remote from the sea - thus contrasting with most pink salmon spawning areas in the Skeena drainage - and because the pink redds are regularly overspawned by a large population of sockeye.

In 1962, small-meshed nets were mounted in 1-ft. square frames and held from the Babine River fence in the path of the migrating fry. These nets were fished from four stations in a randomized series on each of 15 nights during the period April 21-May 30.

By relating the catches to the known cross-sectional area of the water mass at the fence an estimate of the probable output of fry was obtained. From a catch of 14,000, a total fry output of about 30 million was calculated. This indicates a survival of 36% from the 1961 spawning of 70,000 adults. In 1962, 95% of the migration probably occurred between April 25 and May 25 and the peak is estimated to have occurred on about May 10.

The Skeena mainstem usually supports a large population of spawners each year. However, turbid water, and otherwise difficult working conditions, discourage efforts to assess their numbers and spawning success in the open channels. Study of Shames Slough, a side channel, has been used to learn something of the conditions prevailing in the trunk stream.

An estimated 30-40,000 pinks spawned in Shames in 1961. Egg-digging was carried on at monthly intervals during the winter of 1961-62 and, at this time, survival appeared to be poor. Low water at the time of spring breakup permitted fishing most of the slough discharge, but only a few hundred fry were captured and it is believed that nearly all of the fry had died.

Studies in the winter of 1962-63 indicate that survival from the 1962 Shames spawning is again poor, but further effort will be needed to determine if conditions there are representative of those in the open channels.

(b) Method development and evaluation. On the Lakelse River a mechanically driven fry-trapping device was used satisfactorily. A "ladder" of 6" × 12" nets slung vertically between two pontoons was suspended from an overhead pulley system. This gear could be run out to any desired place on the river and the ladder raised and lowered by means of an electrically powered gurdy on the bank. Some improvements in the rate of fishing, and considerably less physical output on the part of the operators, resulted from the use of this installation.

Night-time trapping frequently entails the use of lights either on the river bank or occasionally on the trapping platform while the nets are being emptied. The effects of such lighting upon the distribution of fry was studied.

During the period 22:00 to 00:10 on the night of May 3-4, the trapping platform was fished in mid-stream in alternating 5-minute periods of darkness and of light. The illumination was from a 250-watt flood lamp mounted on the shore about 15 feet above the water. This illuminated the river surface very clearly from bank to bank.

The catches in each of six compartment nets in the vertical ladder from the surface to 6 feet in depth are shown in Table VI.

Table VI. Catches of pink salmon fry during periods of alternating light and darkness, Lakelse River, May 3-4, 1962.

Fishing interval	Lighting	Catch per compartment net						Total catch
		1	2	3	4	5	6	
22:00-22:05	Light	0	2	0	0	1	0	3
22:10-22:15	Dark	1	1	1	0	1	0	4
22:20-22:25	Light	5	3	1	1	2	3	15
22:30-22:35	Dark	9	14	6	2	0	0	31
22:40-22:45	Light	8	26	16	8	7	3	68
22:50-22:55	Dark	12	38	37	16	2	0	105
23:00-23:05	Light	27	31	29	29	29	21	166
23:10-23:15	Dark	24	29	30	26	10	2	121
23:20-23:25	Light	17	17	23	29	19	22	127
00:05-00:10	Dark	36	47	46	32	17	0	178
Totals	Light	57	79	69	67	58	49	379
	Dark	82	129	120	76	30	2	439
Totals	Light & dark	139	308	189	143	88	51	818

The sum of catches in five lighted and five dark periods was 379 and 439 fish respectively. The migration rate was increasing while these catches were being made so the totals do not accurately reflect different susceptibility to capture during lighted and unlighted periods. However, the sum of catches in the three uppermost compartments (net numbers 5 and 6) were 174 and 108 fish respectively. Thus about 46% of the fish were in the top half of the water column during lighted periods but only 25% were there during dark periods. The discrepancy is particularly strong in the surface net and in the later fishing periods when natural light was at a minimum.

This experiment demonstrates the need for care in the use of artificial light while fry trapping. The sum of catches may not differ radically during light and dark periods but the vertical distribution of the catches does.

(9) Lake Sockeye Studies

In 1962 the major field effort was again concentrated on the investigation of the smolt migration through the lake to the outlet. This study was carried out jointly with C. Groot of the experimental biology investigation. Routine sampling of young sockeye and of zooplankton was carried out throughout the lake system and Dr. Patalas of Poland continued a detailed study of zooplankton during the mid-June to mid-August period. In addition, initial testing of sampling gear for spawning grounds was carried out in preparation for future investigation of the egg-to-fry stage in the life of sockeye; and, also looking toward this new field of investigation, Dr. Jonasson of Denmark, a specialist in the bottom fauna, participated on a consultation basis in a preliminary look at the spawning ground environment.

Studies of the smolt migration in the Babine Lake system

An extensive program of tagging and recapture of smolts at various points throughout the lake, transplantation of tagged smolts to various parts of the system (Fig. 15), and aerial observations expanded the findings of the previous two years (now in press for the forthcoming volume of the Journal of the Fisheries Research Board of Canada). The 1962 findings generally confirm the conclusions of earlier work. More fishing and thus greater tag recovery at the uplake sites in 1962 showed that smolts from more remote parts of the system are slower in migrating over the more complex legs of their routes from uplake points to Halifax Narrows than from there to the outlet. This was evident for both normal migrating smolts and for transplanted smolts. In all cases, speed of migration increased with time as the run progressed as shown in the previous years. Speed of tagged smolts from Sandspit was faster than from the Morrison River where a complete change in direction is involved. Also, smolts transplanted to uplake points where a complete change in direction was required in reaching the outlet showed slower rates of speed than those transplanted to points in the main uplake basins.

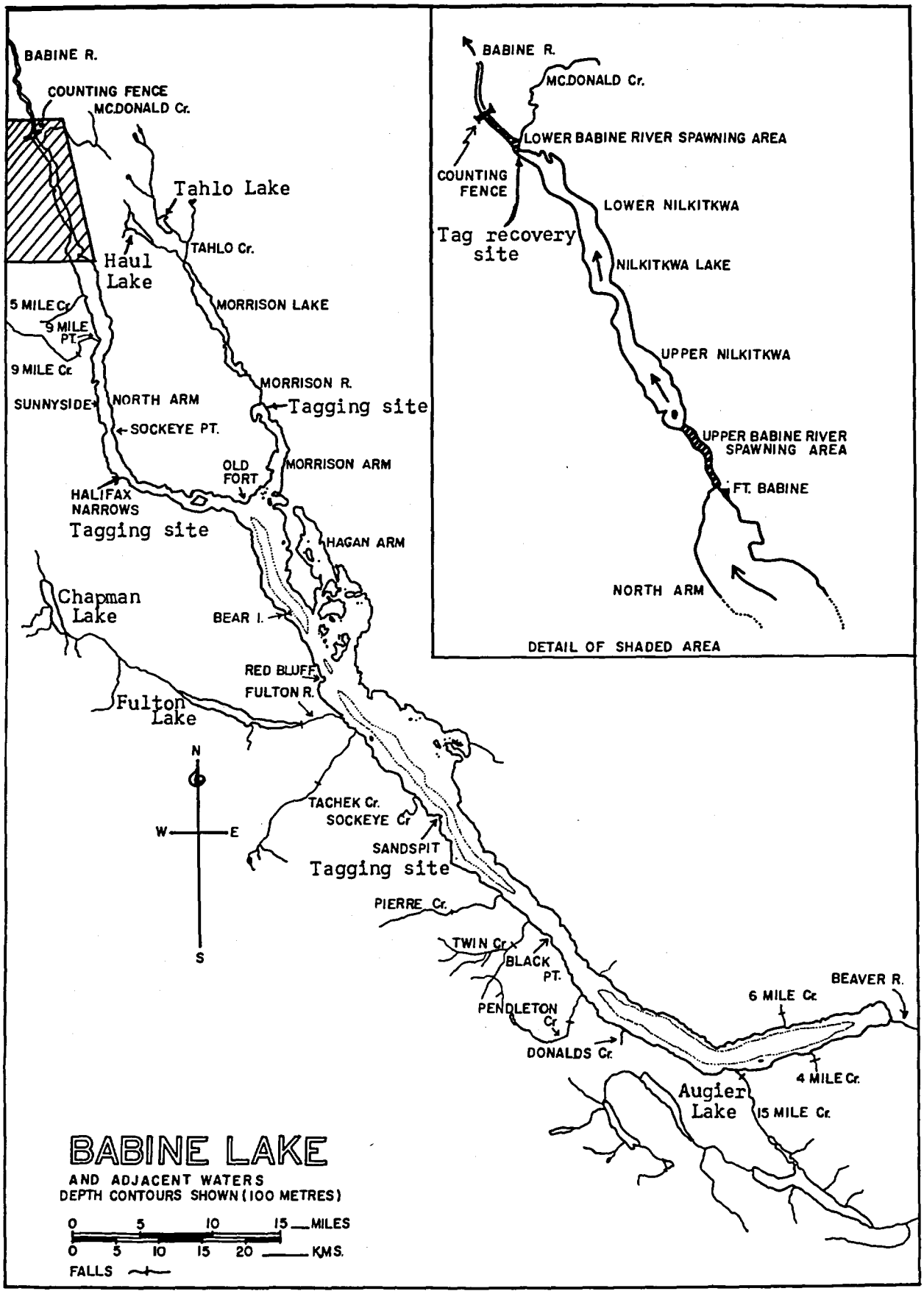


Figure 15. Map of Babine Lake and adjacent waters.

Smolts captured and tagged at Halifax Narrows and Nilkitkwa Lake were transplanted by aircraft to various points in the system including Morrison Arm, Hagan Arm, Bear Island, Sandspit, head of Babine Lake, Haul Lake, Tahlo Lake and Augier Lake. No recoveries were made of the smolts transplanted to Haul Lake or Augier Lake; however, this seems explicable by the fact that the small outlet stream of Haul Lake was found to be effectively blocked by a large number of beaver dams, and the transplant to Augier Lake (115 miles uplake from the outlet by the shortest route) was made too late in the season to permit any recoveries from this great distance before fishing at the recovery sites was discontinued. A good number of recoveries of all the other transplants were made both at Halifax Narrows and Nilkitkwa Lake. This successful emigration of transplanted smolts suggests that the mechanism of one-direction and shifting one-direction orientation postulated as the means whereby smolts find the lake outlet is not a rigid mechanism determining successful out-migration.

Observations from a slow, low-flying aircraft gave a good gross picture of distribution of migrating schools. The schools were sometimes found to be quite randomly distributed over a basin, and at other times more concentrated to one shore or the other. In the latter cases, the concentration was usually toward the downwind shore, probably indicating drift due to wind-induced circulation similar to the wind drift that has been shown for migrating birds. This is seen as a ready explanation of slower movement in areas uplake from Halifax Narrows where such wind-induced drift could easily shift smolts migrating in a single direction off into one of the arms not leading directly to the outlet. The recovery of some smolts tagged and released at Sandspit at the head of Morrison Arm verified the existence of such mistakes in taking the proper route.

For previous years' data, a positive correlation between mean hours of sunlight (as indicative of degree of cloudiness) and mean speed of tagged smolts gave evidence of the probable importance of celestial phenomena in orientation. The 1962 data offer only weak support of such a relationship.

Underyearling sockeye in Babine Lake and their environment

The 1962 populations of age-0 sockeye were progeny of the large 1961 escapement of 941,711 large sockeye as counted through the Babine fence. Of these spawners, approximately 280,000 were estimated on the spawning grounds south of Halifax Narrows and an estimated 400,000+ to 600,000+ spawned on the outlet spawning grounds. In late August, 1962, there were an estimated 51 million age-0 sockeye in the lake regions north of Halifax Narrows and 38 million south of this narrows, a total of 89 million for Nilkitkwa and Babine Lakes (Table VII). Of the 51 million estimated for the North Arm and Nilkitkwa Lake, Nilkitkwa Lake was estimated to have 42.3 million, or 83%. This appears unusually high since the proportion of fish north of Halifax Narrows contained in Nilkitkwa in previous years has averaged 30% and ranged from 21% to 48%. Also, the estimated density in Nilkitkwa Lake was almost double the highest previously recorded, yet their growth rate, although slow, was not as slow as would be expected for the density estimated. For these reasons it is felt that the 51 million estimated may be an overestimate. The total estimate of 89 million for the system is very small considering the large parent spawning escapement. Abundance was low

Table VII. Numbers of spawning adults and resultant age-0 sockeye in the Babine Lake system.

	Estimated number of spawning adult sockeye (excluding "jacks") (thousands)	Estimated number of age-0 sockeye in late August (millions)
	1955	1956
North of Halifax Narrows	19	2
South of Halifax Narrows	28	11
Total	47	13
	1956	1957
North of Halifax Narrows	120	29
South of Halifax Narrows	149	75
Total	269	104
	1957	1958
North of Halifax Narrows	188	40
South of Halifax Narrows	203	68
Total	391	108
	1958	1959
North of Halifax Narrows	270+	83
South of Halifax Narrows	290+	106
Total	560+	189
	1959	1960
North of Halifax Narrows	290+	37
South of Halifax Narrows	300+	59
Total	590+	96
	1960	1961
North of Halifax Narrows	103	23
South of Halifax Narrows	160	39
Total	263	62
	1961	1962
North of Halifax Narrows	400+ to 600+	51
South of Halifax Narrows	280	38
Total	680+ to 880+	89

throughout the period of sampling in the lake, suggesting that the poor survival had occurred earlier during the egg to fry stage. If indeed the Nilkitkwa population was overestimated, survival on the outlet spawning grounds appears especially poor.

The general effect of the extreme late advent of summer was evident in a number of ways. The lake system was not free of ice until May 21. The fry appeared to be later than usual in entering the lake. Lake water temperatures were unusually low until late June and the early summer pulse of zooplankton was similarly about three weeks late in appearing. This lateness of the season and corresponding shortening of the length of the growing season was reflected in the seasonal growth pattern of the young sockeye and the seasonal abundance of the zooplankton. The poor distribution of fry from the outlet Babine River spawning grounds into the North Arm region may also be related to the very late spring and unusually low water levels in the outlet at the time of fry emergence.

Generally the 1962 findings did not contradict the earlier conclusions regarding the ecology of young sockeye during their lake life, but helped greatly in better understanding the overall climatic effect. One paper, "Quantitative aspects of the pelagic entomostracan zooplankton of the Babine Lake system over a 6-year period", is now in press (Vol. XV, Proceedings of the International Association of Theoretical and Applied Limnology). Four other manuscripts treating results of the past seven years investigation of the lake life of sockeye at Babine are in preparation for publication: three treating separately the growth, mortality and production of young sockeye, and one the zooplankton of Babine Lake.

Dr. Patalas of Poland continued his detailed studies of the zooplankton of Babine Lake during the mid-June to mid-August period and results are now in preparation for publication.

(10) Nanika River sockeye salmon rehabilitation program

During the period 1945-53 the annual sockeye escapement to the Nanika River varied between 24,000 and 70,000, with an average of 49,500 for the period. Commencing in 1954, however, this run underwent a serious decline and the annual escapements recorded since then have been in the range of 1,000-6,000.

Rehabilitation by protective regulation in the commercial fishery, with a view to increasing the spawning escapements to the Nanika, proved to be impractical inasmuch as the Nanika sockeye migrate through the Skeena River fishery at the same time as the early and middle Babine runs. It was concluded therefore that the adult escapement could be increased best by improving the production of juveniles; and a study of the various alternatives culminated with the recommendation that the run be rehabilitated through the implementation of artificial propagation measures utilizing a hatchery.

The Nanika River rehabilitation program was initiated in 1960 when a new hatchery, constructed on the right bank of the Nanika one mile upstream from Morice Lake, was brought into partial operation. This hatchery, which embodies many of the latest fish cultural techniques, was brought into full service for

the first time in 1962. A brief description of its most significant features is set out hereunder.

(a) Electrical power to fulfill all hatchery requirements is provided by two 15 kw diesel-driven generators, only one of which is operating at a time, the other being for standby in the event of a mechanical breakdown of the operating unit.

(b) The water demands of the hatchery are fulfilled by a conventional pump-and-tank arrangement. Water is drawn directly from the Nanika River by an electrically-driven pump (max. capacity of one cfs), which feeds a 10,000-gallon elevated storage tank. Water is delivered from this tank, as required, by gravity flow. The pumps and water lines have been duplicated in an attempt to virtually eliminate the threat of losses occurring as a result of mechanical, or other failures.

(c) The hatchery employs the vertical-stack incubation principle in which a series of 20 incubation baskets, each containing from 10,000-15,000 sockeye eggs, are stacked one above the other so that water delivered at the top of the stack must circulate through each tray before passing to the one underneath. The advantages of the vertical-stack incubators are clearly evident in the economies they effect in water usage and floor space, as each stack requires only four feet of floor space and a flow of only 3-6 gpm to incubate up to 300,000 sockeye eggs to the late alevin stage. The hatchery has been designed for 50 stacks of incubator trays, and full utilization of these gives it a capacity between 10 and 15 million eggs.

Eggs for the hatchery are flown in from Fifteen-Mile Creek, a tributary of Babine Lake, where they are obtained by seining and stripping sockeye on the spawning grounds. The entire transfer operation, from egg-taking to unloading at the hatchery, is effected in less than 10 hours.

Fungus growth during the incubation stage is controlled in the hatchery by the twice-weekly application of Malachite green at a concentration of 1:200,000 for a period of one hour. This treatment is discontinued when hatching commences. Each tray of eggs is "picked" at least once during the eyed stage.

Before yolk absorption is complete the alevins are transferred from the incubation trays to a "fry release tank" which consists of a 14-foot diameter, 10,000-gallon woodstave tank, where they are placed in 12 individual pie-shaped pens. These pens, which are four feet deep, are suspended so that their screen floors are approximately 3-1/2 feet below the water surface in the tank. Water delivered at the base of the tank wells up gently to the surface and is discharged via 12 surface outlets which also serve as the fry exits from the pens. Water discharging from these outlets passes into a common trough, which rings the outside of the tank, before emptying into a pipe leading to the river. As the fry reach the migrant stage they are permitted to leave the tank from whence they are conveyed to the river by the trough-and-pipe arrangement. Although fry

release is restricted to the night hours the tank is completely enclosed in order to provide continual darkness.

The 1960-61 hatchery operation was restricted to a small-scale "pilot plant" in order to test the equipment and operating conditions during the severe winters. Several defects and deficiencies detected thereby were immediately corrected, and the hatchery was then operated at half-capacity in 1961-62. Full capacity was achieved for the first time in 1962. The following table summarizes the pertinent details with respect to the hatchery operation to date.

Year	Number of eggs received	Number of fry released	Percent survival egg to fry
1960-61	315,000	74,000	23.5
1961-62	5,200,000	3,800,000 (preliminary estimate)	73
1962-63	11,400,000		

In order to assess the effectiveness of the hatchery operation a long-range program involving comprehensive studies of the juvenile and adult migrations was initiated in 1961.

In 1961 and 1962 the sockeye escapement to the Bulkley system was enumerated at Moricetown Falls, and that portion which migrated to the Nanika was estimated on the basis of live and dead counts on the spawning grounds. Substantial numbers of mature and spawned-out sockeye were also observed on a series of alluvial fans along ten miles of the shoreline near the south end of Morice Lake, and mature sockeye were taken by nets in the Atna River system; but when it proved to be extremely difficult to obtain accurate estimates of these populations by direct means, an indirect approach, which assigned all of the unaccounted for escapement to the Morice and Atna system, was employed to develop the following estimate of the spawning distribution.

Year	Total escapement Moricetown	Nanika	Upper Bulkley	Morice & Atna
1961	14,000	5,000	..	9,000
1962	8,500	3,500	400	4,600

The sockeye migration at Moricetown Falls continues through the months of July and August with the peak occurring about the end of July. The peak of spawning activity in the Nanika River occurs in late September, approximately 10-15 days later than that in Fifteen-Mile Creek, the hatchery donor stream.

The mean fork lengths of female and large male sockeye sampled at Moricetown Falls measured 57.3 cm and 60.7 cm respectively in 1961, and 58.2 cm and 62.1 cm in 1962. These fall within the range of the mean lengths recorded in the period 1949-61 at the Babine counting fence, through which the Fifteen-Mile Creek spawning population would have passed.

Studies to determine the age composition of the Bulkley-Morice sockeye stocks were undertaken at Moricetown Falls in 1961 and 1962 with the following results, which are expressed as percentages.

Year	No. samples	Age						
		3_2	4_2	5_2	4_3	5_3	6_3	6_4
1961	211	..	5.2	1.9	0.5	74.4	17.1	1.0
1962	219	0.5	6.4	11.0	1.8	48.4	31.1	0.9

A downstream sampling program employing equipment which permitted sampling at any point in the river cross-section was conducted on the Nanika River in the spring of 1962 in order to measure the fry output from the 1961 spawning. Fry migration continued throughout the sampling period May 31 to July 16 with the peak occurring on June 25. In this connection it is interesting to note that the fry emigration from the hatchery release tank coincided closely with that from the natural spawning. The mean length of the fry from the hatchery was only 23.0 mm and 26.1 mm in 1961 and 1962 respectively, while those of the natural fry were 27.7 mm and 30.8 mm.

The total natural output of sockeye fry from the Nanika River in 1962 has been computed at 8.5 million, and an additional 3.8 million were contributed from the hatchery. While the native fry were the product of the largest spawning escapement since 1956 the calculated egg-to-fry survival rate is sufficiently high to give rise to the suspicion that the 1961 escapement was greater than previously estimated.

The Nanika River sockeye fry rear in Morice Lake for one or more years before migrating to sea as smolts. In the years 1961 and 1962, the smolt migration from the lake has therefore been sampled with a view to determining its magnitude and timing. The migration was in progress throughout the period April 28 to June 24 in each year with the peak occurring between May 10 and June 3 in both years. Computations based on the smolt-sampling program revealed that the 1961 migration was composed of 59.5 percent Age 1 (Sub 2) fish and 40.5 percent Age 2 (Sub 3) fish, while the corresponding results in 1962 were 31.7 and 68.3 percent, respectively. The mean weights and lengths of the samples taken in both years are set forth in the following table.

Year	Mean length in mm		Mean weight in grams	
	Age 1	Age 2	Age 1	Age 2
1961	76.2	98.6	3.43	7.39
1962	75.0	98.4	3.72	8.10

A tow-netting program was initiated in 1961 to measure the relative abundance and distribution of juvenile sockeye in Morice Lake; and during the same year a limnological study, embracing the collection of temperature data, secchi-disc records, and the relative densities of zooplankton, was also initiated.

(11) Proposed hydroelectric development on the Bulkley River

In January, 1961, the B.C. Power Commission announced plans to develop hydroelectric power on the Bulkley-Morice River system, tributary to the Skeena River. The initial stage of the development included construction of a 75-foot power dam on the Bulkley River at Moricetown, this to be followed in a second stage by construction of a storage dam on the Morice River near the outlet of Morice Lake which would raise the lake level approximately 20 feet. To date, however, no start has been made on the power development, nor are there any known plans for an early start. Nevertheless, Departmental studies, as outlined hereunder, are proceeding with a view to defining the scope of the various fisheries problems posed by the power development should it be proceeded with. The data so obtained will be most useful regardless of whether or not the power project becomes a reality.

In 1961 and 1962, biological studies carried out on the Bulkley River system defined the fisheries problems associated with the proposed hydroelectric development. In 1961, a tagging program conducted at Moricetown Falls, and a survey of the spawning grounds, provided details in connection with the magnitude and timing of the salmon migrations, and their distribution within the system. A similar survey in 1962 was restricted to sockeye salmon. The 1961 and 1962 sockeye smolt migration from the Nanika River were studied to provide details on their magnitude and timing.

The following table sets forth the pertinent details with respect to the results obtained from the tagging program and fishway counts at Moricetown.

Species	Number tagged		Tags recovered in fishways		Fishway counts		Peak migration period (1961)
	1961	1962	1961	1962	1961	1962	
Sockeye	1,132	242	324	19	5,423	946	Jul. 27-Aug. 5
Pinks	1,343	..	472	..	8,531	88	Aug. 4-21
Coho	288	51	78	12	7,226	4,037	Aug. 10-24
Springs	417	148	20	10	916	1,169	Jul. 25-Aug. 4
Steelhead	150	17	9	..	792	207	Aug. 17-31
Total	3,330	458	903	41	22,888	6,847	

On the basis of fishway counts and recovery of tags the calculations reveal that the following numbers of adults reached Moricetown.

Species	Calculated number of fish	
	1961	1962
Sockeye	18,043	9,908
Pinks	23,964	..
Coho	26,310	..

Although the 1962 sockeye escapement to Moricetown was calculated on the basis of only limited recovery data from the fishways, it is considered to represent a good measure of the sockeye population level at that point inasmuch as the Indian fishery records and spawning ground surveys were also considered.

The catch of the important Moricetown Falls Indian food fishery, as recorded in the weekly reports submitted by the local Fishery Guardian, is presented by species for the years 1956-62 in the following table.

Year	Sockeye	Chinook	Coho	Pink	Chum	Steelhead	Total
1956	1,429	3,200	1,617	..	..	296	6,542
1957	175	2,440	461	..	..	52	3,128
1958	165	2,874	244	4	..	112	3,399
1959	624	2,508	1,258	1,021	..	343	5,754
1960			Data not available				
1961	2,092	2,498	1,157	1,178	..	614	7,539
1962	645	2,163	1,362	500	40	405	5,115

Observations at Moricetown Falls confirm that the native fishermen, employing gaffs, seriously injure large numbers of sockeye salmon. It is estimated conservatively that there are at least as many fish injured and lost as there are actually caught. That the majority of these estimated losses represent an actual loss to the stock is borne out by the fact that virtually no injured sockeye salmon have been observed on the spawning grounds, and that very few even pass through the fishways.

The estimate of escapement above Moricetown Falls, as determined by making allowances for the catch of the Indian fishery and the estimated minimum losses from injuries, is set forth in the following table.

	Escapement above Moricetown	
Species	1961	1962
Sockeye	14,000	8,500
Pink	21,500	..
Coho	24,000	..

When it was found that there were too few fish available for a tagging and recovery program on the Nanika River, live and dead counts were made on the spawning grounds during September and October. On the basis of these counts the Nanika River sockeye escapement has been estimated at 5,000 in 1961 and 3,500 in 1962. In the light of the calculated 1962 output of 8.5 million fry the 1961 adult estimate appears to be low. The 1962 adult estimate which was made under better observation conditions, is considered to be more accurate.

The existence of a significant sockeye salmon spawning population in Morice Lake was confirmed in 1961 and reconfirmed in 1962 when mature sockeye salmon were caught in gill-nets at 17 sites along the lake shore. While sockeye were caught throughout the lake the greatest concentrations were found over an area of alluvial fans situated along ten miles of shoreline near its south end.

The discovery of juvenile salmon in the Atna River during the summer of 1961 prompted an examination of that system during the spawning season. The fact that mature sockeye were captured by gill-nets in Atna Lake in both 1961 and 1962 proved that a falls below the lake was not totally impassable, as had previously been reported.

In 1961, the water levels of the upper Bulkley River were too low to permit the entry of salmon during the sockeye migration period. In 1962, however, the local Fishery Officer reported an escapement of 400 sockeye salmon to Maxan Lake, which is situated in the headwaters.

Although no major concentrations of spawning pink salmon were located in 1961, scattered groups were observed throughout the lower Morice River and in the Bulkley River near the Morice confluence. A few were reported to have ascended the Morice River for as far as 20 miles. No spawning ground surveys were conducted in this area in 1962.

On the basis of visual observation made from fixed-wing aircraft and helicopter, it is estimated that 2,000 to 5,000 chinook salmon spawned in the upper ten miles of the Morice River in 1961. This area was not examined in 1962. A small number of chinook salmon have been observed in the upper Bulkley River and several specimens have been taken from sampling gill-nets in Morice Lake.

While the surveys terminated before the start of coho spawning, migrants of this species were observed in the Bulkley, Morice, and Nanika Rivers, and some were captured in nets at several sites near the shore of Morice Lake. It is probable that this species utilizes all of the accessible streams in the Bulkley-Morice watershed.

Steelhead trout have been observed throughout the Morice River and several which were tagged at Moricetown Falls have been recovered by anglers in the Morice River.

Temperature records were obtained at Moricetown Falls and from the Morice, Nanika, and Atna Rivers in both 1961 and 1962. In addition, vertical temperature series were recorded at four stations on Morice Lake during both years. These data are not available for presentation at this time.

(12) Proposed hydroelectric development on Fulton River

Early in 1961, the B. C. Power Commission announced plans for a hydroelectric development on the Fulton River, which would consist of a dam at the outlet of Fulton Lake, a power-house located some distance downstream at the base of the falls, and an inter-connecting tunnel and penstock. Although the entire development would be located above the upstream limit of salmon migration, its possible effects on the lower reaches of the river required that all relevant factors be assessed to ensure that the fisheries interests could be adequately protected. To date this project has not yet been initiated and there is a possibility that it has been abandoned. Nevertheless Departmental studies, as outlined in the following, are proceeding unabated. The data so obtained will be most valuable from the fisheries viewpoint whether or not the power project is undertaken.

The Fulton River constitutes the most valuable sockeye salmon spawning area tributary to the main basin of Babine Lake. During the years 1953-60 the sockeye salmon escapement to this river, as estimated by the local Fishery Officers, have ranged from 17,000 to 140,000, with an annual average of 90,000.

In August of 1961, a study was initiated to determine the magnitude, timing, and distribution of the sockeye salmon spawning escapement. This study included a tagging program located near the mouth of the river and an extensive dead-recovery program on the spawning grounds. The spawning population was also sampled for size, composition, egg content, and success of spawning.

A downstream-sampling program, employing equipment which permitted vertical and horizontal sampling within a cross-section of the stream, was conducted on

the Fulton River during May and June of 1962, to measure the fry output from the 1961 spawning, and to define the period of downstream migration.

Temperature records were taken during the months of salmon migration at stations located at Fulton River and Fulton Lake.

A summary of the tagging and recovery data, and the calculated adult escapement, fry output, and egg-to-fry survival are presented hereunder.

Adult	Number tagged	7,185
	Number of tags recovered	3,590
	Number of dead recovered	98,527
	Calculated number of fish	189,049
	Calculated egg deposition	237,705,770
Fry	Calculated number of fry	25,323,613
	Percent egg-to-fry survival	10.7

The sex ratio of the 1961 adult escapement has been calculated at 45.2 percent females, 44.6 percent large males, and 10.2 percent jacks.

A few adult sockeye were present on the spawning grounds when the study was initiated on August 11, but no significant numbers appeared until August 24. The peak period of entry to the river was August 30 to September 15 and spawning reached a peak during the last two weeks of September.

The sockeye fry migration which had just begun when the downstream studies were initiated on May 2, was still in progress when sampling was terminated on June 21, but the bulk of the migration had occurred between May 15 and June 15, with May 29 being the calculated peak night.

Fry migration at the sampling site was restricted almost entirely to the hours of darkness, with the nightly peak consistently occurring between 11:00 p.m. and 1:00 a.m., P.S.T.

An impassable falls, approximately four miles from the mouth of the Fulton River, constitutes the upstream limit of salmon migration. With the exception of a few salmon which utilized the area immediately below the falls, spawning was confined, primarily, to those reaches lying between the lower one-third mile and the upper one-half mile of the river.

In 1961, water temperatures were recorded at two sites: one near the outlet of Fulton Lake and the other at the downstream end of the spawning grounds. In 1962, temperatures were recorded at the lower site only. While temperatures in excess of 70°F were recorded at the beginning of adult migration the daily mean temperatures at the downstream site, during the peak period of migration and spawning, ranged between 47.5° and 61.0°F. During the 1962 fry migration the daily mean temperatures recorded at the lower site ranged from 39.3° to 54.5°F.

During July and August of 1961, temperatures above the falls were consistently lower than those at the downstream site, with the maximum recorded increase of daily mean temperature between the two sites being 4.7°F which occurred on

August 14. During September and October the situation was reversed.

Vertical temperatures were recorded at Fulton Lake during the period June to October of 1961. A thermocline which was first noted on July 23 at a depth of 12 feet, was situated at approximately the same depth on August 22, but by September 18 it had descended to 39 feet. By October 16 the lake had approached an isothermal condition.

A comparison of temperatures in the lake and river on July 23 and on August 22, indicate that the river was drawing, in part, from within the thermocline; and it was concluded from this that a surface spill over the proposed dam at the lake outlet could cause dangerous temperature increases on the spawning grounds.

(13) Babine Lake salmon development program

Studies undertaken by the Fisheries Research Board of Canada have shown that the smolt production from Babine Lake currently represents only one-third of the lake's estimated productive potential; and in view of these findings it would seem that the lake could sustain a fry input some 300 percent greater than that which now occurs. Accordingly, the Department of Fisheries and the Fisheries Research Board, at the direction of the Skeena River Management Committee, have initiated studies looking to determining the most suitable means by which the full potential of the Babine system might be realized.

Sixteen streams tributary to Babine Lake currently provide spawning grounds for 300,000 to 500,000 sockeye, but one-third of this area is of only sporadic value from the production viewpoint because of unstable flow regimens. Furthermore the commercial fishing operations at the mouth of the Skeena River are regulated in accordance with the recommendations of the Skeena River Management Committee to ensure that the spawning escapements are of a magnitude which will fully utilize these available spawning areas. In view of these considerations preliminary assessments determined that improvement and extension of the existing spawning grounds, looking to increasing the fry input to the lake, constituted the most reasonable approach to developing the full potential of the Babine Lake rearing area. Engineering and biological surveys have therefore been initiated with a view to formulating a program of development which would achieve this objective.

Surveys undertaken to date have revealed that three spawning streams (Morrison River, Fulton River, and Fifteen Mile or Pinkut Creek), by virtue of their lake-fed water supplies and relatively stable conditions, warrant serious consideration for intensive development. These streams accommodate the largest existing spawning runs to the system and their geographical locations are such that each contributes its fry output to one of the three major rearing basins in Babine Lake. Grizzly Creek, a tributary of Sutherland River at the south end of Babine Lake, is also receiving consideration for possible development because of its strategic location and its lake-fed water supply. Its priority, however, would be lower than the other three in view of its relative isolation and its smaller potential.

The Morrison River, which serves as a spawning ground and as a waterway to spawning grounds upstream, is frequently obstructed by beaver dams. The stream bed, which is composed of boulders, bedrock, and some gravel, can accommodate an estimated maximum of 30,000 spawning sockeye. Preliminary results of the surveys indicate that development of this stream should be directed first to the access problem, after which attention should be centred on improvement of the spawning grounds, and possibly to the implementation of flow regulation measures.

The Fulton River which is accessible for a distance of four miles, one-quarter of which is canyon, is currently undergoing a special productivity study. The 1961 spawning run of 189,000 sockeye, which is considered to be its current capacity, represented a potential deposition of 237.7 million eggs. Fry output in 1962 was 25.74 million for a computed egg-to-fry survival of 10.8 percent. The 1962 spawning run which consisted of 86,000 sockeye represented a potential egg deposition of 137 million. Fry output and the egg-to-fry survival rate will be determined in 1963. Some spawning ground improvements could be effected in parts of the presently used areas.

A float survey, conducted in 1962, determined that there were 159,400 square yards of suitable spawning gravel in a 16-mile reach of the river upstream from a falls which now constitutes the upstream limit of salmon migration. As this upper area constitutes an area as extensive as that now being utilized, engineering surveys are being considered to determine the physical and economic feasibility of implementing measures to allow fish to surmount the 60-foot falls.

Fifteen-Mile Creek, which is accessible to salmon for a distance of less than one mile, constitutes a productive spawning area with an estimated capacity for 20,000 sockeye. While it may be that the spawning potential of this stream in the upper areas is not large the extensive flats located near the river mouth suggest that it might be a practical undertaking to construct a spawning channel or hatchery for purposes of supplementing the natural production.

While these investigations will be continued in more detail, preliminary results indicate that it might be possible to improve fry production by a program of intensive development of three, and possibly four, strategically-located spawning areas.