1961

SKEENA SALMON MANAGEMENT COMMITTEE

ANNUAL REPORT 1961

COMMITTEE MEMBERS

W.R. Hourston

A.W.H. Needler

IN CHARGE OF INVESTIGATIONS

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ADVISORY BOARD MEMBERS

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J.R. Daniels

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Biological Station
Nanaimo, B. C.
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Terms of Reference

The Skeena Salmon Management Committee, upon its appointment by the Minister of Fisheries late in 1954, was directed to investigate the condition of Skeena River salmon stocks, to improve management of the runs, and increase the yields where 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.

Mr. A. J. Whitmore, past 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, were appointed members of the Committee upon its formation. Mr. Whitmore, upon his retirement in 1960, was replaced by Mr. W. R. Hourston, present Director for the Pacific Area.

After 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 recommendations for regulation of the fishery. Advisory Board members for the year 1961 are listed on the front page of this report.

Record of Meetings

The Committee met at Vancouver on November 18, 1960, to examine the available evidence concerning the likely abundance of the 1961 Skeena sockeye and pink runs, and discuss appropriate regulation.

The Committee noted that the 1961 sockeye run would be composed of 4-year-old fish from the 1957 spawning and 5-year-olds from the 1956 spawning. The progeny of the 1956 spawning returned poorly as 4's (278,000). It was expected, therefore, that more fish from the brood would return as 5's, probably 500,000. The 1957 spawning was moderate in size but well distributed over the spawning grounds and produced a large run of smolts (38,000,000). With average conditions, a total return of 4's well in excess of 500,000 could be expected in 1961. In the past, however, when the jacks (3-year-olds) had been of small size, fish returning as 4's and 5's in the succeeding two years had been less abundant than anticipated and more tended to return as 5's than as 4's. Presumably, these findings reflected mainly the effect of poor growth and survival in the ocean. The 1960 jacks were small and it was therefore likely that the return of 4's in 1961 would be less than would otherwise be expected. On this basis, the return of 4's in 1961 was expected to amount to about 400,000. When small numbers of fish of other ages were included, the anticipated total return of Skeena sockeye in 1961 was 1,000,000.

The 1961 pink run would return from a relatively large escapement of nearly 1,500,000 in 1959. The survival from egg to fry following this spawning appeared to be good. For past odd-numbered years the return averaged about 2.4 times the number of spawners. Assuming that the young from the 1959 spawning encountered average ocean conditions, the most likely return would be 3,600,000. It was noted that this number would support a substantial fishery.

On the basis of the above forecast, the Committee released on November 28, 1960, a statement containing proposals for regulation of the 1961 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 18, 1961, only gill-nets 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 gill-nets of any mesh size be permitted after 6:00 p.m. Sunday, June 18, 1961, until the end of the fishing season, as follows:

(i) From June 18 to July 23 - 106-hour weekly closed time 8:00 a.m. Wednesday to 6:00 p.m. Sunday;

(ii) From July 23 to August 20 - 96-hour weekly closed time, from 6:00 p.m. Wednesday to 6:00 p.m. Sunday;

(iii) From August 20 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:

<u>Area 3, Nass River - Sub Areas 3X and 3Y only</u>

(i) Same weekly closed times as in (c) above from July 9, 1961, to August 20, 1961.

<u>Salmon Purse Seine Area No. 5 - Beaver Passage and Ogden Channel only</u>

(i) Same weekly closed times as in (c) above from July 23, 1961, to August 20, 1961.

(e) Provisoes:

(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, 1961, and held a public meeting in Prince Rupert on January 25, 1961. A further public meeting of the Committee and the Advisory Board was held on February 2, 1961, in Vancouver. The 1960 Skeena salmon runs and the results of investigations were reviewed at these meetings. All available information regarding the expected size of the 1961 sockeye and pink runs was presented and the 1961 regulations proposed in the Committee's release of November 28, 1960, were discussed.

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

At the meetings with its Advisory Board, the Committee pointed out that in proposing regulations for 1961, it had, as in 1960, considered the hardships faced by the industry generally in recent years. The anticipated 1961 run of sockeye was 1,000,000 and the proposed regulations would permit a catch of approximately one-half this number. This catch would allow an escapement substantially below that considered necessary for best use of the spawning grounds. In the case of pink salmon, the Committee noted that the regulations proposed would result in an escapement below the size which maintained pink salmon production at its early high level.

The Committee referred to its attempt since 1956 to provide additional protection to the "early" sockeye runs which spawn in streams tributary to the under-utilized main basin of Babine Lake. This added protection has resulted generally in increased escapements to this area as well as to several other relatively small sockeye lakes in the Skeena system. The size of the escapements in 1956 and 1957 indicates that the return in 1961 would probably be large enough to warrant a limited fishery. The Committee, therefore, proposed that limited fishing for sockeye begin on June 18, 1961, thereby providing for the taking of that portion of these early runs not required for reproduction.

Several alternate proposals for regulation were received from Advisory Board members, individuals, and organizations. These involved relaxation of the weekly closed times and postponement of the opening of sockeye fishing.

The Committee gave full consideration to these alternative proposals at a meeting held in Vancouver on February 8, 1961. Having regard for the requirements for rehabilitation and maintenance of Skeena stocks, the Committee concluded that changes in the regulations originally proposed in its November, 1961, release were not warranted. It noted, however, that weekly closed times would be modified on the basis of the actual sizes of the runs as they developed.

A meeting of the Committee with members of the Kitwanga and Kitwancool bands was held at Kitwanga, B. C., on May 30, 1961. Views regarding the commercial and Indian food fishery and the Committee's operations in the area were received by the Committee at this meeting.

At the conclusion of the 1961 season, the Committee met at Vancouver on December 12, 1961, to examine the 1961 stocks and the effect of the regulations recommended by the Committee. The pertinent information is presented in the following section.

The 1961 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 the following table:

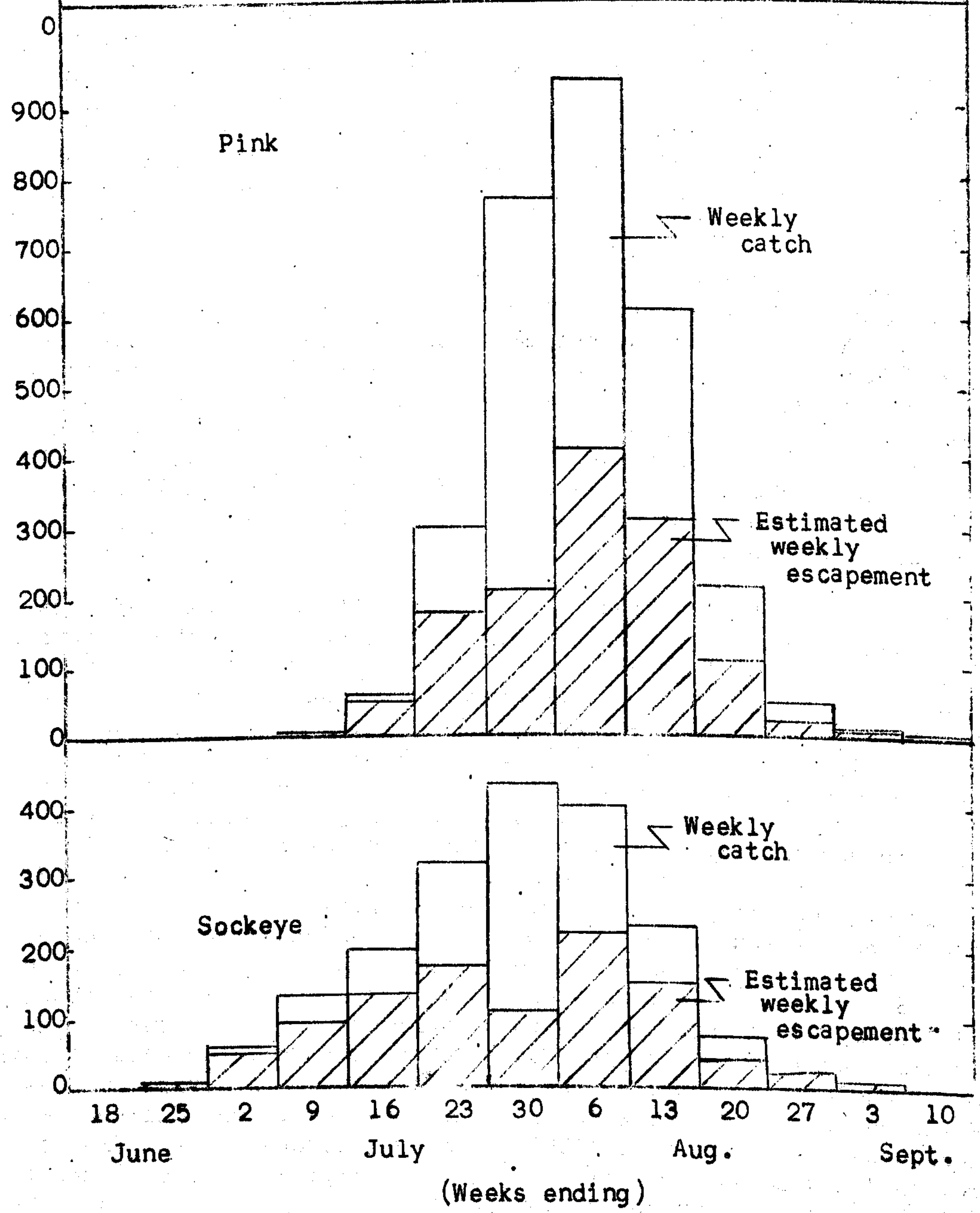
Week Ending		Sockeye	Spring	Pink	Coho	Chum
May	6		34			
	13		18			
	20		59			
	27		106			
June	3	4	390			
	10	33	446			
	17	80	1,045			3
	24	6,464	616	4	46	147
July	1	13,318	874	87	374	333
	8	36,577	1,549	879	261	1,275
	15	59,342	2,609	10,975	915	749
	22	147,502	1,419	74,982	952	903
	29	323,047	1,628	366,103	3,598	2,732
August	5	187,585	450	288,673	4,624	3,332
	12	81,528	138	189,947	6,858	5,656
	19	32,145	116	77,961	5,931	4,773
	26	5,631	51	25,121	4,281	3,048
September	2	1,194	19	5,728	5,515	2,145
	9	214	9	737	2,067	702
	16	33	3	93	1,849	457
Totals		894,697	11,579	1,041,290	37,271	26,255

As fishing progressed it became evident that the sockeye run was larger than expected. This better-than-expected run resulted from a large return of 4-year-olds (1,460,000) from the 1957 spawning. The return of 5-year-olds amounted to 330,000 and was less than expected. 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 of pink and sockeye (catch plus escapement). The early run, which was fished for the first time since 1956, provided a catch of about 55,000 sockeye up until July 9, the approximate date of commencement of sockeye fishing from 1957 to 1960. During this early part of the season the rate of exploitation was low (less than 30%) but increased to about 46% in the third week of July when an extra half day's fishing was permitted. During the last week of July, when an extra day of fishing was allowed, the rate of fishing increased to 74%. During the first and second weeks of August the exploitation rates dropped to 45% and 35% respectively as a result of restrictions in fishing time. The total catch of sockeye in the Skeena Gill-net Area amounted to 894,000 pieces.

The escapement, which was about 1,000,000, was the largest recorded since the formation of the Committee. The escapement to the Babine-Nilkitkwa watershed was 942,000, close to the estimated optimum for the system. The spawners were well distributed over the Babine spawning grounds. The three large, stable streams tributary to the main portion of Babine Lake - Fulton, Morrison and 15-Mile Rivers - were well seeded. Due to low-water spawning conditions, some sockeye died unspawned in some of the smaller streams. The escapement of sockeye to Morice Lake was estimated to be between 12 and 15 thousand, the largest escapement since 1954. Other Skeena sockeye spawning areas were moderately seeded.

The 1961 Skeena pink run amounted to about 3,000,000, somewhat less than the anticipated number. A considerable proportion of the 1961 pink run entered the Skeena Gill-net Area via Ogden Channel. The catch in the Skeena area was about 1,000,000 pinks. An estimated 640,000 Skeena-bound pinks were taken in the seine fishery in Ogden Channel. The total catch of pinks therefore was close to 1,650,000. Figure 1 illustrates the weekly abundance of Skeena-bound pinks in the Skeena Gill-net Area and in Ogden Channel, and the division of the stock by week into catch and remaining escapement upriver. Pinks appeared in moderate numbers in the second and third weeks of July. During the last week of July, when fishing time was increased to 4 days to harvest the sockeye run, large numbers of pinks (approximately 73% of the numbers present) were taken. Since the pinks were subjected to both the intense seine fishery in Ogden Channel and the heavy gill-net fishery in the estuary of the Skeena River, it became necessary to provide some additional protection for them and yet provide for the required catch of sockeye. The Committee recommended for the week ending August 6 that only two days' fishing be permitted in Ogden Channel and at the mouth of the Skeena River, but that 3 days' fishing be permitted in the outer portion of the Skeena Gill-net Area. In the following week the amount of fishing time was reduced in the Skeena Gill-net Area and in Ogden Channel from the 3 days originally recommended to 2 days by delaying the commencement of fishing by 24 hours. The rates of exploitation in these first two weeks of August were estimated to be 56% and 49% respectively.

Days fishing recommended	2½	2½	2½	2½	2½	3	3	3	3	4	4	4
Days fished	2½	2½	2½	2½	3	4	2*/3	2**	2	3	4	4
Estimated rates of exploitation (%)												
Pink			17	18	42	73	56	49	50	52	39	11
Sockeye		21	27	30	46	74	45	35	44	21	16	



*River 2 days, outside 3 days
**24-hr delayed opening

Fig. 1. Catch, escapement, and estimated rate of fishing, Skeena sockeye and pinks, 1961.

The escapement of pink salmon was 1,434,000, comparable to that in the brood year 1959. Some 1,335,000 spawned in tributaries of the Skeena River or in the river itself, while 99,000 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 1959. Escapements to the "early-run" streams (primarily the Kispiox, Kitwanga, and Bear Rivers) were less than one-half of those in the parent year. The run to the Babine River was of the same size as in 1959. The escapements of the "late" runs were larger than in the cycle year. The spawning in the Lakelse River was almost twice as great as in 1959, while that in the main stem of the Skeena appeared to be 3 times heavier than in the cycle year.

The 1961 Skeena gill-net catch of spring salmon was about 11,600, the lowest catch since the present system of catch statistics was begun in 1950. The escapements to most spring spawning areas were reported by Departmental officers to be light. The escapements to the Bear and Morice Rivers, the largest single spawning areas, were particularly low. The count of spring salmon at the Babine Fence was one of the lowest recorded since counts began in 1946.

The gill-net catch of coho salmon in the Skeena area in 1961 was approximately 37,000, about one-half of the 1950-60 average. The escapements to the Bulkley, Morice and Kispiox Rivers were reported to be light, to the Bear and Kitsumgalum Rivers to be of medium intensity, and to the Lakelse and Babine Rivers to be above average.

The 1961 gill-net catch of chums in the Skeena area, which totalled about 26,000 pieces, was one-half of the 1950-60 average. The escapement to the streams in the Skeena-Lakelse area and to the streams tributary to the Skeena estuary, with the exception of the Ecstall River, were reported to be light. The escapement to the Ecstall River was reported as heavy.

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 1961 are shown in Figure 4.

Investigations and Fish Cultural Projects

This is the seventh year in which the Skeena Salmon Management Committee has been responsible for recommendation of fishing regulations, of fish cultural aid to the stocks, and of research to provide information for management purposes. Reports of progress in research and fish culture during 1961 follow this section.

The primary objective of salmon management is to provide the largest sustained catch. To achieve this, the stocks must be maintained at a level which will result in the best possible use of the freshwater and marine environments. Considerable variation in the growth and survival of salmon is known to take place in the sea. However, present information points to the freshwater environment, particularly the amount and quality of available spawning and rearing areas, as finally limiting production. The first step

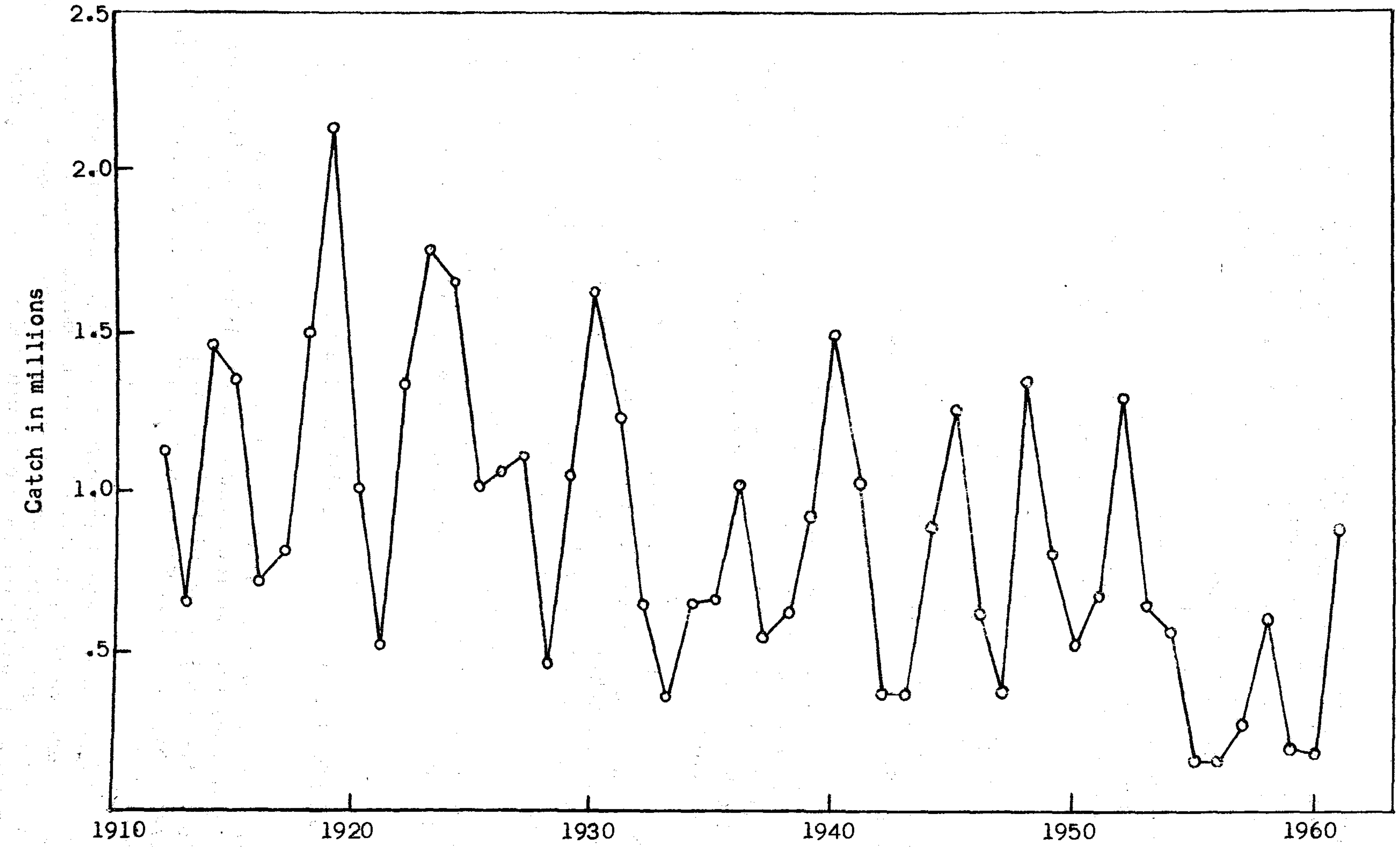


Fig. 2. Annual catch of sockeye in the Skeena Gill-net Area (from British Columbia Catch Statistics of the Department of Fisheries, 1950-61, and from pack and sampling data, 1912-1949.

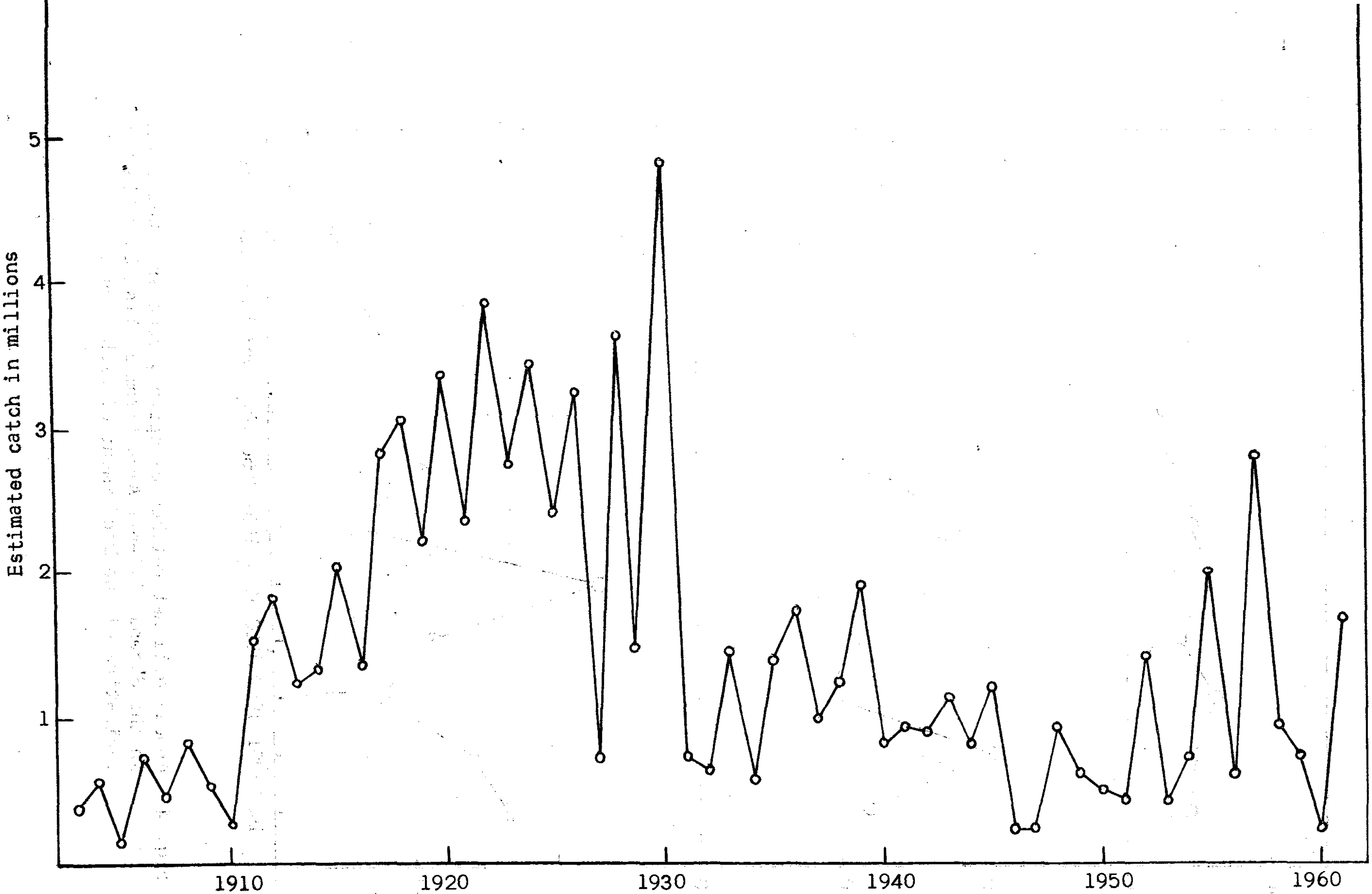


Fig. 3. Estimated annual catch of Skeena River pink salmon (1903-1949, using pack figures and available information of annual average fish per case; 1951-1961, from British Columbia catch statistics of the Department of Fisheries). In years 1955-1961 the estimated catches of Skeena fish caught in adjoining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

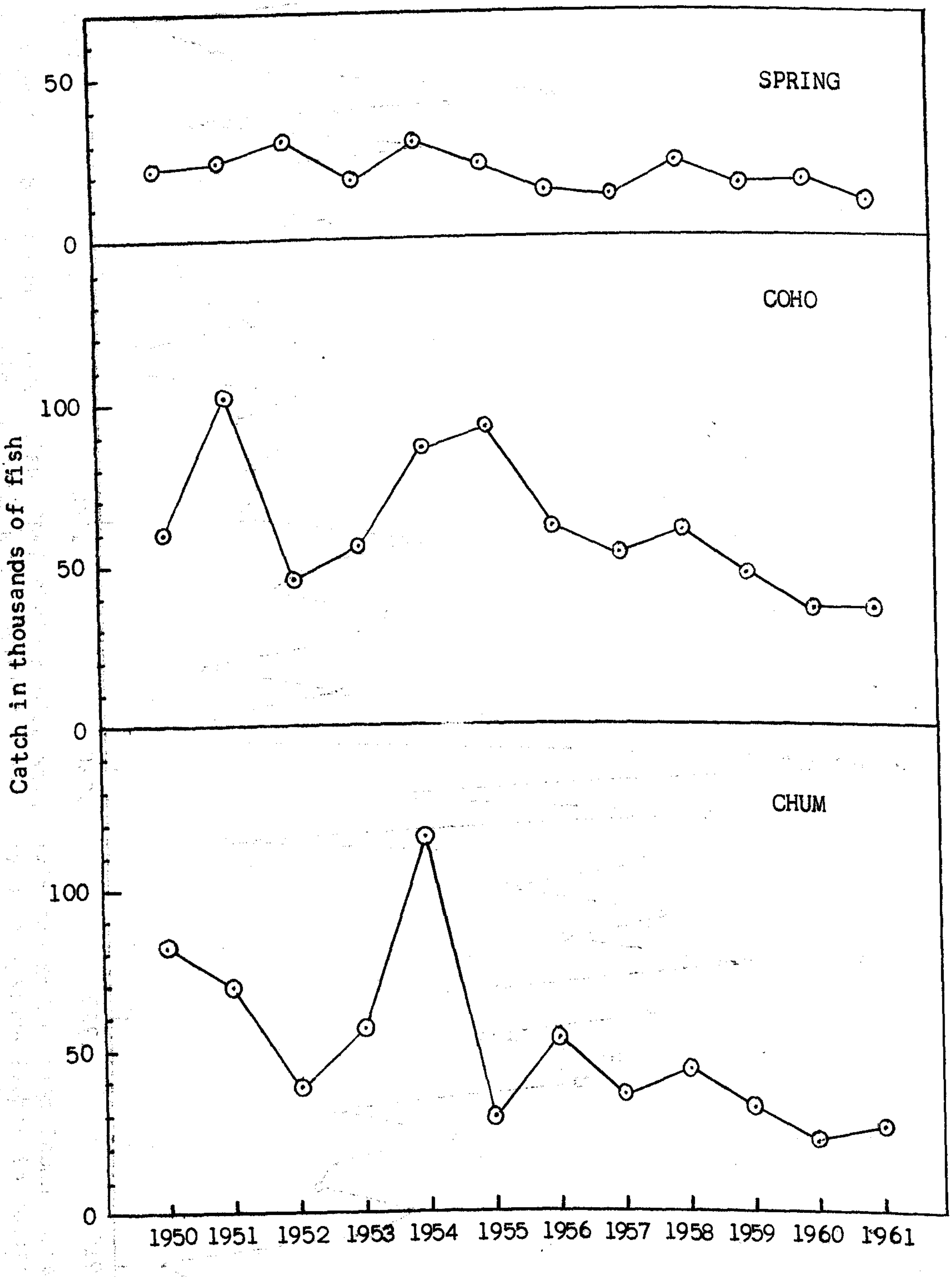


Fig. 4. Annual gill-net catches of spring, coho and chum salmon in the Skeena Gill-net Area (from British Columbia Catch Statistics of the Department of Fisheries).

toward sound management then, is to provide, by regulation of the fishery, the number of spawners which will most effectively use the spawning and rearing areas available.

Sockeye and pink salmon make up the bulk of the Skeena net fishery. For each species, the "run" is made up of a number of individual stocks, each dependent for reproduction on spawning and rearing areas of different size and quality. Each stock, therefore, has its own escapement requirements and must be managed accordingly.

Skeena salmon investigations have been conducted to provide sufficient information to define the various stocks, their escapement requirements, and finally to provide a firm basis for regulation of the fishery so that the most effective or optimum escapement can be achieved.

Optimum escapements. Historically, Babine Lake sockeye have comprised 80% or more of the total sockeye run to the Skeena. Records of escapement and return have revealed that in the past, escapements of from 800,000 to 1,000,000 sockeye to Babine have resulted in the largest average return. In 1951 and 1952, a land-slide in the Babine River seriously reduced escapements to this area. The Skeena Salmon Management Committee has attempted, through regulation, to restore escapements to at least pre-slide levels and, when possible, to the higher optimum level. As a consequence, in most years sockeye escapements have been of the same order as those in pre-slide years and, in 1958, 1959 and 1961, were close to the estimated optimum size (Fig. 5).

Studies of the growth and distribution of young sockeye at Babine Lake have revealed that not only the number of parents, but also their distribution throughout the Babine system, must be considered if best use of the available spawning grounds and nursery area is to be made. In the small, northern lake basins, as indicated by a lessened growth rate at higher population levels, the number of spawners has been often large enough to provide sufficient young to use this nursery area to near capacity. In the relatively large, southern basin of Babine Lake, the numbers of spawners and resulting young has always been less than those needed to fully use the available rearing areas. This uneven distribution of parents and subsequent uneven distribution of young has been reflected in the growth and final size attained in fresh water. Those reared in the small and more densely populated northern basins were consistently smaller than those reared in the large and sparsely populated southern basin.

Since 1956, the Skeena Salmon Management Committee has provided additional protection to those runs spawning in tributaries adjacent to the southern basin. Studies to assess the abundance and growth of the young sockeye resulting from both the increased number and the redistribution of parents achieved since 1956 are continuing. In general, larger escapements have resulted in a greater abundance of young, particularly in the large southern basin. At the same time, the large size of young sockeye produced in this basin has been maintained.

Pink salmon have contributed significantly to the Skeena commercial fishery for over 50 years. An intensive study of the stocks did not begin until 1956. Since then, considerable effort has been directed toward defining major stocks in terms of the timing through the fishery, the catch, and escapement size and distribution.

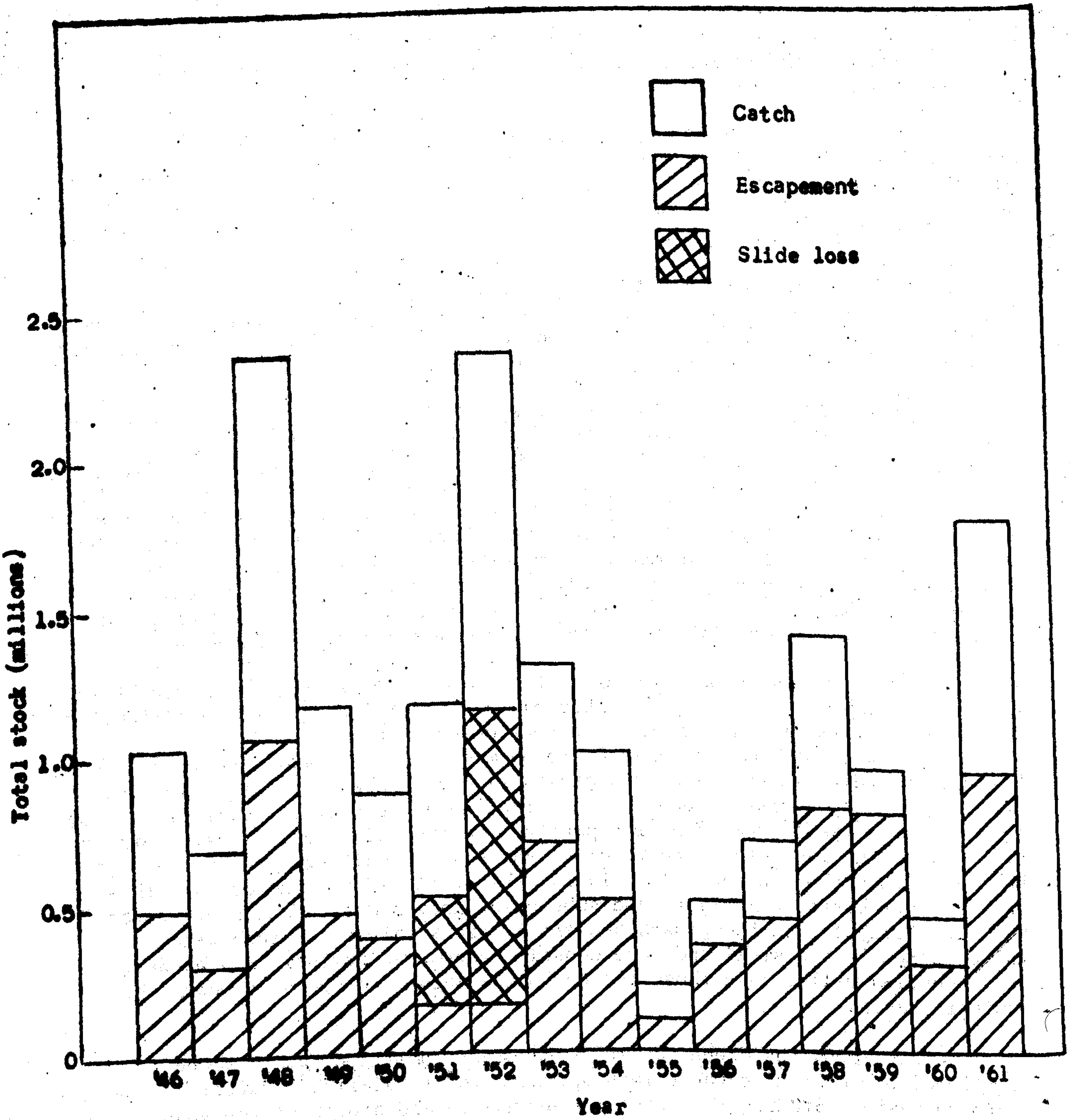


Fig. 5. Skeena River: catch and escapement of 4_2 and 5_2 sockeye, 1946 to 1961.

Analysis of past catch statistics revealed that for 30 years or more, Skeena pinks have been at a low level of abundance relative to the level maintained for many years at the height of the fishery. The records also showed that spawnings in years of abundance more often resulted in large returns than did spawnings in years of scarcity.

Observations made since 1956 of escapement size and the output of young at several major-producing tributaries have supported the conclusion that the present escapement level is below that required for best production. Within the range of escapement size observed, the fry output has been roughly proportional to the number of parents.

Since 1955, the escapements in 4 odd-numbered years has ranged from nearly 1 million to 1.4 million pinks. The total return in 1957, 1959 and 1961 was 5 to 6 million (including an estimate of those taken outside B. C. waters), 2 million, and 3 million respectively. The even-year escapement and return has remained relatively small. Escapements in the order of 0.3 and 0.7 million in 1956 and 1958 resulted in returns of about 1.7 and 0.5 million respectively. The odd-year runs, while relatively large, are still below the past high level. Even-year runs remain seriously depressed.

Regulation. Fishing regulations are established well in advance of each season, providing the industry with an opportunity to gear their operations according to the expected size of the runs and the fishing times considered necessary to provide the desired catch and escapement. The greatest problem in establishing regulations in advance of the season is estimating the abundance of the runs. At present, prediction is based largely on past performance of the stocks, and, where known, the number of young which went to sea. For Skeena sockeye, which return mainly as 4- and 5-year-olds, the proportion of each age-class in the return must also be anticipated.

Studies have indicated that growth rates of young sockeye may influence the age of return (maturity). Analysis of the scales of 4- and 5-year-old Skeena sockeye have revealed that those which leave fresh water as large smolts tend to return more often as 3- or 4-year-olds (rather than 5-year-olds) than do relatively small smolts. An association between growth and age of return is also suggested by a positive relation between the number and size of "jacks" or 3-year-olds and the proportions returning as 4's and 5's from the same brood. Thus, knowledge of the numbers and the sizes of young sockeye going to sea and of jacks returning in advance of the main run will assist in predicting the return in any one year.

Changes in regulation become necessary during the season as the size of the runs, their migration pattern and route, and the effect of the fishery varies from that anticipated. These changes in regulation are based on almost daily estimates of the catch and escapement. This information is provided by the collection of preliminary catch statistics, special test fishing carried out above the fishing boundary to indicate escapement, and sampling catch and escapement to reveal the age composition of the run.

Fish culture. The maintenance and improvement of the freshwater potential for salmon production is becoming an increasingly important aspect of salmon management. The continued expansion of the forest industry, hydro-electric development, and other forms of industrialization, pose many salmon conservation problems which must be met. Also, as the requirements for salmon propagation become better understood, fish cultural aids such as hatcheries, artificial spawning channels, and improvement of natural spawning areas, can be expected to become increasingly effective and more widely used.

In 1961, the Department of Fisheries continued with its program of rehabilitation of the presently depressed sockeye run to the Morice Lake system. This program began with the construction of fishways at Moricetown Falls and the removal of a partial obstruction to the passage of salmon at Hagwilget Canyon. Both sites are on the Bulkley River, part of the migration route of Morice Lake sockeye. These remedial measures were followed in 1960 by the construction and operation of a hatchery on the Nanika River, the major spawning area tributary to Morice Lake. A hatchery unit was considered the most effective means of providing the needed boost to the presently small natural spawning.

Operation of the hatchery in 1960-61 was limited to a "test" run so that facilities and techniques could be tested. In September, 1961, the first large-scale transfer of eggs (5.2 million) was made to the hatchery from a donor run at Babine Lake.

Following an announcement early in 1961 by the B. C. Power Commission of its intention to proceed with hydroelectric development in the Bulkley River and Babine Lake areas, the Department of Fisheries immediately initiated studies of the B. C. Power Commission's proposals and the possible effect of the proposals on salmon production. The development called for a dam on the Bulkley River at Moricetown Falls, or, as a short term alternative, dams on the Fulton River and Pinkut Creek, both tributaries to Babine Lake and both important sockeye producing areas. Because of the importance of these streams to Skeena salmon, biological surveys of the Bulkley River-Morice Lake system and the Fulton River were carried out to assess more precisely present utilization and potential capacity of these areas as salmon producers, and the possible effect of the proposed hydroelectric development on the runs.

In 1961, the Skeena Salmon Management Committee directed its research and fish culture staffs to examine the feasibility of developing, by the use of modern fish cultural techniques, the potential of Babine Lake as a sockeye producing area. Studies of the abundance and growth of young sockeye at Babine Lake have indicated that the main lake basin is presently underutilized as a rearing area. Production appears limited by the amount and quality of spawning area adjacent to the main lake basin rather than from limited rearing capacity. Available evidence suggests that any significant increase in the number of fry entering the main lake basin would result in an increased output of smolts and returning adults.

A biological and engineering program was initiated to (1) determine the present level of adult to fry survival, (2) reveal the significance, if any, of lake spawning at Babine, (3) describe the essential physical features of the spawning streams and their drainage areas. This "feasibility study" is continuing. The information obtained will indicate whether an increased fry output is biologically and economically possible and if so, the fish cultural aids which might be used.

Reports of Progress in Research and Fish Culture Projects, 1961

(1) Babine fence counts and sampling in 1961

Each year the escapement of sockeye to Babine Lake comprises a very large proportion of the total escapement to the Skeena system. Babine fence counts and sampling, therefore, serve as a gauge of the effect of sockeye commercial fishing regulation as well as permitting a description of the age, size and sex composition of the escapement.

The counts of the 5 species of salmon for the years 1946-1961 (excepting 1948, when floods washed the fence out) are shown in Table II.

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

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

The 1961 escapement of 969,563 sockeye was the largest counted. Daily counts began on July 8 and rose rather steadily to a peak of 38,000 on August 27. There followed a rapid decline, and between September 15 and September 21 (when counting was terminated), daily counts had dropped to less than 1,000. This pattern of migration was similar to that of past years. On the average, about 95% of the run passes between July 20 and September 15, and the mid-point is usually reached by August 20.

The escapement of 2,921 spring salmon was below average. During the first 5 to 6 weeks the run consisted mainly of "jacks", though large fish predominated later. Spring salmon spawn both above and below the fence, and therefore the fence data provide only an index to the total escapement of this species to the Babine system.

The count of 70,044 pink salmon was the largest of any year of fence operation. Some pinks normally spawn below the fence and this year the estimate was 5,000, to give a total Babine River pink escapement of 75,000.

To determine the composition of the 1961 Babine sockeye escapement, a number of fish equal to 1% of the previous day's fence count was inspected daily; half in the morning and half after noon. The length and sex of each fish was determined, as was the number of large sockeye which were net-marked, injured or "normal".

Excepting only 1951 and 1952 (both years when the run was severely damaged by the Babine River rockslide), the large females have outnumbered the large male sockeye in all years. In 1961 the sex ratio of large fish was 47% males and 53% females. These data are shown in Table III.

Table III. Percentages of male and female sockeye

Year	% Male	% Female
1946	43.52	56.48
1947	45.56	54.44
1948	---	---
1949	40.99	59.01
1950	43.74	56.26
1951	51.88	48.12
1952	58.90	41.10
1953	44.15	55.85
1954	39.72	60.28
1955	47.16	52.84
1956	48.62	51.38
1957	49.00	51.00
1958	39.38	60.62
1959	39.56	60.44
1960	44.30	55.70
1961	46.99	53.01

The samples indicated that sockeye in the 1961 run were of average size (Table IV).

About 8% of the 1961 sockeye were net-marked, and 2.4% were gashed or otherwise injured. Records of the percentage marked, injured and normal in all years are shown in Table V.

Table IV. Average length, in centimetres, of sockeye in the proportionate samples.

Year	Large males	Jacks	Females
1949	61.5	37.4	59.9
1950	57.7	38.3	57.1
1951	60.1	38.9	58.4
1952	58.9	38.3	57.7
1953	62.4	38.6	60.3
1954	66.6	38.3	63.0
1955	55.7	38.2	57.9
1956	58.1	36.0	57.1
1957	57.6	37.8	57.0
1958	61.6	38.5	59.4
1959	62.3	37.4	60.4
1960	55.6	36.5	55.2
1961	58.0	37.9	57.6

Table V. Condition of sockeye passing the Babine fence.

Year	Normal	Net-marked	Injured
1946	--	--	--
1947	84.5	11.35	4.2
1948	--	--	--
1949	86.9	6.22	6.8
1950	84.2	12.34	3.5
1951	51.6	18.33	31.1
1952	69.2	1.00	29.9
1953	93.0	4.27	2.7
1954	89.3	8.26	2.5
1955	87.2	6.12	6.7
1956	94.2	4.27	1.5
1957	90.2	8.26	1.5
1958	83.5	13.91	2.6
1959	91.5	4.17	4.3
1960	85.0	9.88	5.1
1961	89.6	8.00	2.4

The average egg content was estimated to be 3,113 per female. Since the number of female sockeye surviving the Indian fishery above the fence was estimated to be 485,688, the potential egg deposition was approximately 1,511,000,000.

(2) Babine smolt output

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

At Babine the abundance of the smolt run has been measured annually by mark and recovery programs since 1951. From 1951 through 1959, fins were clipped at Fort Babine and in the last two years, small staples were employed to mark a portion of the runs as fish passed through Nilkitkwa Lake (Fig. 6). The ratio of marked to unmarked fish in samples taken at the lake outlet provides the basis for determining the numbers in the migration. The age and size of smolts has been determined from representative sampling during the course of the run.

Estimates of numbers, age and size of smolts in past years have been given in Annual Reports of this Station. Recently these estimates have been revised in the light of improved understanding of the nature of the runs.

Prior to 1958, the existence of a substantial run of "early" smolts emigrating throughout a short period following ice break-up was not suspected. In 1958 and 1959, however, the abundance of parts of these early runs was estimated by mark and recovery programs, and parts by observation of relative numbers of smolts passing over the floor of the adult counting fence. The estimates for this early period were somewhat speculative and were re-evaluated in 1960 and 1961. In these last two years the entire run was estimated by mark and recovery. Comparison of the timing of the run in 1960 and 1961 with the incomplete picture obtained in earlier years suggested that a rather consistent pattern of migration had prevailed over the years.

In general the migration begins in early May - apparently associated with the time of ice break-up. The numbers in nightly migrations increase rapidly and a high level of output is maintained for about two weeks. There follows a period from a few days to a week or more wherein output is low. It in turn is followed by a second period of high output which prevails for two or three weeks. The run falls rapidly and in most years is essentially over by mid-June. In 1960 and 1961, about 95% of the run occurred within a 30-day period. The seasonal pattern and nightly size of migrations is shown in Figure 12.

The bimodal migration curve reflects the timing of the early and late smolt runs. As shown by tagging of smolts up-lake, the early run is derived mainly from Nilkitkwa Lake and the North Arm of Babine Lake, and the late run mainly from Babine Lake outside the North Arm. In 1960 and 1961, these two populations migrated without appreciable intermixture.

Johnson has weighed sockeye underyearlings during October in the main lake basins, and in Nilkitkwa Lake and the North Arm in the years 1955-1960. In most years the Nilkitkwa and North Arm fish have been considerably smaller, a fact which is reflected in the mean lengths of smolts in the early and late runs passing out of Nilkitkwa Lake. In Figure 7 the weekly mean lengths of smolts has been related in time to the output of numbers and it is apparent that the early-run fish are smaller than those of the late run.

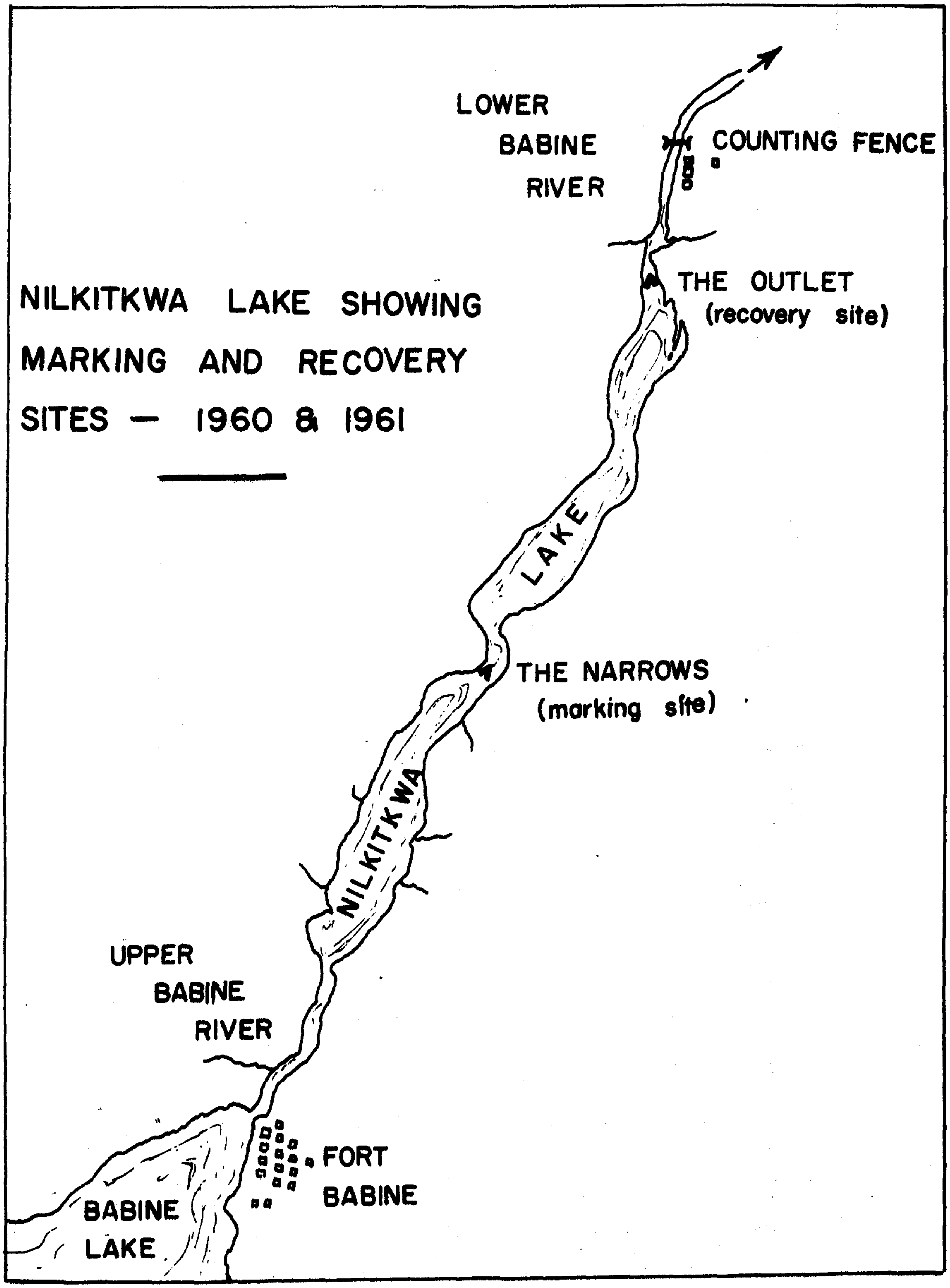

LOWER
BABINE
RIVER
COUNTING FENCE
NILKITKWA LAKE SHOWING
MARKING AND RECOVERY
SITES — 1960 & 1961
THE OUTLET
(recovery site)
LAKE
THE NARROWS
(marking site)
NILKITKWA
UPPER
BABINE
RIVER
FORT
BABINE
BABINE
LAKE

Figure 6

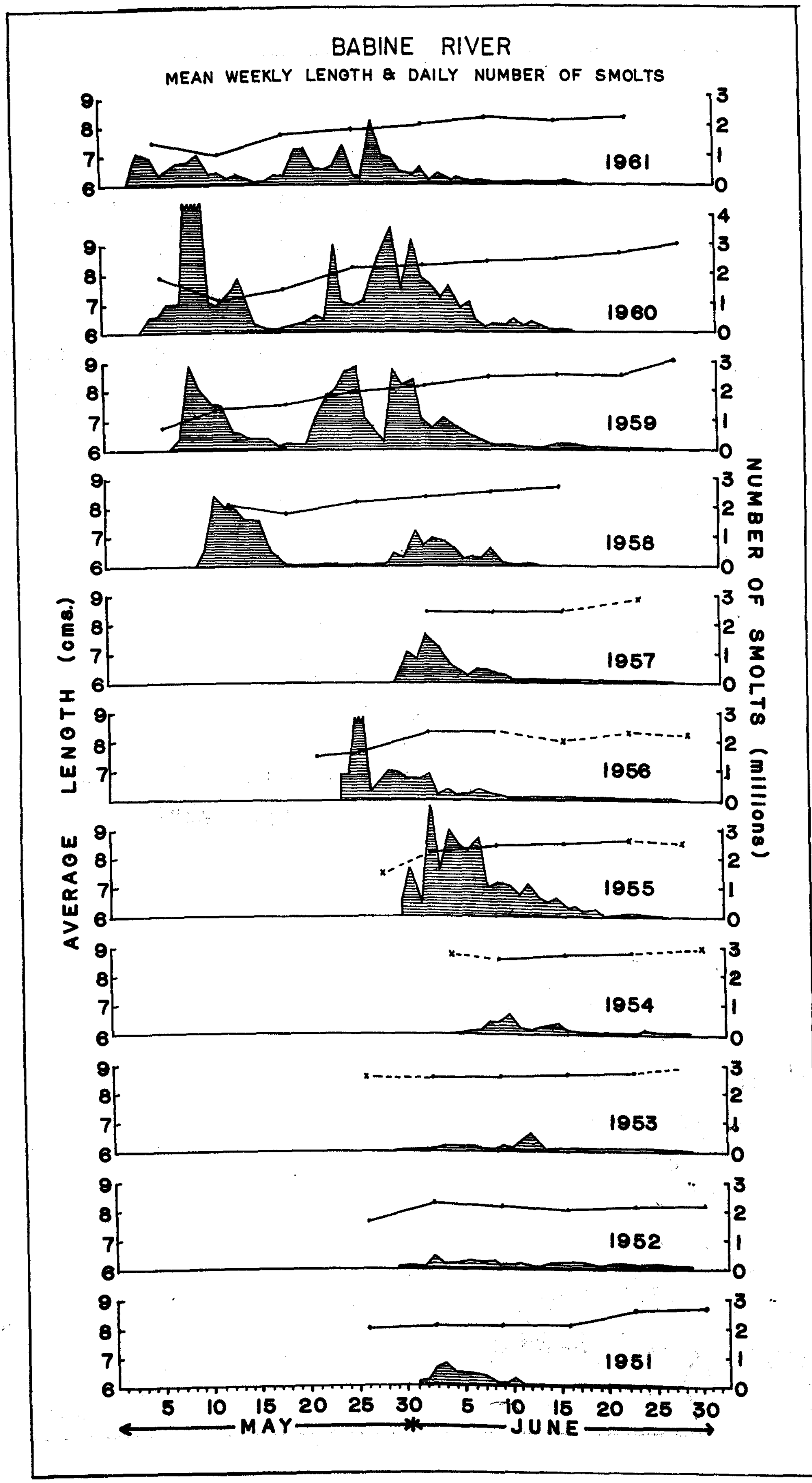

BABINE RIVER
MEAN WEEKLY LENGTH & DAILY NUMBER OF SMOLTS
1961
1960
1959
1958
1957
1956
1955
1954
1953
1952
1951
AVERAGE LENGTH (cms.)
NUMBER OF SMOLTS (millions)
5 10 15 20 25 30 5 10 15 20 25 30
MAY
JUNE

Figure 7

The best estimates of survival from egg to smolt for the brood years 1956-1959 are presented in Table VI. Survival is also shown for smolt to adult, and egg to adult, for the 1956 brood year. Returns from brood-year 1957 are not complete, but the total of 4-year-olds returned in 1961 shows that the survival from it has already been good.

On the other hand, the 16 million smolts estimated from the 1959 brood year indicate a survival from egg to smolt of only 1.0%, the lowest yet recorded at Babine. To obtain the 1961 smolt estimate, more than 101,000 smolts were marked, 614,000 were checked as they migrated from Nilkitkwa Lake, and 3,866 marks, or 3.8% of those released, were recovered.

Table VI. Preliminary survival estimates for Babine smolts from brood years 1956-1961.

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	1,456+[b]	5.25	4.24+[a]	2.23+[a]
1958	812,043	1,547	45,000	--	2.91	--	--
1959	782,868	1,554	16,000	--	1.03	--	--
1960	262,719	403	--	--	--	--	--
1961	941,700	1,511	--	--	--	--	--

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

b/ Incomplete until 1962 run of 5_2 adults returns.

(3) Babine Lake spawning

The existence of extensive lake spawning of red salmon has long been recognized in the vast spawning areas of Bristol Bay, Alaska. Lesser populations also use the lake basins in such widely scattered drainages as Chignik and Karluk in Alaska, Dalnee in the U.S.S.R., Great Central and Morice in British Columbia, and Baker Lake in the State of Washington. At Babine Lake significant numbers of spawned-out salmon have been reported floating on the lake, or washed up on the shore long after fish from recognized populations have spawned and decomposed.

To investigate the possibility that self-perpetuating populations of sockeye salmon spawn in the Babine Lake basins, as well as in the streams tributary to the basins, preliminary surveys were carried out in 1958 and 1961. The first survey was made in late October, 1958. On that occasion, 53 sockeye were caught in gillnets sunk in 50 to 100 feet of water at two widely-separated locations. From the condition of the fish at the time of capture, they were considered likely to be lake spawners though it is possible that they were spawners which failed to reach their streams, and were wandering aimlessly in the lake.

In 1961, further investigations of possible lake spawning were conducted. Nets of various dimensions (20 to 100 feet long) and variable mesh size (1 inch to 5 1/4 inches) were fished from the shoreline of Babine Lake in overnight sets from October 5 to 13 and from October 26 to November 1. A total of 33 sets took 390 sockeye; only 3 failed to take fish. The range of catches was 0 to 135 and the mean catch per set was 15 (Fig. 8). All fish were measured and scales sampled, and most were opened to establish the condition of their gonads. Fish in all stages of advanced maturity from ripe and unspawned to completely spawned out appeared to be represented in the samples taken.

The 1961 sets were distributed throughout much of Babine Lake and were made in bays and on points, in shallow water and in deep, and were made at a time when stream spawning, other than that in Babine River, was long past. The presence of these fish strongly suggests the occurrence of lake spawning in Babine. However, there are several observations which conflict somewhat with the evidence from netting:

(a) The length and scale sampling conducted during the 1961 sampling did not suggest a population different in size or age from that occurring in the tributary streams or in Babine River. In other systems, lake-spawning populations often differ from stream spawners in these respects.

(b) On two occasions during the month of October, aerial surveys of the entire Babine Lake shoreline revealed only one group of 50 to 100 lake-spawning fish. In other systems, a portion of the lake-spawning population can usually be seen in relatively shallow water or alluvial fans around the margins of the lakes.

(c) From November 10 to 13, Mr. Martell of the Fisheries Research Board, and Inspectors L. J. Gelley and P. J. Sims of the Department of Fisheries of Canada, engaged in a co-operative survey of the Babine Lake beaches to count the dead. A total of 18 miles of lake shore was carefully checked by surveys made in one-half mile sections every 5 miles in accordance with prescribed notations on a map of the lake. Except for Morrison and Hagan Arms, the entire shoreline from Halifax Narrows south was sampled. Totals of only 80 males and 128 females were counted, much fewer than would be expected if lake spawning was extensive.

(d) A short dive at the site of the largest gillnet catch on November 1 revealed precipitous, apparently unsuitable, bottom contours for at least the first 30 feet of depth despite the capture of large numbers of sockeye throughout the range from 0 to 50 feet or more at that site.

Application of techniques for underwater observation will be required before the problem can be assessed further.

RECORD OF GILL NET CATCHES OF 390 SOCKEYE SALMON FROM BABINE LAKE IN OCTOBER AND NOVEMBER, 1961

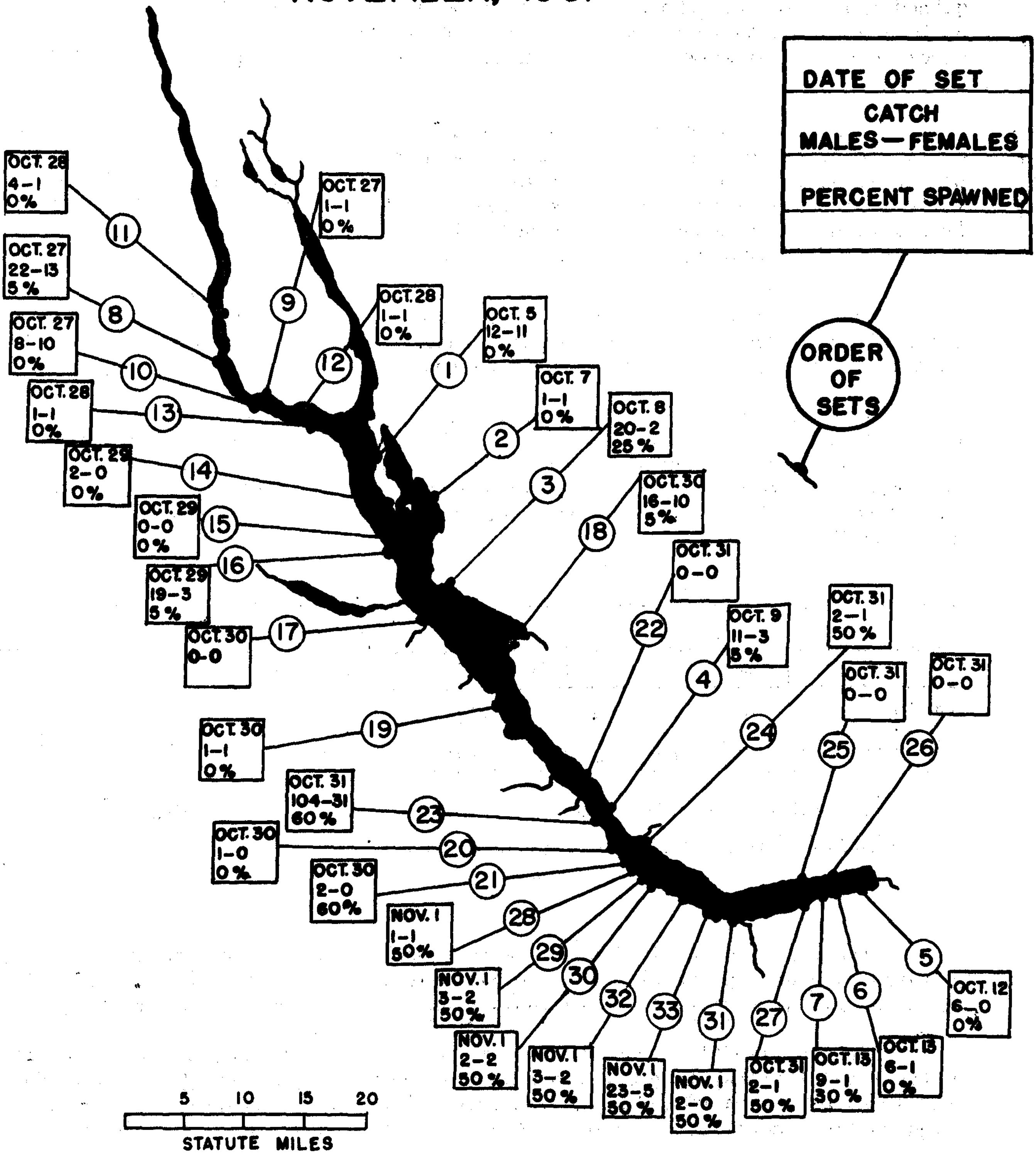


Figure 8

(4) Skeena pink salmon escapements

In order to regulate the fishery effectively, and also to establish escapement optima, the yearly numbers and distribution of salmon spawners in the Skeena system must be determined. For on-the-spot regulatory purposes, periodic rates of escapement are obtained from test-fishing catches, but improvements in the interpretation of these must come as a result of knowledge gained from complete counts on the spawning grounds. Similarly, for determining optimum escapements to the entire river, and to its component spawning grounds, accurate counts of spawners and resultant stock must be compared over a period of years.

To provide the desired information, counts of pink and sockeye escapements are obtained from as many Skeena spawning grounds as possible. Because of the large size and relative complexity of the Skeena system (Fig. 9), a variety of enumeration methods are necessary. Considerable effort is expended in improving these methods, and in determining the most suitable techniques for use in different locations and situations.

Counting fences, tag and recovery programs, strip counts, aerial observation and photography, seining, sample counts, boat and foot surveys and carcass counts are employed in obtaining pink salmon estimates.

Counting fences provide the most accurate data and also afford opportunities to test more approximate techniques of estimation. Currently a fence is being maintained on Lakelse River and studies are under way to determine the degree of accuracy afforded by a tag and recovery program on pink salmon there. The comparisons of population estimates obtained on Lakelse in 1960 and 1961 are:

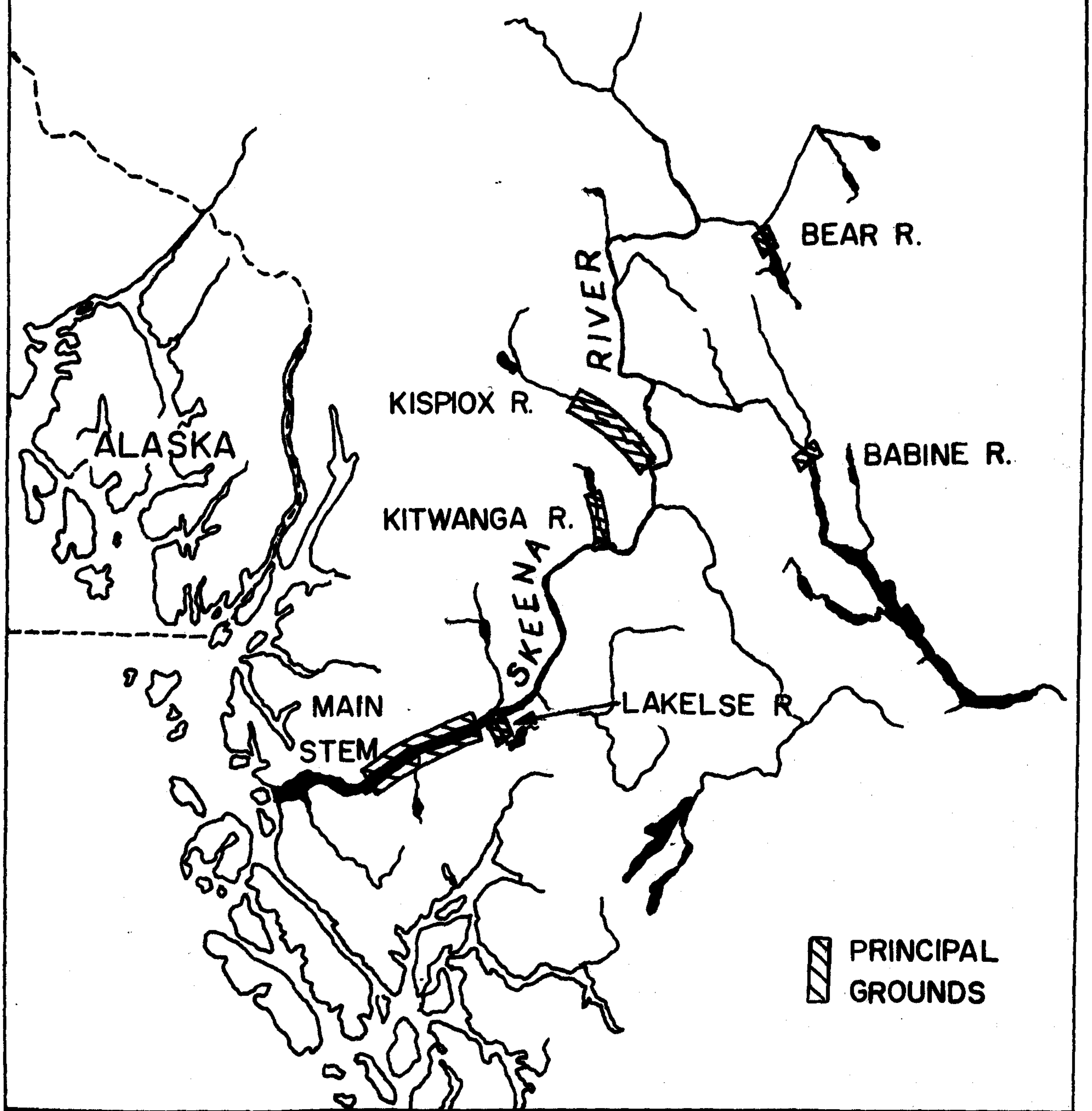
Year	Fence count[a]			Tag and recovery[b]			% Error		
	Males	Females	Both	Males	Females	Both	Males	Females	Both
1960	55,764	56,172	111,936	72,865	99,776	158,376	30.7	77.6	41.5
1961	141,874	163,801	305,675	180,495	211,194	387,155	27.2	28.9	26.6

a/ Sex ratio calculated from daily samples and weighted by daily counts.

b/ Males, females and both calculated independently.

The error in the 1961 estimate is somewhat comparable with that demonstrated by Hourston for pinks in the Glendale River in 1961, but is far smaller than in similar experiments with sockeye on the Babine River in earlier years.

On the Glendale, tags attached to pinks at the fence provided an estimate which was 17% higher than the fence count. On Babine in the years 1946, 1947 and 1958, errors of 90%, 41% and 98% respectively were encountered. These figures are summarized below with those discussed above for pink salmon:



PRINCIPLE RECOGNISED PINK SALMON SPAWNING GROUNDS.– SKEENA DRAINAGE 1961

Figure 9

Year	Species	Tagging location	% Error
1946	Sockeye	Babine fence	+90
1947	"	" "	+41
1958	"	" "	+98
1960	Pink	Lakelse fence	+41.5
1961	"	" "	+26.6
1961	"	Glendale fence	+17.0

In strip counting the best estimate of spawners per linear yard of measured streams is established from counts on one-yard strips taken at right angles to stream flow. Strips are chosen randomly, or according to measure, at a rate of about 3 per 100 linear yards. On a 2.4-mile section of Kitwancool River, strip counts of spawners at the peak of the 1961 pink run yielded a population estimate of 24,500 salmon. The total count over this same section on the same day yielded 22,590. The great savings in time afforded by the strip-count method would have more than compensated for the 8.5% discrepancy between estimates.

Aircraft are used extensively to chart the progress and general distribution of the runs. The levels of confidence appropriate to aerial counts under a variety of conditions are being investigated, as are the relative merits of conventional craft and helicopters. Aerial photography provides a record of the timing and abundance of spawning runs in remote or otherwise inaccessible regions.

Seining is being studied as an index to numbers of salmon migrating through the Kispiox River. In 1961, hourly catches were compared with hourly sample counts of salmon as they passed an observation post on their spawning migration. During the 9-day period August 11 to 19, seine catches clearly reflected the abundance of migrants.

Direct counts from boats, or as observers walk the banks of streams, are basic means of obtaining estimates in small streams. In silted waters, such as those of the main stem of the Skeena, counts of carcasses provide at present the best means of estimating population size. Improved techniques for obtaining main stem estimates are receiving high priority in the study of enumeration techniques.

The escapements of Skeena River pink salmon for the years 1955 to 1961 were as follows:

Estimated escapement of Skeena pink salmon, 1955 to 1961

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

A strong, cyclic pattern is apparent in the 7 years of escapement data. Total Skeena River escapements have invariably been larger in the odd than in the adjoining even years. Moreover, the smallest odd-year escapement recorded was 970,000 in 1957, about 50% higher than the largest even-year escapement.

The preponderance of odd-year runs also prevails within the sub-systems, though less strongly in some instances. It is interesting to note that the numerical superiority of odd-year runs over even-year runs is strongest in streams farthest from the coast, e.g., Bear, Babine and Kispiox. The coastal rivers and Lakelse and Kitwanga show less odd-year dominance and in 1958 the coastal rivers and Lakelse escapements exceeded those of both 1957 and 1959.

In the main stem of the Skeena the odd-year runs also appear to predominate, but escapement estimates prior to 1959 may have been too inaccurate to provide the true relationship of odd-year to even-year runs.

(5) <u>Freshwater survival of progeny from the 1959 and 1960 pink salmon escapements</u>

Estimates of the abundance of escapements and resulting fry migrations have been obtained from several large spawning areas tributary to the Skeena River each year since 1956 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.

Indices of fry abundance were obtained from Lakelse, Kispiox and Kitwanga Rivers from 1956 to 1959 by fishing small trap-nets in a consistent manner near the confluences of these rivers with the Skeena. The results showed that within the range of escapements observed, the fry output in these "control" rivers was, in general, proportional to the number of parents producing them.

In 1960 and 1961 the method was further developed to obtain actual estimates of total output rather than relative indices of fry abundance. These estimates permit calculation of the survival from parent or egg to fry, and following the return as adults, some indication of survival in the sea.

Data for the 1959 and 1960 brood years are given below.

River	Brood year	Estimated escapement	Potential eggs ($\times10^6$)	Estimated no. fry ($\times10^6$)	Survival from egg to fry (%)
Lakelse	1959	185,000	167	30	18
	1960	122,000	110	21	19
Kispiox	1959	650,000	585	132	23
	1960	45,000	51	20	39
Kitwanga	1959	250,000	225	34	15
	1960	27,000[a]	24[a]	15	61[a] (30)

[a] An escapeage at the Kitwanga fence in 1959 resulted in an underestimate of spawners, and correspondingly an over-estimate of percent survival. A minimum survival of 30% is indicated by available information from fry estimates and escapement estimates other than that provided by the fence.

The survival from egg to fry from escapements less than 50,000 and as high as 650,000 has ranged from 15 to 39%. This is comparable to survivals recorded at Port John, B. C., for the 1959 and 1960 brood years (15 and 37% respectively) but well above the average survival recorded in the past at Port John, and at McClinton Creek, B. C.

It is also noteworthy that the indicated survival from the currently much smaller even-year escapement was somewhat higher than that from the relatively large 1959 escapement of the odd-year cycle.

Escapements to the Lakelse, Kitwanga, and Kispiox Rivers comprised a large proportion of the total Skeena escapement in 1959 and 1960. If the level of survival observed in these rivers is representative of that elsewhere in the system, then the likely abundance of fry in the entire Skeena output may be calculated as follows:

Brood year	Ratio of numbers in parent escapements - control rivers to Skeena total	Estimated total fry output ($\times10^6$)
1959	1:1.36	267
1960	1:1.34	75

It must be pointed out that, in recent odd-numbered years at least, a substantial spawning occurred in the main stem of the Skeena River. Estimates of the numbers of spawners are gross and survival to fry may or may not approximate that occurring in the 3 'control' rivers. However, within reasonable limits of error in assessing the size and effectiveness of main stem spawning escapements, the level of total fry output indicated above would not change materially.

In 1961 a return of approximately 3 million adults from a fry output in the order of 267 million indicates a downriver and overall survival of 1.2%. This is low when compared to the average of 4.3% estimated by Parker for Port John pinks in past years. The return of only 2 adults per spawner from the 1959 brood, as compared to the long-range Skeena average of 2.5 to 3.0, together with the good survival to the fry stage in the three 'control' rivers also suggests that marine survival was low.

(6) Lake Sockeye Studies

In 1961, effort was concentrated on a study, in conjunction with C. Groot of the Experimental Biology Investigation, of the smolt migration through the Babine Lake system. In addition, tow-net collections of young sockeye and routine sampling of zooplankton were carried out to provide the annual assessment of the abundance, distribution, growth rate and food supply of age-O sockeye at Babine.

a. Young sockeye in Babine Lake

The lake populations of age-O sockeye in 1961 were progeny of the 1960 spawning escapement of 262,719 large sockeye as counted through the Babine fence; of these parent spawners, an estimated 100,000 spawned on the outlet spawning grounds and the remainder on grounds tributary to the lake regions south of Halifax Narrows. In late August, 1961, there were an estimated 22.8 million age-O sockeye in the lake areas north of Halifax Narrows and 38.9 million south of this narrows.

Regression analyses are being carried out on tow-net catch data to study seasonal changes in availability of young sockeye. Preliminary examination of the data suggests that a direct relationship exists between survival rate and size of underyearlings during lake life. These analyses have permitted more precise comparisons of the abundance of young fish in the various basins in different years. Based on these analyses, in Table VII revised estimates of the total number of age-O sockeye in the two sections of the Babine—Nilkitkwa system north and south of Halifax Narrows are compared with the numbers of parent spawners for the brood years 1956-60. This tabulation lists the total population of age-O sockeye, whether they are progeny of anadromous or the kokanee form; it was believed in some previous years that the populations south of Halifax Narrows might be made up of considerable numbers of the kokanee form. However, with no means of reliably differentiating the two forms as to parentage, and no evidence that considerable numbers do not migrate seaward as smolts, it is now believed that the contribution of the kokanee form to the total population is usually small (less than 20%), and impossible to consider separately.

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

Lake Region	Estimated number of spawning adult sockeye (excluding "jacks") (thousands)	Estimated number of age-O 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

As indicated in the above Table, the numbers of age-O sockeye present in 1961 was commensurate with the rather small spawning escapement and suggest 'normal' survival during the early life stages, when compared with that of previous years (except 1960 when it appears that early survival was poor). The distribution and growth rate of the 1961 age-O sockeye followed the pattern expected for such a relatively small population — only in Nilkitkwa Lake and in the north basin of the North Arm of Babine (nearest the outlet) were populations of sufficient density to depress the growth rate somewhat; populations were sparse and growth rates high in all basins further up-lake.

b. Zooplankton

Detailed analyses of zooplankton data throughout the Babine Lake system over the period 1956-61 are approaching completion. Some of the most salient features are as follows:

The quantity of zooplankton (expressed as the dry weight of organic matter) shows both striking similarities and dissimilarities from year to year and basin to basin. Within any one year there were great differences in the mean standing crop of zooplankton in the different basins. It appears to be (a) directly correlated with mean depth, (b) inversely correlated with the rate of flushing, and (c) inversely correlated with the population density of the age-0 sockeye population (a grazing effect). From year to year, quantity of zooplankton in all basins generally varied similarly; for example, 1958 was a year of general low zooplankton abundance and 1959 a year of high abundance. This suggests a common causative climatic control. However, we must not ignore the possibility of causative connection with fluctuations in the sockeye population; at present this seems remote, but data from future years' observations seem desirable.

During the period May-July, 1961, we were fortunate in having with us at Babine, Dr. K. Patalas of Poland, under a research grant from the Rockefeller Foundation. Dr. Patalas carried out detailed studies on the production of zooplankton at the species level. Results will appear in a forthcoming publication.

c. Sockeye smolt migration studies at Babine Lake

In 1960 and 1961 a large-scale cooperative project between the author and C. Groot, of the Experimental Biology group, was conducted to study the spring emigration of sockeye smolts from Babine Lake. These studies involved direct observations of the direction and rates of movement of actively migrating schools, tagging at various locations and observations on the directional position of individual smolts held in experimental tanks. This appendix summarizes data on the observed movements of smolts at Babine.

Periodically during the migration, smolts were captured, tagged and released at 3 different up-lake locations. Tags of a different colour, or colour combination, were used for each tag release. Trapping of migrating smolts at the outlet and at the tagging sites throughout the run allowed for recovery of tagged fish. Figure 10 shows the location of the up-lake tagging sites and the outlet recovery site; it also lists the total number of smolts tagged at each site and the number of such tagged fish subsequently recovered. In 1960, fish were tagged at the Halifax Narrows site only. In 1961, smolt trapping at three up-lake sites permitted recovery of tagged fish other than

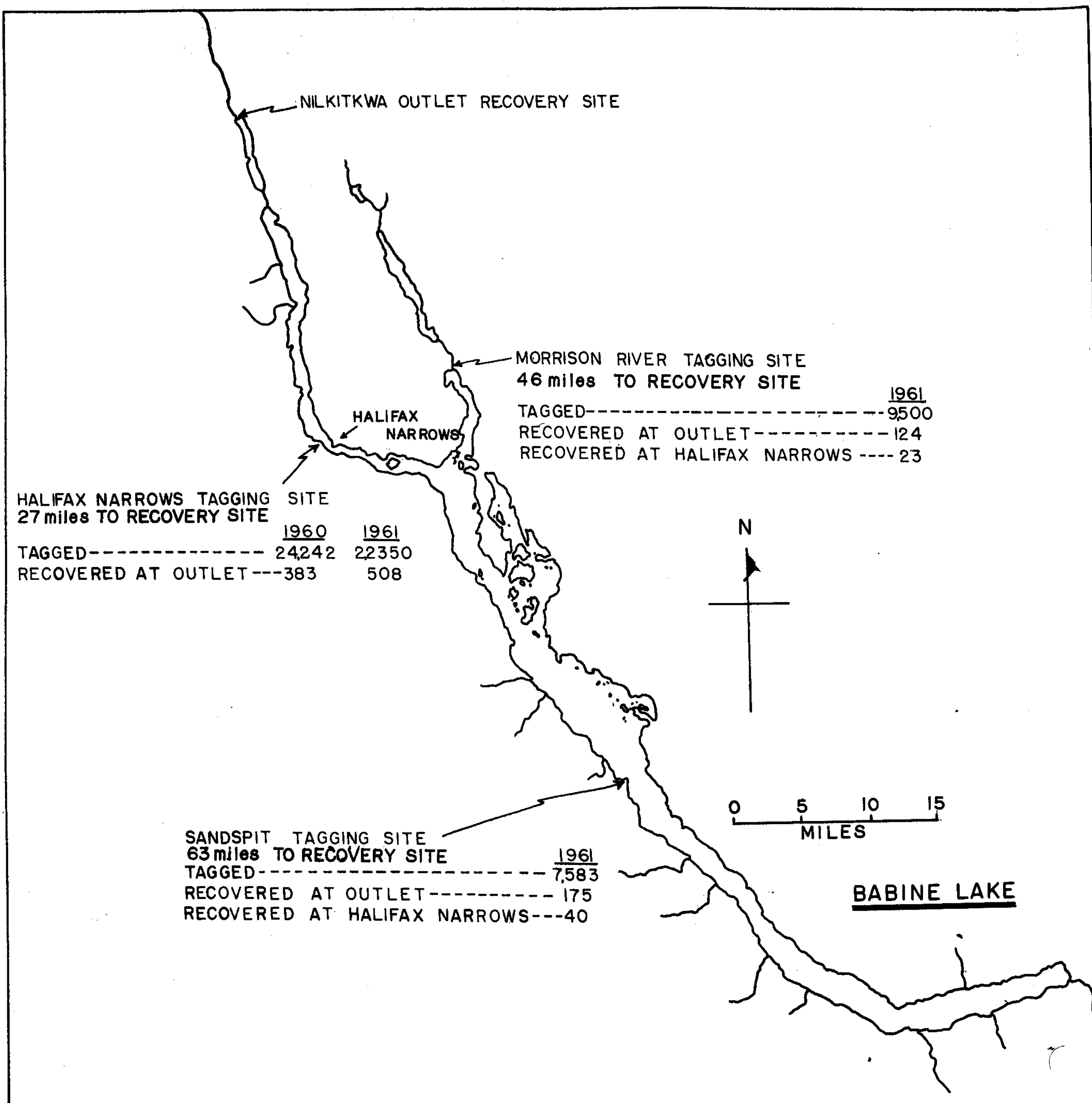


Figure 10. Tagging and recovery sites, 1960 and 1961. Shows number of smolts captured, tagged and released at each tagging site and the number and location of these subsequently recaptured.

at the outlet: 23 of the smolts tagged at Morrison River and 40 of the smolts tagged at Sandspit were recaptured at the Halifax Narrows site. No recaptures of tagged smolts from other tag-release sites were made at either the Morrison River or Sandspit sites. This indicates well-oriented, non-random movement in the direction of the lake outlet. Also indicative of non-randomness and good orientation is the fact that wherever near-surface migrating schools were observed they were seen moving in the direction of the most direct lake route to the outlet: the few exceptions to this were usually moving in the diametrically opposite direction. "Reverse orientation" under experimental conditions is noted in the discussion of orientation in the Experimental Biology section of this report.

Rate of travel from tagging site to outlet is expressed as the average number of miles per day covered on the most direct route (26 miles, 46 miles and 63 miles, respectively) in the time between release and recapture, i.e., the number of miles on the most direct route to the outlet divided by the number of days between release and recapture. All releases and recaptures were made at the same time of day — during the evening twilight and early dark period when the diurnal peak of migration activity occurs.

Figure 11 shows the rate of travel of tagged fish from their points of release to the outlet. There is shown in all cases an increase in rate of travel as the season progressed. There is a striking similarity in the values of the regression coefficients. Increase in migration rate with time would be expected owing to the effect of increasing spring temperatures on swimming speed. Another possible cause might be the increasing discharge rate of the water during this time of year, effecting passive transport of the fish toward the outlet. Based on Brett's estimates of swimming speeds at different temperatures and data on seasonal changes in the net rate of surface-water movement toward the outlet, Figure 11D shows that only part of the increase in rate of migration can be accounted for by changes in temperatures and water transport. The residual, unaccounted-for increase is believed to be due either to a general increase in duration of migration per day, or to an increase in speed of swimming associated with a more straightforward orientation, or to a combination of these factors.

Regardless of causative factors, it is obvious that in comparing rates of travel and effects of environmental factors on rates of travel, at different times during the migration, the relationships with time as shown in Figure 11A-C must be taken into account. This has been done in all cases to follow by adjusting to the mean date on the regression line for comparison within a year and to a common date (June 1) for comparison of the two years.

The adjusted mean rate of travel from Halifax Narrows to the outlet was 3.5 miles per day in 1960 and 4.9 miles per day in 1961. This difference is significant and it will be considered below. There were no significant differences in rates of travel to the outlet from the 3 tag-release sites of 1961, the adjusted means being:

Halifax to outlet	- 4.9 miles/day
Morrison to outlet	- 4.2 miles/day
Sandspit to outlet	- 4.4 miles/day
and, the overall 1961 mean	- 4.6 miles/day

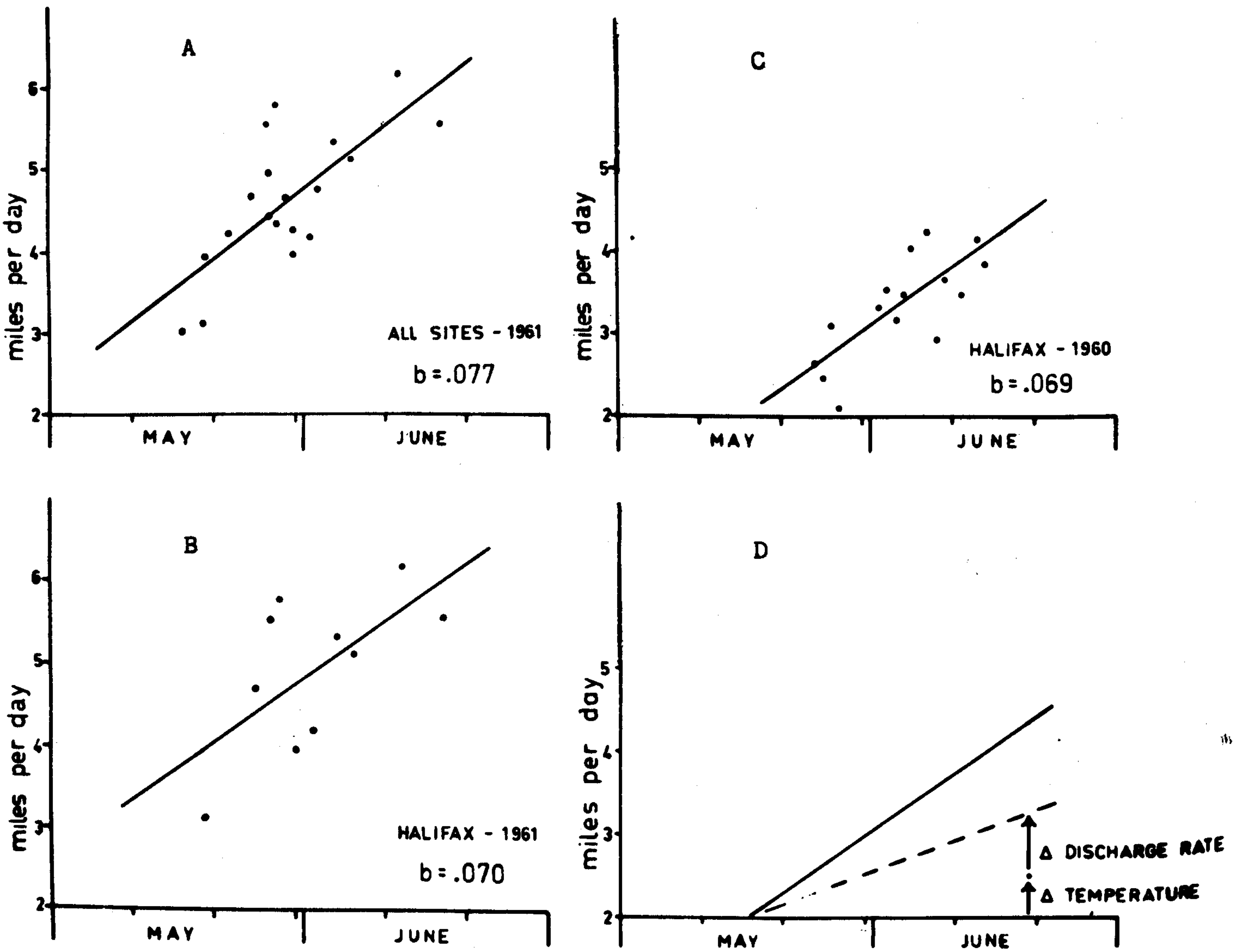


Fig. 11. Rates of travel on most direct route from tag and release sites to the outlet recovery site showing regression lines and regression coefficients.

A. All tag releases, 1961.

B. Halifax tag releases, 1961.

C. Halifax tag releases, 1960.

D. Solid line is the regression line of C; broken line shows the increase in rate of travel which might have been expected as a result of increasing temperature and discharge rate during this period, 1960.

We might next ask if these rates of travel as indicated by tagging are reasonable with respect to the swimming abilities of this species and the diurnal and seasonal timing of the migration.

The cruising speeds of sockeye salmon smolts as determined experimentally by Brett and his associates indicate that smolts of the size and in the temperature range with which we are dealing are capable of sustained swimming speeds of 0.8 to 1.1 ft/sec. Direct measurements of the actual speed of near-surface, migrating schools made at Babine Lake during 1960 and 1961 showed speeds ranging from .65 to 1.0 ft/sec with a mean of 0.8 ft/sec. To accomplish the rates of travel to the outlet shown by tagging, these fish would have had to swim on direct course at this speed (0.8 ft/sec) for a total of 6 1/2 (1961) to 8 1/2 (1960) hours each day. A number of sources give evidence that approximately this number of hours of each day is spent in active migration. Figure 12 shows the diurnal distribution of two activities indicative of migration as observed in aquaria-held smolts. Both fluttering and position changes show diurnal peaks at dusk and dawn. The exodus of smolts from lakes as shown by catches at the outlet characteristically show peaks at dusk and dawn — the dusk peak being the predominant one. Direct observation of near-surface migratory activity in the lake itself also verifies this. Migration may, of course, be proceeding at greater depths; however, the consistent evidence of migrating schools by the hundreds suggests this near-surface migration around dusk and continuing into darkness as the major phenomenon. Certainly the lake migration is not going on continuously for, with rare exceptions, schools observed near surface during the day are either stationary or moving slowly and randomly and obviously feeding (shown also by stomach contents).

The seasonal timing of the migration is also in good agreement with rates of travel to the outlet shown by tagging. Figure 13 shows the lake distribution of sockeye prior to the 1960 migration, together with a graph showing their progressive exodus as indicated by the mark and recapture estimates at the outlet. The first smolts left the lake on May 3 and their rate of exodus in the next few days increased explosively and then declined again after May 10. During this early peak of exodus from May 4 to 12, an estimated 14 million smolts passed the outlet; they were fish of small mean size that obviously had originated from the heavily populated basins nearest the outlet. The out-migration remained relatively low from May 13 to May 23 (during which an estimated 6 million passed the outlet), followed by a second peak from May 23 to June 9 when an estimated 25 million passed downstream. This later peak obviously originated from the furthest up-lake regions, as evidenced by (1) decreasing lake catches reflecting an emptying of the North Arm as the early peak progressed, and (2) increased lake catches and the manifestation of increased near-surface migration activity directed toward the outlet in the North Arm—Halifax Narrows region after May 18.

If all smolts commenced their migration at the same time and travelled on a quite direct route to the outlet at the average speed of 3.5 miles per day shown by tagging, this picture of their rate of exodus at the outlet is approximately what would be expected, for the near-outlet concentration of smolts would peak within a few days and the second peak from the furthest up-lake concentration (centered about 75 miles up-lake) would be expected about 22 days later.

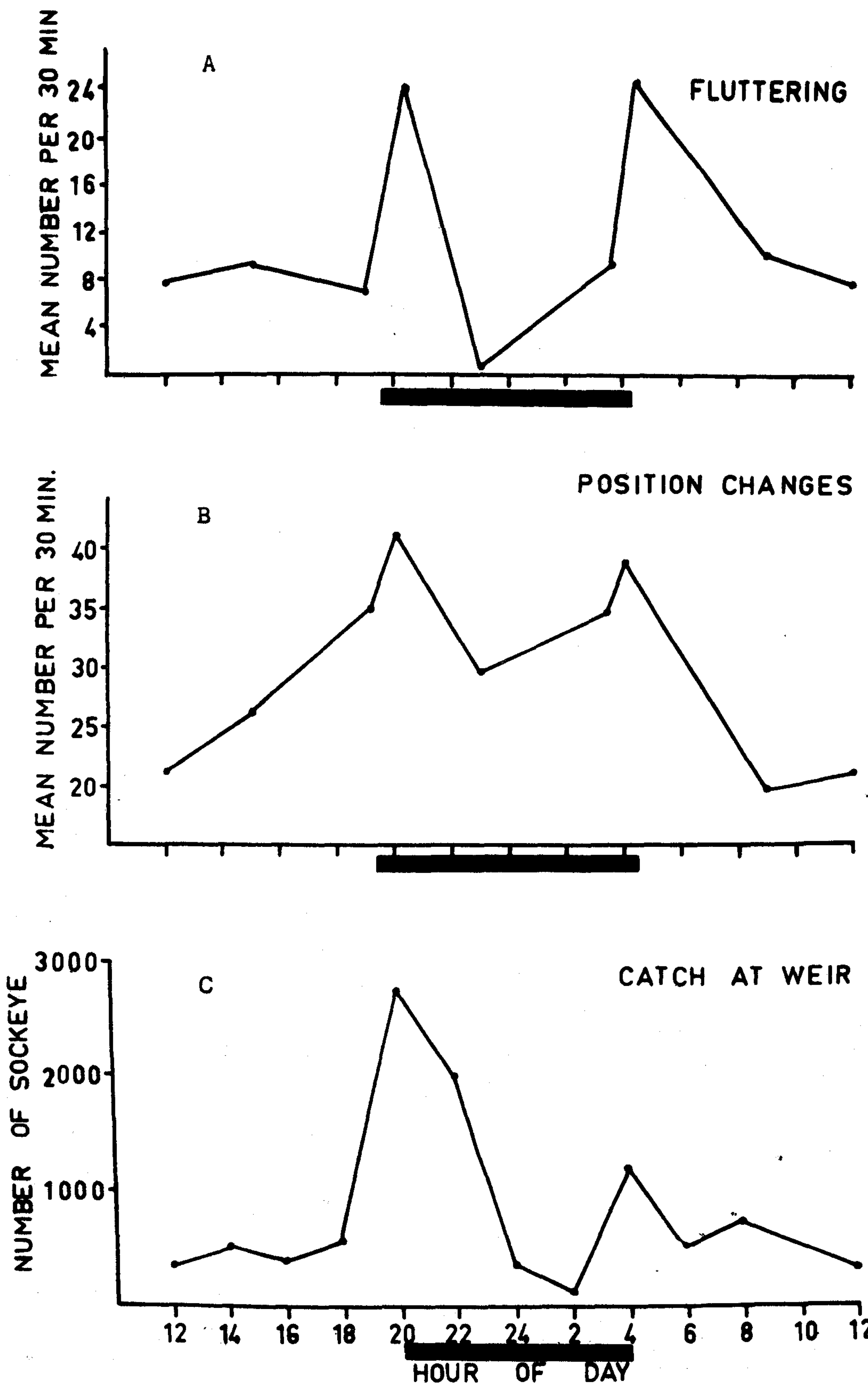


Figure 12. Diurnal distributions of:

A. Fluttering (after Groot)

B. Position changes (after Groot)

C. Total catch at lake outlet during migration (after Brett and Alderdice, 1958).

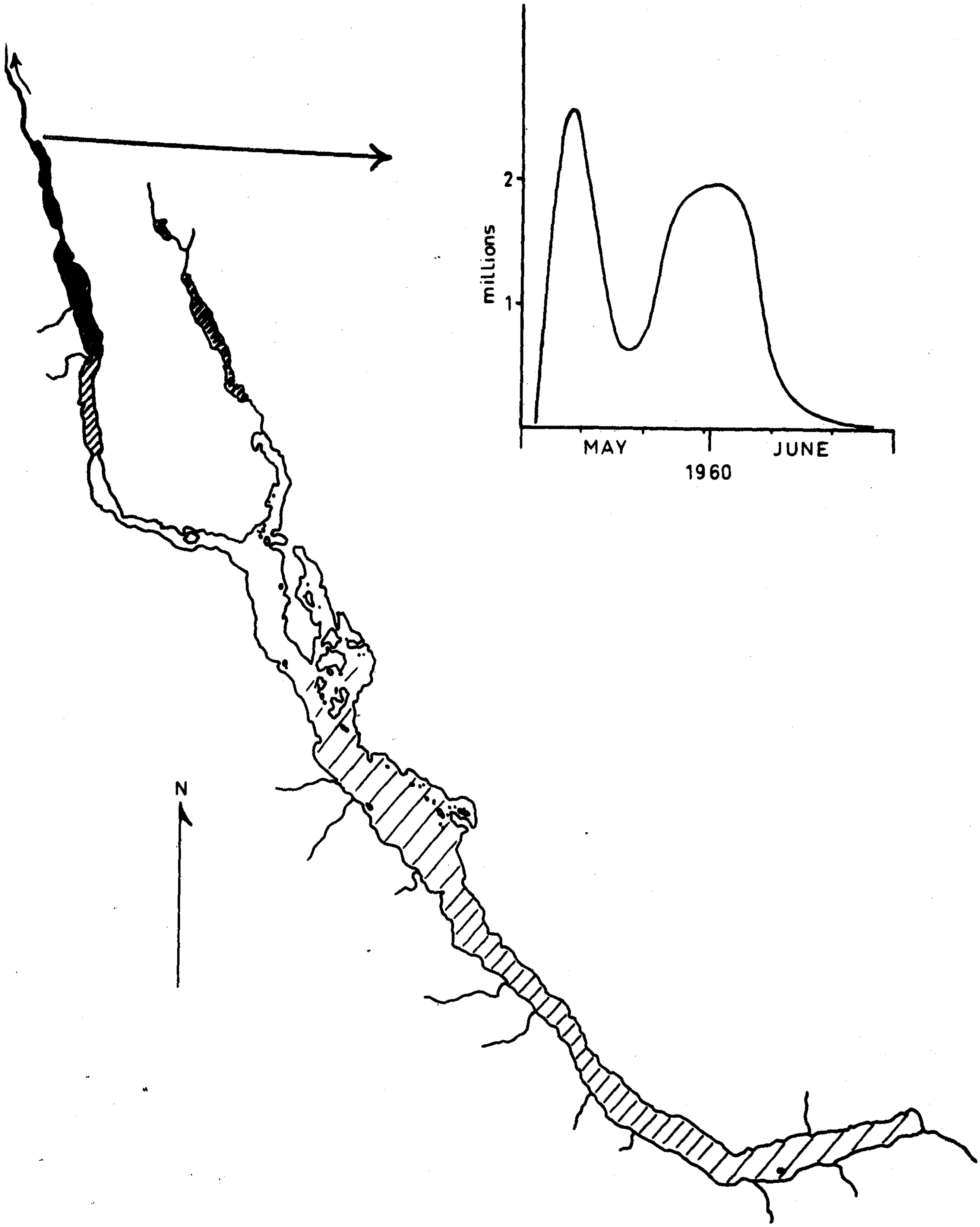


Figure 13. Map showing the distribution of sockeye prior to migration and graph illustrating their migration from the lake as estimated at the outlet.

The 1961 exodus from the lake (from a similar lake distribution) followed a similar pattern except that the second peak followed sooner after the first. This appears reasonable from the faster mean rate of travel of up-lake smolts to the outlet in 1961 than in 1960 as shown by tagging.

All evidence indicates that the migration of smolts through the lake to the outlet is an active and well-oriented migration on a quite direct route to the outlet. Also, it appears that commencement of the migration from all lake regions is triggered at about the same time - likely by a common stimulus.

The work by Groot indicates the importance of celestial phenomena in orientation. Comparison of the results of tagging in 1960 and 1961 provide supporting evidence for this work. It was noted above that the rate of travel of smolts to the outlet was significantly faster in 1961 than in 1960. Examination of the records of hours of sunshine at the nearest weather station (30 miles from the lake) (Fig. 14), shows that there were 376 hours of bright sunshine during the period May 1 to June 20 in 1961 as compared to 296 hours for the same period in 1960. This might indicate that in 1961, with the sunshine record indicative of more clear skies, the sockeye smolts were able to orient better, so keep on a more direct course to the outlet and thus show a higher rate of travel. This is, of course, only a two-point correlation. However, further examination of this hypothesis is available by comparing the rates of travel shown from the various tag releases and the hours of sunshine on the days immediately following release. This relationship was examined for all releases in which the number of recaptures was 10 or more (Fig. 14A). Rates of travel were adjusted to a common date (as outlined earlier). The number of days immediately following release date, which forms the basis for mean hours of sunlight, were as follows:

Halifax site:	-	5 days
Morrison site:	-	8 days
Sandspit site:	-	12 days

These periods were determined by distance to outlet and the time taken to cover the distance by the faster-migrating fish as shown by tagging. As shown in Figure 14A there is a positive relationship between mean hours of sunshine for the days immediately following release and rate of travel to the outlet. This evidence supports the view that celestial phenomena might be important as guiding cues in the orientation during this migration.

(7) Nanika River sockeye salmon rehabilitation program

During the spring of 1961 the first sockeye incubated in the Nanika River Hatchery were released as fry. Of the estimated 309,000 eggs transferred to the hatchery from 15-Mile Creek during September, 1960, 74,000 fry representing 23.6 percent of the eggs transferred were released from the hatchery. The main causes of the very high mortality of eggs and alevins appeared to be accumulation of silt in the baskets and frequent reductions of flow to the incubating stacks. The reductions in flow to the stacks were caused by accumulation of debris in the water lines and taps.

The release tank used in 1961 consisted of a 4 x 4 foot wooden tank 4 feet deep with a bottom intake and a surface spillway outlet leading to the

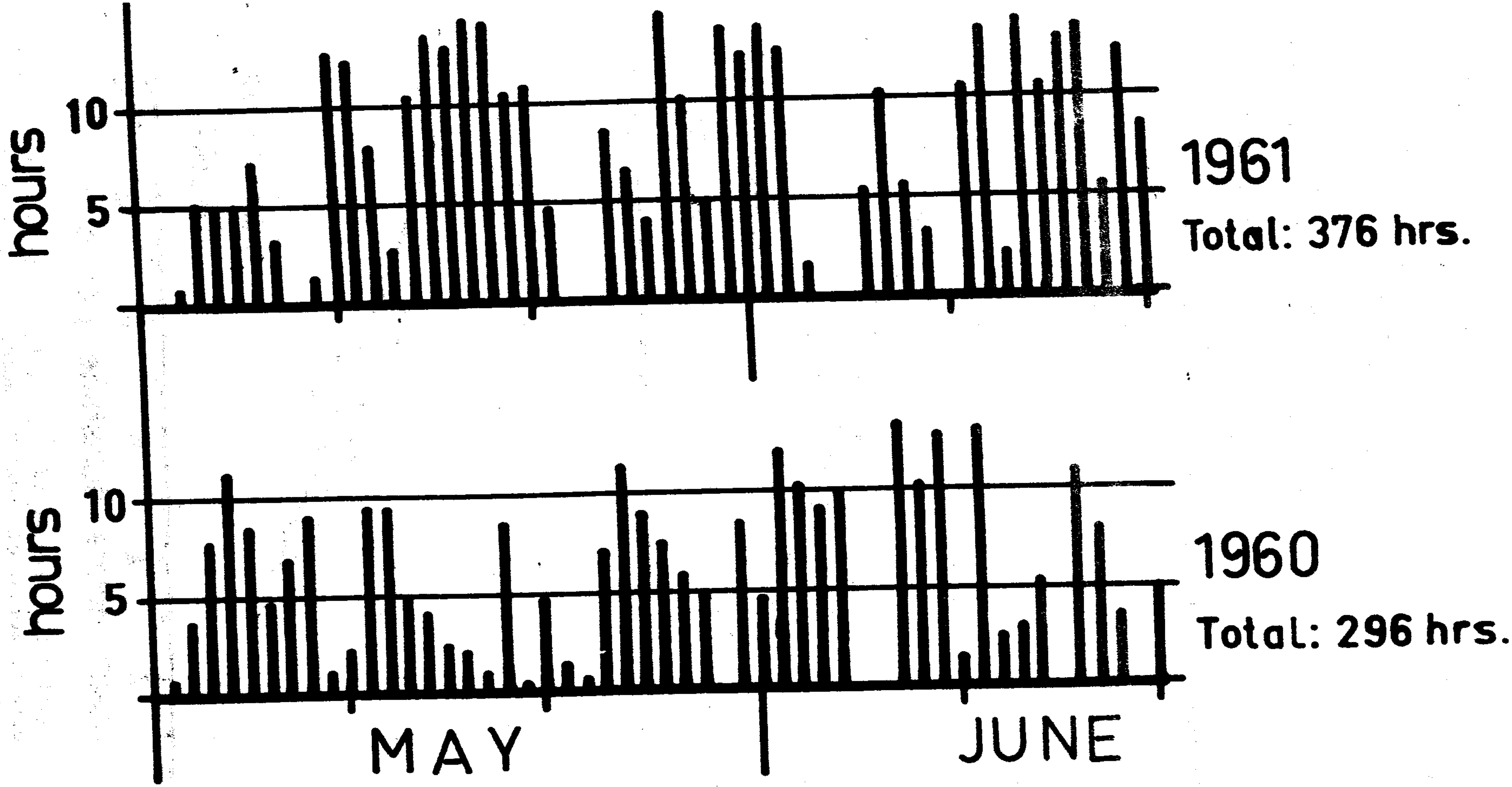


Fig. 14. Hours of bright sunshine per day at Smithers, B. C.

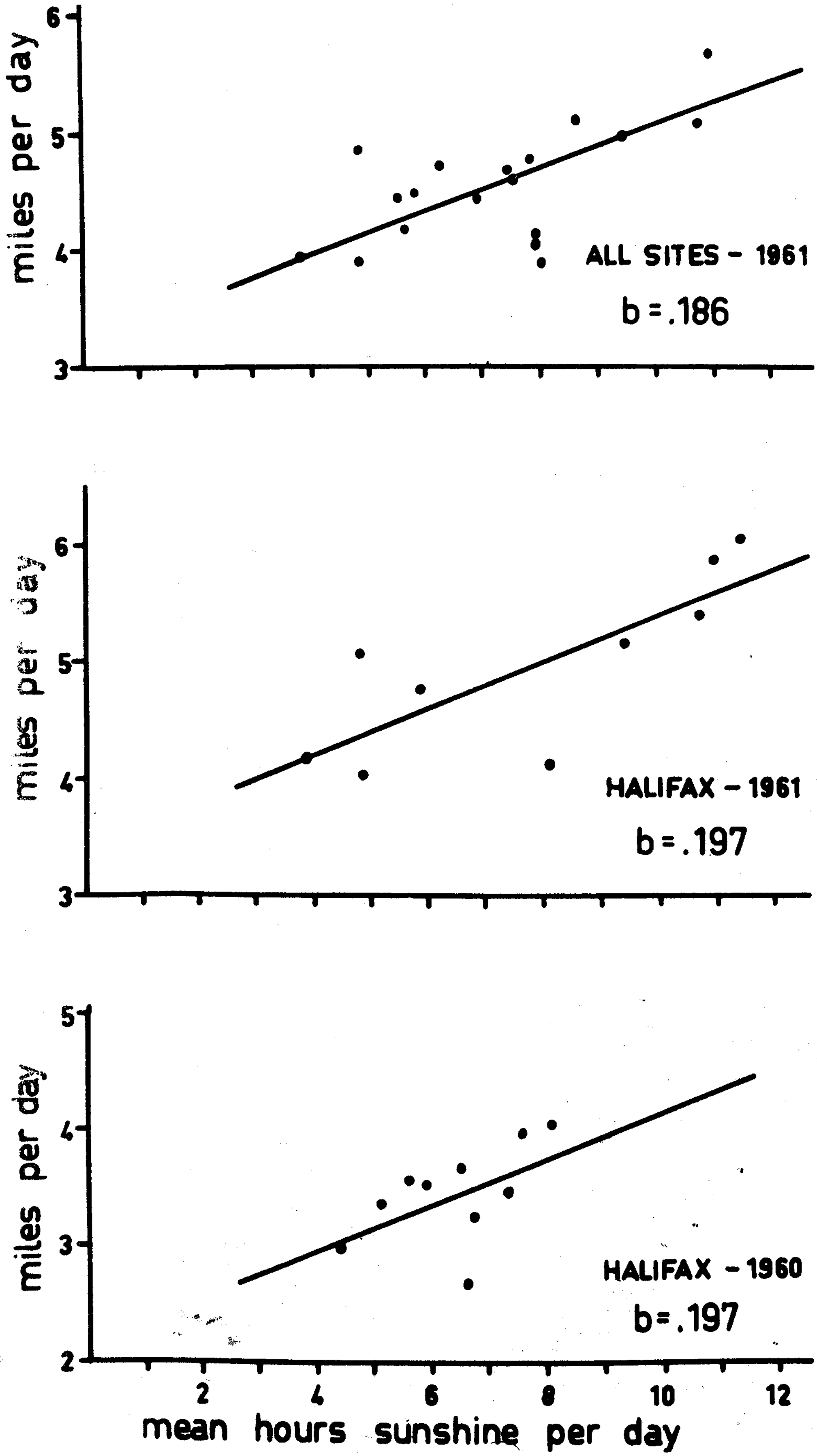


Figure 14 A. Relationship between adjusted rates of travel on most direct route to outlet as shown by tagged fish and the mean hours of sunshine per day on the days immediately following release. Regression lines and coefficients are shown.

river. A screen false bottom was installed several inches above the inlet lines and the fry were therefore supplied with fresh water upwelling from the bottom of the tank. The fry were permitted to leave the tank during the hours of darkness.

The operation completed in 1961 was of value to test equipment and assess weather, transportation and communication problems. The 74,000 fry released cannot be considered a significant contribution to the system but the problems encountered during their incubation have resulted in modifications that will greatly benefit future production.

During the summer of 1961 the permanent diesel electric plants and the electric pumps were installed and 23 of the permanent stacks of incubator trays were made ready. The new stacks increased the capacity to more than five million eggs. The incorporation of clean-out drains reduced the possibility of accumulation of silt in the baskets and the installation of screens in the water lines and a different type of tap reduced the occurrence of flow reduction. In addition, an alarm system was installed to provide instant warning of reduction of flow to any stack.

A 10,000 gallon wood stave tank was installed at ground level and connected to the hatchery water outlet to serve as part of a re-circulation system to be used if for some reason water could not be pumped from the river. This tank will be modified to serve as a release tank in the spring of 1962.

Also completed in 1961 was a building to provide storage, a workshop, and additional personnel accommodation.

In September 5.2 million eggs were transferred from 15-Mile Creek, Babine Lake to the hatchery. These were distributed to the trays in loadings of 10,000 to 15,000 eggs. The eggs were picked at the eyed stage during October and survival to that time was approximately 95 percent. Mortality has been negligible during the remaining period of incubation. The eggs were provided with water at the rate of three gallons per minute to each stack and this was increased to six gallons per minute when hatching began. The increase of flow was considered important as an extra safety factor.

In 1962 the balance of the incubator trays will be installed, thus increasing the capacity to 10 to 13 million eggs.

During 1961 lake studies and a limited tow-netting program were conducted on Morice Lake to assist in evaluating the productive capacity of the lake and to obtain an index of abundance and a measure of the distribution of sockeye juveniles. Also, in order to obtain a measure of abundance and timing of migration, the smolt population leaving Morice Lake was sampled by means of an inclined plane trap.

Data obtained at Moricetown Falls and on the spawning grounds in connection with the hydroelectric study were also important to the assessment of the rehabilitation project.

(8) Proposed hydroelectric developments in the Bulkley-Babine area

In January, 1961, the B. C. Power Commission announced that it was interested in proceeding with plans to develop hydroelectric power at Moricetown Falls on the Bulkley River by means of a dam which would raise the normal water level of the Bulkley in order to develop from 75 to 95 feet of head. Power would be generated at site and would be used to serve the area Burns Lake to Hazelton, and possibly Terrace. This proposal envisaged, as a second stage, the construction of a storage dam at the outlet of Morice Lake which would raise the water level of this lake by as much as 20 feet.

In view of the importance of the Bulkley River system as a salmon producer, the Department of Fisheries immediately advised the Power Commission that several years of intensive studies would be required to assess the fisheries problems posed by the proposed power developments. In its reply, in February, 1961, the Power Commission stated that the need for a new power source in the area was so urgent that it could not await the outcome of these studies, and that it therefore was directing its attention to the development of smaller blocks of power on Fulton and Pinkut Creeks, tributary to Babine Lake, pending assessment of the Moricetown problems.

The Department was gravely concerned with the fisheries problems inherent in the development of these two sites as well, and concluded that while these problems might not be as numerous and as complex as those associated with Moricetown, they nevertheless required very careful consideration before any decision could be reached as to whether or not the proposed power development would result in serious losses to the fishery. The Power Commission was notified therefore that several years of careful study would be required at these sites. Their reply indicated that they could not await the outcome of these studies, and that they would proceed with plans for the development of the Fulton site in accordance with a schedule which would put the plant in service by October, 1963 (construction to start early in 1962).

To date, a water licence for the Fulton project has not been issued, and there is some indication that this project might be deferred or abandoned as a result of the recent amalgamation of the B. C. Electric Company and the Power Commission. In the meantime, studies of the possible effects of these developments by Department of Fisheries engineers and biologists are continuing, as outlined hereunder, and the information being obtained will be useful, whether or not the power projects are undertaken.

a. Fulton River biological survey

The Fulton River is the most important salmon spawning stream in the main basin of Babine Lake.

A tagging and recovery program designed to provide a measure of population size, distribution and timing of spawning sockeye salmon was carried out on the Fulton River in 1961. In addition, daily temperatures were obtained from two locations on the river and thermal conditions were measured in Fulton Lake periodically during the year.

A preliminary estimate of the sockeye escapement to the Fulton River was made, amounting to 192,000 fish. The main period of entry to the river was August 28 to September 19 and the peak spawning period was September 16 to October 9. Examination of dead females for retained eggs indicated a spawning efficiency in excess of 95 percent.

A falls nearly 100 feet high located approximately four miles upstream from Babine Lake forms the upper limit of migration of salmon in the Fulton River. For approximately one-half mile below the falls the river flows through a steep-walled canyon and the river bottom is largely bed rock and boulders. Spawning here is very light. Most of the population spawned in three miles of river below the canyon. No spawning was observed in the lower one-third mile of river. The spawning grounds did not generally appear to be over-crowded.

During the spring of 1962 the emergent fry will be sampled using gear similar to that used to sample pink fry on the Skeena. This equipment will permit both vertical and horizontal sampling within a stream cross-section.

With the addition of this information a preliminary assessment of the fisheries problems associated with the proposed hydroelectric development should be possible.

b. <u>Bulkley River biological survey</u>

In 1961 biological studies were carried out on the Bulkley River system to define the fisheries problems associated with the proposed hydroelectric development. A tagging program was carried out at Moricetown Falls and the spawning grounds were surveyed to provide information on the population, size, timing of migration and distribution of all species of salmon utilizing the system.

All species of Pacific salmon and steelhead trout migrating upstream through the Moricetown fishways during the main migration period were enumerated. Numbers of fish and their time of passage at Moricetown are described in Table VIII.

Table VIII. Numbers of fish passing through Moricetown fishways and timing of migration.

Species	Number tagged	Peak migration period
Sockeye	5423	July 27-August 5
Pinks	8531	August 4-21
Coho	7226	August 10-24
Springs	916	July 25-August 4
Steelhead	792	August 17-31
Total	22,888	

All species of salmon and steelhead trout were tagged at Moricetown below the fishways. Tagged fish were recovered in the fishways, from the Indian fishery and on the spawning grounds. Preliminary calculations using the fishway counts and tag recoveries showed that 18,043 sockeye, 23,964 pink and 26,310 coho salmon reached Moricetown. Insufficient data were available to permit calculation of escapements for the other species.

After subtracting the estimated number of salmon caught by the Indian fishery the estimated escapement above Moricetown Falls is reduced to 14,000 sockeye, 21,500 pink and 24,000 coho salmon.

The sockeye salmon escapement to the Nanika River was estimated at 5,000 fish. The balance of the population, an estimated number of 9,000 fish, spawned on the beaches of Morice Lake and in the Atna River system.

Pink salmon were observed spawning in the lower Morice River and in the Bulkley River near the mouth of the Morice River. No estimate was made of the numbers of fish spawning in these areas.

The main concentration of spawning spring salmon was located in the upper ten miles of the Morice River. This population was estimated at 2-5,000.

Coho salmon were observed in the Bulkley River, Morice River and at the mouth of the Nanika River, and were caught in gill-nets set at several sites on the shore of Morice Lake. No estimate of the numbers of coho salmon spawning in these areas was made.

During 1962 studies will be continued to collect information necessary for defining the problems associated with the proposed hydroelectric development. The sockeye fry migration from the Nanika River and the smolt migration from Morice Lake will be sampled and the juvenile sockeye population in Morice Lake will be examined. In addition, the program at Moricetown Falls and on the spawning grounds will be repeated.