INTERNATIONAL PACIFIC SALMON FISHERIES COMMISSION

APPOINTED UNDER A CONVENTION
BETWEEN CANADA AND THE UNITED STATES FOR THE
PROTECTION, PRESERVATION AND EXTENSION
OF THE SOCKEYE SALMON FISHERIES IN
THE FRASER RIVER SYSTEM

BULLETIN V

THE SELECTIVE ACTION OF GILLNETS ON FRASER RIVER SOCKEYE SALMON

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THE SELECTIVE ACTION OF GILLNETS ON FRASER RIVER SOCKEYE SALMON

INTRODUCTION

In the program undertaken by the International Pacific Salmon Fisheries Commission for the rehabilitation of the Fraser River sockeye salmon runs particular consideration is being given to the quantitative and qualitative features of the escapements of fish to the spawning grounds. While provision for optimum numbers reaching the spawning areas is essential, it is possible that gillnet selectivity may have an effect on productivity if the average size of the individuals of a population and thereby the average number of eggs is reduced or if the sex ratio is greatly changed from the normal relationship.

The present report is a study of the selective action of linen gillnets for size, age class, sex ratio and numbers of sockeye salmon. The results from two years of experimental fishing with various mesh sizes of gillnet are presented. The selectivity of the commercial fishery is indicated. Variations in the size and sex ratio and possibly numbers of fish in the escapement are shown to be related to the indicated selectivity of the commercial gillnet fishery.

TYPES OF FISHING GEAR IN THE FRASER RIVER SOCKEYE FISHERY

The commercial fishery for Fraser River sockeye salmon operates with four types of fishing gear, namely, purse seines, gillnets, traps and reef nets. The fishery in the United States Treaty waters is predominantly a purse seine fishery, with the bulk of the sockeye being caught in the "inside" waters on the migration paths between Salmon Banks (San Juan Islands) and Point Roberts, but also with relatively small catches being made during certain years in the High Seas area near Swiftsure (Plate 1). Gillnets and reef nets, which operate in the "inside" waters, catch small numbers of sockeye in relation to the purse seines and can be considered of lesser importance. The trap fishery, which was abolished after 1934 in Puget Sound by the passage of an initiative measure in the State of Washington, was formerly the most important fishery in United States waters.

In Canadian Treaty waters (Plate 1) the main fishing gear is the drift gillnet which takes the major portion of the Canadian sockeye catch. Gillnets were the first to be developed of the four types of gear used on the Fraser River sockeye, and from 1873 to 1934, according to Rounsefell and Kelez (1938), gillnets captured 46 per cent of all sockeye taken by both nations. The predominant gear in the present Canadian fishery is still the gillnet. Three to five fish traps

This investigation was outlined originally by Dr. R. Van Cleve, now Director of the School of Fisheries, University of Washington. While the scope of the earlier investigation has been widened, appreciation is expressed by the Commission for the valuable data collected under the supervision of Dr. Van Cleve and for his helpful criticisms in the preparation of this initial report.

operate at Sooke on Vancouver Island, but their catches are negligible by comparison. Purse seines have been permitted to fish off the mouth of the Fraser River for restricted time periods during the late-season fishing in certain years for either sockeye or pink salmon, and in recent years purse seines have fished along the "West Coast" of Vancouver Island with increasing success. However, the bulk of the Canadian catch is still being taken by the gillnet fleet operating in the lower reaches of the Fraser River and in the adjacent Georgia Strait. In recent so-called "big" years, such as 1946, as many as 3,000 gillnet boats have operated in this area. The upper limit of the fishing area in the river is at Mission about 50 miles upriver from the mouth, as shown in Plate 1.

The gillnets are not restricted as to mesh size during sockeye fishing periods, and a wide range of mesh sizes is used for taking sockeye varying from about 5 1/4 to 6 1/2 inch mesh, stretched measure. The most popular sizes of mesh range from 5 3/4 to 6 inch. Gradations in mesh size are most commonly by eighths of an inch, although 5 13/16 inch and more rarely 5 11/16 and 5 15/16 are also utilized.

In the very early days of the fishery there was no restriction on mesh size, but by 1882 a 5 7/8 inch minimum mesh size had been prescribed. In 1916 a 5 3/4 inch minimum was set, and in 1928 all mesh limitations for sockeye fishing were abolished, according to Rounsefell and Kelez (1938). However, for the spring salmon fishery prior to July 1 and for the fall fishery beginning about October 1 a 6 1/2 inch minimum mesh size, first set about 1923, has remained in effect. Also, since 1946 when the Salmon Commission began regulating the sockeye fishery, an 8 inch minimum has been prescribed for periods which have been closed to sockeye fishing for escapement purposes.

The depth of the gillnet is restricted to 60 meshes, while the length limitation is 150 fathoms in the river above Garry Point and 200 fathoms outside the river below Garry Point.

Only the floater drift gillnet, described fully by Craig and Hacker (1940), is allowed. Sunken nets (diver nets), trammel nets and net aprons are prohibited. Until very recently the gillnets used on the Fraser River have been exclusively of linen mesh, but in 1952 a considerable number of nets having a mesh made of nylon twine were also fished.

On the Fraser River the sockeye gillnet specifications vary with the individual fishermen not only by mesh size but also according to the size and ply of twine, method of "hanging" the net, color of webbing, brand of net and type of lines used, as described in Western Fisheries (1945).

The Fraser River gillnet boats vary greatly in length and design. Most are between 26 and 38 feet in length. All now have the net roller on the stern and a power net drum near the stern for paying out and hauling in the net.

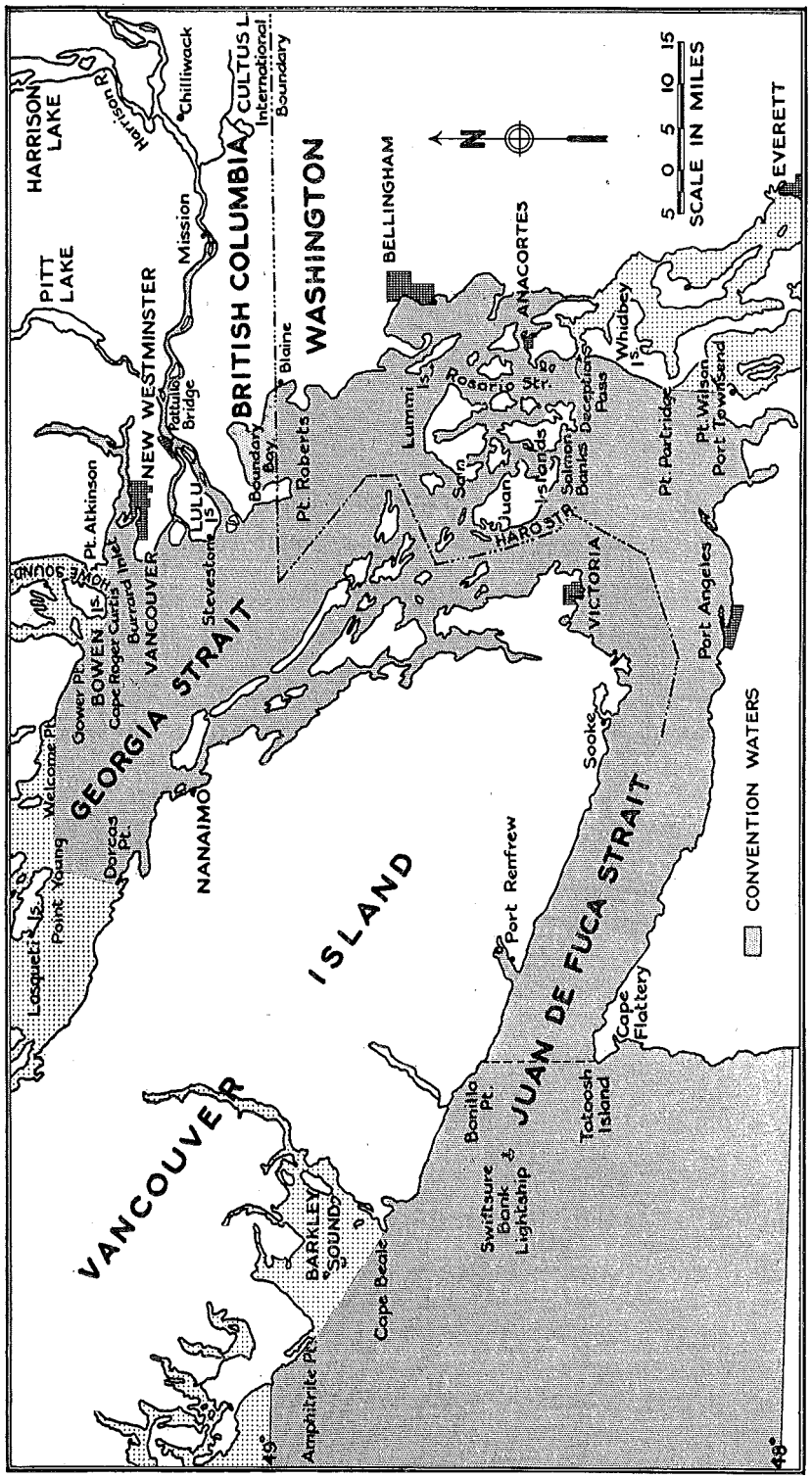

Plate 1. Commercial Fishery Waters of the Sockeye Salmon Fisheries Convention.

A LITERATURE REVIEW ON FRASER RIVER GILLNET SELECTIVITY

One of the first observations made on the selective action of gillnets for size composition and sex ratio of Fraser River sockeye salmon was by Gilbert (1914). From small samples of the 1913 trap catches landed at Esquimalt and Bellingham he noted that males and females were found in approximately equal numbers. The samples consisted of 138 males and 139 females at Esquimalt and 598 males and 607 females at Bellingham. Contrasted with this equality of the sexes was the sample from Steveston gillnets taken between July 7 and August 15 where the males numbered 323 and the females 210. Gilbert also compared length frequency distributions by separate sexes from the Bellingham trap landings with those of the Steveston gillnet landings and noted that the gillnet fish of both sexes were slightly larger. The lengths, taken from the tip of the snout to the fork of the tail over the curve of the body, averaged for males 24.70 inches from gillnets and 24.46 inches from traps and for females 24.20 inches from gillnets and 23.78 inches from traps. Gilbert's data indicated that the 1913 gillnet fishery may have been selective for males and for the larger fish.

A summary of sex ratio data presented by Gilbert (1917-1925) and Clemens and Clemens (1926-1938) shows that the average annual percentages of all males and females sampled at the Sooke fish traps on Vancouver Island from 1915 to 1937, inclusive, were 50:50. For the predominantly abundant four-year-old age group the average percentages for the combined years were 49 per cent for males and 51 per cent for females. Variations in annual percentages in this age group were from 55:45 to 42:58.

Foerster (1931) referred to the diverse ratio of males to females in the escapement at Cultus Lake in the years, 1925-1929. In 1925 the ratio of males to females was two to five, in 1927 one to two, 1928 one to three and 1929 one to two. In 1926 the run was predominantly male in the ratio of five to three, but these males were mainly the small "jack" three-year-olds preceding the dominant 1927 run. The "jacks" are so small in size that they are rarely taken in the gillnet fishery.

Foerster (1936) indicated from the returns of marked sockeye salmon in 1932 and 1933 released at Cultus Lake in 1930 and 1931 that the Fraser River gillnet fishery may be highly selective for males. He showed that in 1932 58.6 per cent (480 males, 339 females) of the recoveries in the gillnet fishery were males; 38.5 per cent (436 males, 695 females) were males in the commercial fishery excluding the Fraser River; and 25.8 per cent (465 males, 1,334 females) were males in the spawning escapement (from the 1930 marking). Similarly, the 1933 recoveries consisted of 57.3 per cent males (1,038 males, 772 females) from the gillnet fishery; 44.3 per cent males (3,259 males, 4,092 females) from the remainder of the commercial fishery; and 35.8 per cent males (1,022 males, 1,834 females) in the escapement (from the 1931 marking). In both years the gillnet recoveries were preponderantly male while the other commercial recoveries

from mainly purse seines and traps had a much lower percentage of males. In both cases the escapement showed the lowest percentage of males of any of the three recovery areas.

The returns in 1938 recorded by the Commission from another Cultus Lake marking experiment originally undertaken by the Fisheries Research Board of Canada showed a recovery from the Fraser River gillnet fishery of 54.0 per cent males (538 males, 458 females); from the U.S. purse seine fishery 42.4 per cent males (1,040 males, 1,413 females); and from the escapement 17.9 per cent males (1,597 males, 7,347 females). As in the case of the previous Cultus Lake experiments a comparatively high percentage of males was taken in the gillnet fishery, while a low percentage of males occurred in the escapement.

THE USE OF CONTROLLED FISHING IN THE DETERMINATION OF GILLNET SELECTIVITY BY MESH SIZE

Experimental Methods and Equipment

Controlled fishing experiments were conducted by the Commission in 1947 and 1948 using ten different sizes of mesh covering the full range of sockeye mesh sizes and small spring salmon mesh sizes, namely 5 1/4, 5 1/2, 5 3/4, 6, 6 1/4, 6 1/2, 7, 7 1/2, 8 1/4 and 8 3/4 inch mesh, stretched measure. Two chartered gillnet boats fished with the ten meshes simultaneously. Each boat used a 200-fathom net which was composed of five 40-fathom sections of gillnet with each section of different mesh. The experimental fishing was conducted only on the weekends closed to commercial fishing and only in the lower area of the main channel of the Fraser River between Steveston and the Sandheads Lightship, in order to avoid competition with the gillnet fleet and to avoid operating on populations already fished intensively by gillnets. The period of operation was from July 5 to October 5 in 1947 and from July 3 to September 26 in 1948. The boats fishing were the "Uriel" in 1947 and 1948, the "NBF-1" in 1947 and the "Coastal Chief" in 1948.

The distribution of the mesh sizes between the two boats and the respective position of each mesh in the full net were changed each weekend. In distributing the mesh sizes between the two boats, the ten sizes were grouped by two's into five groups with group I including the 5 1/4 inch and the 5 1/2 inch meshes; group II, the 5 3/4 inch and 6 inch meshes; group III, the 6 1/4 and 6 1/2 inch meshes; group IV, the 7 inch and 7 1/2 inch meshes, and group V, the 8 1/4 inch and 8 3/4 inch meshes. Each boat fished with a mesh size from each of the five groups on every weekend (with the exception of the 8 1/4 inch mesh in 1947 which was not available until mid-season), and the designation of sizes in each group was determined randomly by a card-drawing system. The respective position of each mesh section in the full net was also determined in a random manner. The mesh sizes used by each boat each weekend in 1947 and 1948 are shown in Table 1. Neither end of the net can be classified as "boat end" or "buoy end", since the two ends were sometimes switched during the fishing operations.

TABLE I

MESH SIZES IN INCHES USED BY EACH GILL NET BOAT EACH WEEKEND IN 1947 AND 1948

		Boat NBF-1, 1947 Boat Coastal Chief, 1948 Position in Net					Boat Uriel, 1947 and 1948				
Dates		1	2	3	4	5	1	2	3	4	5
1947											
July	5- 6	5-3/4	7	5-1/4	8-3/4	6-1/2	6-1/2	7-1/2	5-1/2	6-1/4	6
	12-13	5-1/2	8-3/4	5-3/4	6	6-1/2	7	7-1/2	6	5-1/4	6-1/4
	19-20	5-3/4	7	5-1/2	7-1/2	6-1/4	5-1/4	6-1/2	5-1/2	6	8-3/4
	26-27	5-1/2	7	5-3/4	7-1/2	6	6-1/4	5-1/4	8-3/4	6	6-1/2
Aug.	2- 3	5-3/4	5-1/4	6-1/2	7-1/2	7	7-1/2	6	8-3/4	5-1/2	6-1/4
	9-10	7-1/2	5-1/4	8-3/4	5-3/4	6-1/4	7	7-1/2	6-1/2	5-1/2	6
	16-17	8-3/4	6-1/4	6	7-1/2	5-1/2	7	5-1/4	7-1/2	6-1/2	5-3/4
	23-24	6-1/2	6	5-1/2	8-1/4	7	7-1/2	5-3/4	5-1/4	8-3/4	6-1/4
	30-31	7	6-1/4	6	8-3/4	5-1/4	8-1/4	5-3/4	6-1/2	7-1/2	5-1/2
Sept.	6- 7	6-1/2	8-3/4	5-1/2	7-1/2	5-3/4	5-1/4	6	6-1/4	7	8-1/4
	12-14	5-3/4	7-1/2	6-1/4	5-1/2	8-1/4	5-1/4	6	7	6-1/2	8-3/4
	19-21	5-1/2	8-3/4	6-1/2	6	7	6-1/4	8-1/4	5-3/4	5-1/4	7-1/2
	26-28	6	7-1/2	8-1/4	5-1/4	6-1/4	7	5-1/2	8-3/4	6-1/2	5-3/4
Oct.	3- 5	6-1/4	7	6	5-1/4	8-1/4	5-3/4	5-1/2	6-1/2	7-1/2	8-3/4
1948											
July	3- 4	5-3/4	8-3/4	7	5-1/4	6-1/4	7-1/2	5-1/2	8-1/4	6	6-1/2
	10-11	5-3/4	8-1/4	5-1/4	6-1/4	7	8-3/4	6-1/2	6	7-1/2	5-1/2
	17-18	5-1/2	6-1/2	7-1/2	8-3/4	5-3/4	7	6	5-1/4	8-1/4	6-1/4
	24-25	6	5-1/4	7-1/2	8-3/4	6-1/4	6-1/2	7	5-3/4	5-1/2	8-1/4
July	31- 1	5-1/4	6-1/2	6	7-1/2	8-3/4	8-1/4	6-1/4	7	5-3/4	5-1/2
Aug.	6- 8	7	5-1/2	8-1/4	6	6-1/2	7-1/2	6-1/4	5-1/4	5-3/4	8-3/4
	14-15	8-1/4	5-3/4	6-1/4	7	5-1/2	8-3/4	6	5-1/4	6-1/2	7-1/2
	21-22	7-1/2	8-3/4	6	5-1/4	6-1/2	6-1/4	8-1/4	5-3/4	5-1/2	7
	28-29	7-1/2	5-1/4	8-1/4	5-3/4	6-1/4	5-1/2	7	6-1/2	6	8-3/4
Sept.	4- 5	6	6-1/2	8-3/4	5-1/4	7	8-1/4	7-1/2	5-3/4	6-1/4	5-1/2
	11-12	7-1/2	5-1/2	5-3/4	8-1/4	6-1/2	6-1/4	8-3/4	7	6	5-1/4
	18-19	6-1/2	6	7	8-3/4	5-1/4	7-1/2	5-1/2	5-3/4	8-1/4	6-1/4
	25-26	5-3/4	8-1/4	6-1/2	5-1/4	7-1/2	6-1/4	5-1/2	7	6	8-3/4

In the construction of the nets each mesh section was held to a standard depth of about 25 feet, the number of meshes deep ranging from 66 meshes in the 5 1/4 inch mesh to 39 meshes in the 8 3/4 inch mesh. The nets were "hung" similarly to those used by the majority of the fishermen of the Steveston to Sandheads fishing area. Each mesh size was "hung in from the half" with approximately 88 fathoms of stretched webbing utilized to make a fishing net 40 fathoms in length.

In 1947 the boats fished a total of 32 days between July 5 and October 5, inclusive. Prior to September 8 the boats fished two days each weekend (Saturday and Sunday), while after September 8 they fished three days each weekend (Friday, Saturday and Sunday). In 1948 the boats fished 27 days between July 3 and September 26. The boats fished two days every weekend except the weekend

of August 6-8 when they fished three days. Although a three-day weekly closure was in effect from August 6 to the last day of experimental fishing in 1948, the chartered boats fished only two-day weekends after the weekend of August 6-8 because it was deemed that adequate samples were being taken with the lesser amount of fishing.

The amount of time fished and the number of drifts made per day varied greatly, depending on such factors as number of fish present and tidal conditions. On the average each boat was out four to five hours a day making four or five drifts. However, at times the boats were out a maximum of eight or nine hours making eight to ten drifts each. The minimum time out fishing was about three hours with the boats making two or three drifts each in a day. It was not necessary to place any hard-and-fast restrictions on the fishermen regarding the amount of effort and time expended on fishing, since they fished on a percentage-of-the-catch basis. However, in certain instances when fish were scarce, a point was made to fish at least three hours usually making two long drifts or three shorter drifts. On the other hand, when fish were abundant, the numbers taken daily by each boat had to be limited to about 225 to 250 sockeye because of the lack of time to measure, weigh and determine the sex of any more than this number.

The fishing was done either in the ship's channel or on the bar adjacent to the channel at a number of different drift locations between Steveston and the Sandheads Lightship. The majority of the drifts were made starting from one of the following channel markers: 6 buoy, 12 buoy, 16 buoy, 18 buoy or 22 buoy (Plate 2). A few drifts were also made at 21 buoy, 24 buoy, the Albion dykes and at the Finn drift which is a short distance upriver from Steveston.

The two fishermen timed their fishing so that the majority of the drifts were made on an incoming tide beginning at lower low water. The first drift on an extremely low tide was fast because of the swift outgoing river current. By the time the second drift was in progress, the river current usually had decreased to a moderate outgoing current because of the incoming tide. The third drift was often made on a slow outgoing current; while the fourth and fifth drifts were made during a slow outgoing current, slack water or even a reverse tidal current in some cases.

The fishermen usually made the first drift or two the farthest downriver at 6 buoy or 12 buoy where the outgoing current was not as fast as at the drift locations farther upriver. Then as the tide came in, each drift was made farther upriver at the next adjacent drift location.

The two boats were equipped with power-driven net drums for paying out and hauling in the nets. All handling of the fishing gear and operating of the boats were performed by the two fishermen.

A logbook was used on each boat in which were recorded for each drift the time, the weather conditions, the relative speed of current, the location and direction of set and the mesh sizes fished. The time each of the five mesh sections was in the water was also recorded.

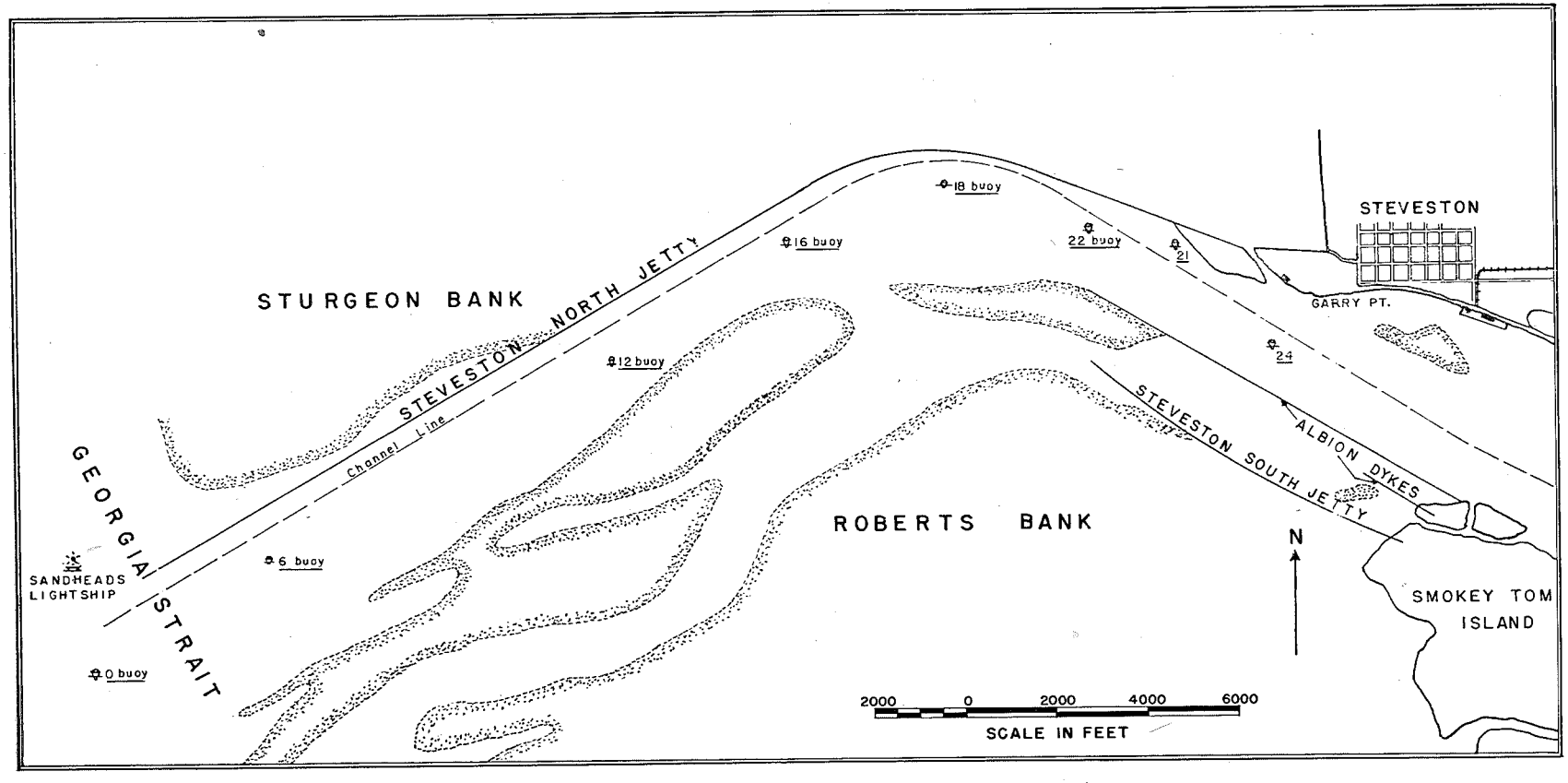

Plate 2. Fraser River from Steveston to Sandheads Lightship.

No measuring, weighing or sexing of fish was conducted on the fishing boats because of the limited time and working facilities available. Hence, each fish had to be marked in order that the mesh size by which it was taken could be identified after the fish were sampled at the cannery. Initially, each fish was marked by means of a numbered paper tag inserted in the mouth. However, this method was not entirely satisfactory, because some tags were lost during the unloading process at the cannery dock. A better method proved to be the use of numbered aluminum cattle tags affixed to the gill covers of the fish. None of these tags was lost during the unloading procedure.

Notes were kept on the activities of the hair seals around the nets. Seals were present on all fishing days in both years and they robbed the nets of unknown numbers of salmon. Ordinarily, during the regular fishing week the seal herd was spread out over the entire lower river fishing area, taking fish from the nets of the entire fleet; but on the closed weekends the seals concentrated on the nets of the two boats. Shotgun fire, used in an attempt to scare the seals from the nets, minimized the depredations.

One Commission observer was sufficient on each boat when the catches were light. However, when the catches were heavy it was necessary that two observers be aboard, one to mark fish, the other to keep the logbook record.

The fish were measured, weighed and sexed at the Imperial Cannery at Steveston. A measuring board was used to take the fork length (tip of the snout to the fork of the tail), maximum depth and maximum width of each fish; all measurements were taken to the nearest millimeter. Most of the weights were taken on a dial-type 30 lb. capacity spring scale, registering to the nearest ounce. A beam-type scale used prior to July 20 in 1947 was found to be too slow and cumbersome. The sex of each fish was distinguished positively by slitting open the fish and observing the gonads. Scale samples were also taken from each fish.

There was no chance of observer bias in measuring, weighing and sexing the fish. All fish from all mesh sizes were mixed in the different fish carts in the cannery. The mesh size in which each fish was caught was unknown to the sampling crew, since only the tag number was recorded with the measurements. All length, depth and width measurements on the catches of the two boats throughout both seasons of fishing were made by the same individual.

Shrinkage of Mesh Sizes

In order to determine the amount of shrinkage and to ascertain the exact size of each mesh used each weekend of fishing, a system of mesh measurements was carried out. On the day prior to each weekend of fishing measurements from each net section were made. Three strips of webbing from cork line to lead line, one strip near each end of the net and the third strip in about the middle of the net, were measured. A rigid steel rule was employed, and the measurements were made uniformly from the inside of one knot to the outside of the next knot with the twine stretched taut. The measurements were considered to be representative samples of the whole net sections.

Approximately 25,000 individual meshes from the ten mesh sizes were measured in the two years. In Figure 1 is shown the measured average size of each mesh size from 5 1/4 inch to 7 1/2 inch mesh taken at weekly periods throughout the 1947 season. Most of the shrinkage occurred during the first three weekends of fishing, and the various mesh sizes remained reasonably stable after these initial fishing periods. In both years at the first of the season the runs were very small, and therefore insignificant numbers of fish were caught while shrinkage was taking place in the nets. New nets were used at the beginning of both the 1947 and 1948 fishing seasons.

The total shrinkage during the first three weeks of fishing for the various mesh sizes in both years is shown in Table II. The average shrinkage in the different sizes ranged from 1/32nd to 4/32nds of an inch, with the average shrinkage of all sizes combined in both years equalling 2.6/32nds of an inch.

TABLE II

MEASURED AVERAGE SIZE AND SHRINKAGE IN THE DIFFERENT MESH SIZES USED IN THE MESH EXPERIMENTS

	1947 Nets		1948 Nets	
Labelled Size (Inches)	Shrinkage in 32nds of an inch	Measured Size After Shrinkage (Inches)	Shrinkage in 32nds of an inch	Measured Size After Shrinkage (Inches)
5-1/4	4	5-11/32	1	5- 9/32
5-1/2	3	5- 1/2	2	5- 1/2
5-3/4	2	5-13/16	2	5-13/16
6	3	6	4	6- 3/32
6-1/4	2	6- 9/32	2	6- 1/4
6-1/2	4	6- 1/2	4	6-19/32
7	3	7	2	7
7-1/2	1	7-15/32	1	7-15/32
8-1/4	4	8- 5/16	4	8- 1/4
8-3/4	2	8-25/32	3	8-21/32

Shrinkage values shown are during first three weekends of fishing. Measured sizes are averages of all measurements taken after this initial shrinkage.

The measured average sizes after the initial shrinkage compared favorably with the labelled sizes, but slight discrepancies which occurred are indicated in Table II. Seven of the ten mesh sizes in 1947 and six of the ten mesh sizes in 1948 measured within 1/32 of an inch of the factory labelled sizes. The discrepancies included the 5 1/4 inch mesh which measured 5 11/32 in 1947, the 5 3/4 which measured 5 13/16 in both 1947 and 1948, the 6 which measured 6 3/32 in 1948, the 6 1/2 which measured 6 19/32 in 1948, the 8 1/4 which measured 8 5/16 in 1947 and the 8 3/4 which measured 8 21/32 in 1948. Because the variations were small, the labelled sizes have been used in this report except in the correlation analysis between mesh size and fish length where the measured average mesh sizes were utilized.

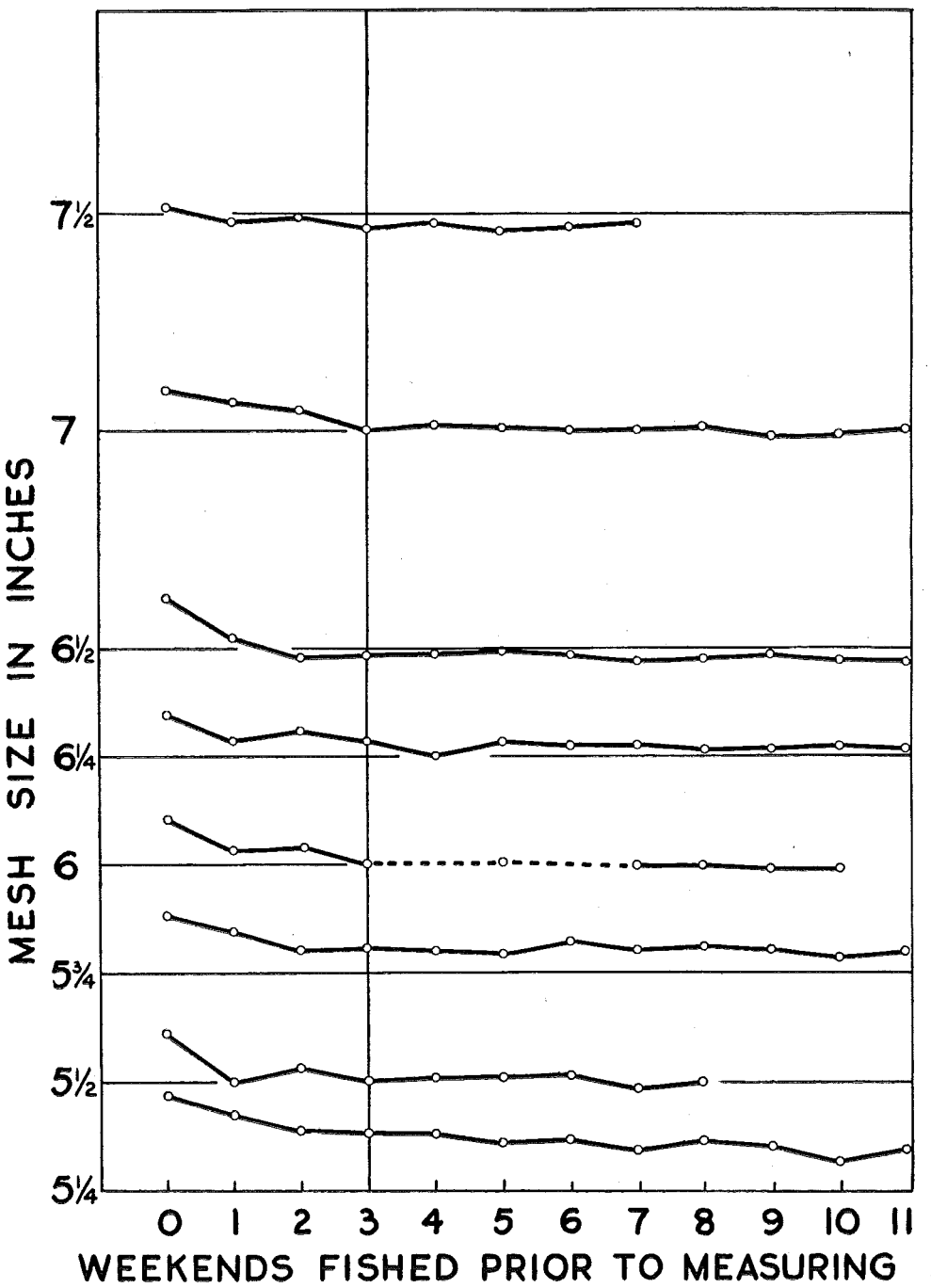

Figure 1. Measured Average Mesh Size of Gillnets Used in 1947 According to Length of Time Fished.

Comparison of the Weekend Catches between Boats

The numbers of sockeye caught on each weekend of fishing in both 1947 and 1948 by each boat are shown in Table III in three ways:

1. The actual catches, unadjusted for fishing time or number of drifts.
2. The catch per standard fishing time, with the catch of each mesh size adjusted to a standard fishing time of 5.5 hours per weekend (approximating average fishing time).
3. The catch per drift, determined by dividing the number of sockeye caught each weekend by the number of drifts made.

In Figure 2 are shown the actual sockeye catch, the catch per standard fishing time and the catch per drift each weekend throughout the 1947 season for each boat. It is noted that three "peak" catches, on the weekends of July 26-27, August 16-17 and September 19-21, occurred for each boat. Although fishing was good for both boats on these three weekends, the Uriel made larger catches than the NBF-1. This higher efficiency by the Uriel was in part due to its greater speed and maneuverability and partly due to the fishing methods and experience of the Uriel's skipper in the fishing areas between Steveston and the Sandheads Lightship. Most of the drifts made by the Uriel were in the deep water of the ship's channel, while many of the NBF-1 drifts were made on the bar adjacent to the channel. The channel drifts consumed less time than the bar drifts; hence, the Uriel in 1947 made more drifts and in addition caught more fish than the NBF-1. The total sockeye catch by boats during the 1947 season was 1,824 sockeye for the Uriel and 1,262 sockeye for the NBF-1.

In Figure 3 is given the actual catch, the catch per standard fishing time and the catch per drift each weekend throughout the 1948 season for each boat. The weekend catches in 1948 were poor at the start of the fishing season; then they gradually increased to a peak fishing weekend on August 6-8, and tapered off from this peak throughout the remainder of the season. The 1948 run was composed principally of fish headed for the Chilko River spawning grounds, according to the 1948 Annual Report of the Commission. Only one peak in the catch was established because of the predominance of this single race of sockeye. The catches made each weekend by the two boats were comparable and with little variation followed a similar trend throughout the 1948 season. The total sockeye catch for the two boats during the 1948 season was 1,806 for the Uriel and 1,629 for the Coastal Chief.

The sockeye catches per standard fishing time for each boat by weekend are shown in the middle graphs of Figure 2 for 1947 and of Figure 3 for 1948. All catches of each mesh have been converted to a standard fishing time of 5.5 hours per weekend, and the catches of the various meshes fished by each boat have been added to give the total catch for each boat. It was judged necessary to adjust the catch to a standard fishing time because of the variation in the amount of time the different meshes were fished within a weekend and also because of the variation in fishing time between weekends in a particular year.

TABLE III

NUMBER OF SOCKEYE CAUGHT BY EACH BOAT ON EACH WEEKEND THROUGHOUT THE 1947 AND 1948 SEASONS

Year	Actual Catch			Total %	Catch per Standard Fishing Time			Total %	Catch per Drift			Total %
	Uriel	NBF-1	Total		Uriel	NBF-1	Total		Uriel	NBF-1	Total	
1947												
July 5- 6	15	3	18	0.6	16.8	3.2	20.0	0.6	1.2	0.3	1.5	0.4
12-13	6	9	15	0.5	4.4	8.2	12.6	0.4	0.3	0.6	0.9	0.3
19-20	41	38	79	2.6	41.8	39.0	80.8	2.6	4.6	3.8	8.4	2.5
26-27	238	198	436	14.1	154.0	136.5	290.5	9.4	19.8	19.8	39.6	12.0
Aug. 2- 3	134	130	264	8.6	94.2	91.5	185.7	6.0	12.2	13.0	25.2	7.6
9-10	234	117	351	11.4	174.8	97.4	272.2	8.8	21.3	16.7	38.0	11.5
16-17	525	286	811	26.3	778.9	385.1	1164.0	37.7	47.9	47.7	95.6	29.0
23-24	18	14	32	1.0	28.6	25.2	53.8	1.8	2.2	2.8	5.0	1.5
30-31	68	85	153	4.9	79.5	103.7	183.2	5.9	7.6	12.1	19.7	6.0
Sept. 6- 7	52	26	78	2.5	68.9	32.5	101.4	3.3	6.5	4.3	10.8	3.3
12-14	186	110	96	9.6	138.1	71.0	209.1	6.8	10.3	12.2	22.5	6.8
19-21	265	212	477	15.5	261.2	178.6	439.8	14.3	24.1	30.3	54.4	16.5
26-28	30	30	60	1.9	28.7	23.1	51.8	1.7	3.0	3.8	6.8	2.1
Oct. 3- 5	12	4	16	0.5	15.9	4.7	20.6	0.7	1.1	0.4	1.5	0.5
TOTAL	1824	1262	3086	100.0	1885.8	1199.7	3085.5	100.0	162.1	167.8	329.9	100.0
	Uriel	Coastal Chief	Total	Total %	Uriel	Coastal Chief	Total	Total %	Uriel	Coastal Chief	Total	Total %
1948												
July 3- 4	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-11	2	2	4	0.1	7.6	3.9	11.5	0.4	0.3	0.3	0.6	0.2
17-18	17	33	50	1.5	23.9	28.7	52.6	1.6	1.7	3.7	5.4	1.5
24-25	175	157	332	9.7	211.6	176.7	388.3	12.1	15.9	22.4	38.3	10.5
31- 1	451	353	804	23.4	403.6	256.2	659.8	20.6	41.0	32.4	73.4	20.1
Aug. 6- 8	600	561	1161	33.8	479.7	482.4	962.1	30.0	60.0	56.1	116.1	31.8
14-15	250	245	495	14.4	218.2	215.2	433.4	13.5	22.7	30.6	53.3	14.6
21-22	160	130	290	8.4	189.2	135.3	324.5	10.1	20.0	18.6	38.6	10.6
28-29	20	34	54	1.6	30.8	51.8	82.6	2.6	2.5	4.2	6.7	1.8
Sept. 4- 5	38	34	72	2.1	40.6	54.0	94.6	3.0	4.2	5.7	9.9	2.7
11-12	28	28	56	1.6	28.5	34.6	63.1	2.0	3.5	4.0	7.5	2.0
18-19	39	12	51	1.5	42.3	16.5	58.8	1.8	4.3	1.5	5.8	1.6
25-26	26	40	66	1.9	34.7	39.3	74.0	2.3	3.7	5.7	9.4	2.6
TOTAL	1806	1629	3435	100.0	1710.7	1494.6	3205.3	100.0	179.8	185.2	365.0	100.0

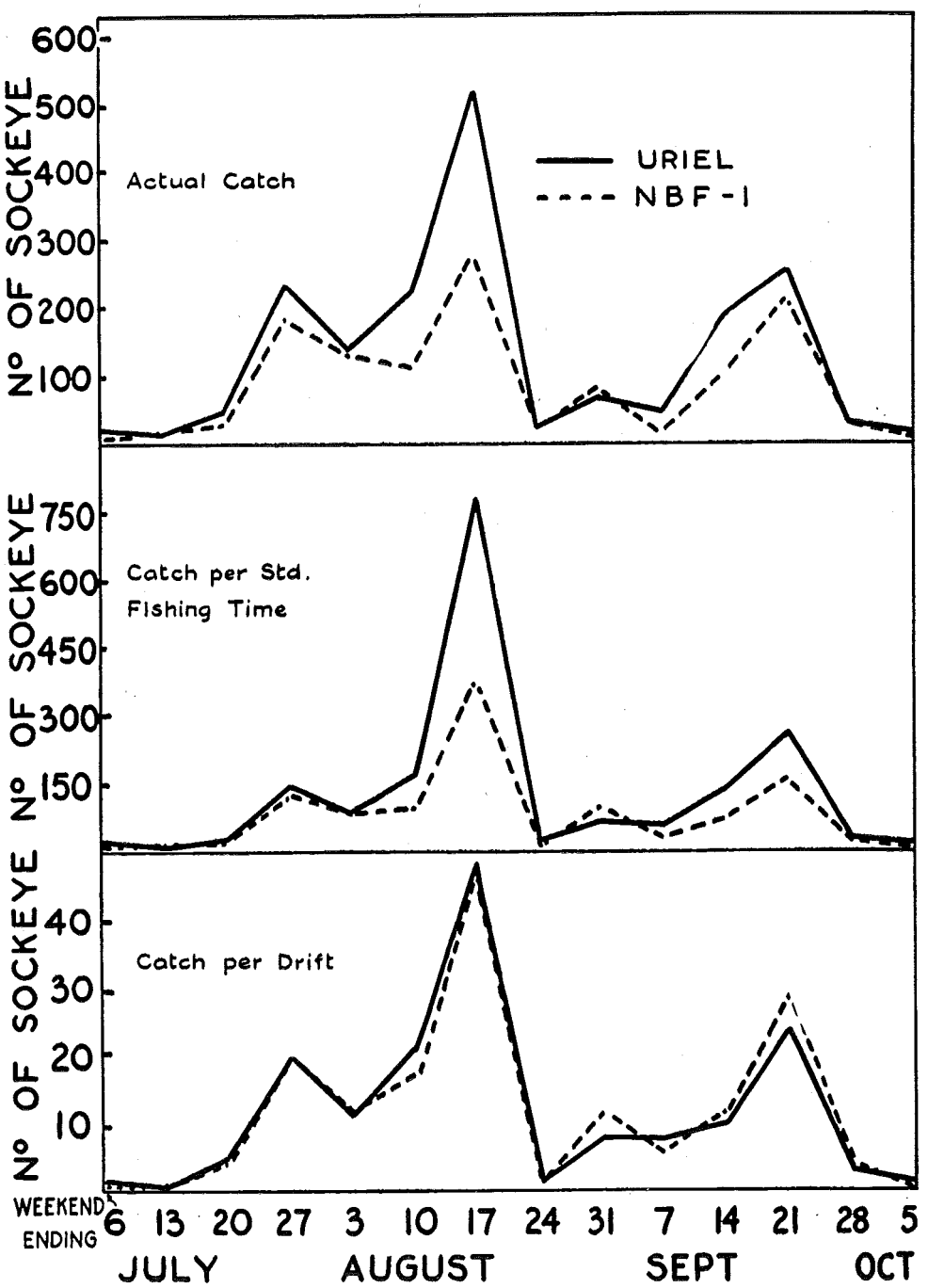

Figure 2. Number of Sockeye Caught by Each Boat Each Weekend in 1947.

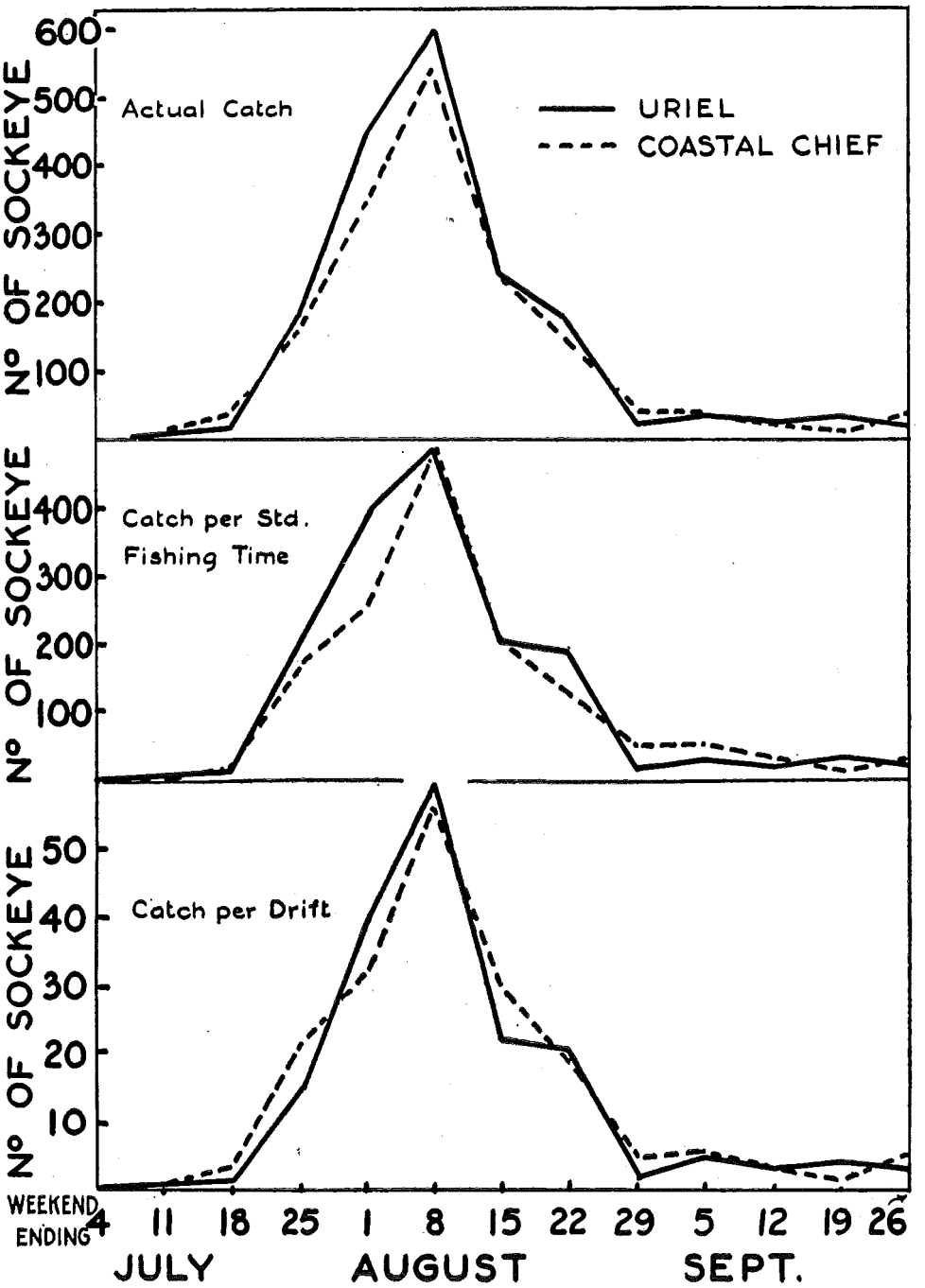

Figure 3. Number of Sockeye Caught by Each Boat Each Weekend in 1948.

Variations occurred within a weekend in the time the different meshes were fished, because the full net of five different mesh size sections was not always fished. On some drifts only three or four sections and a fraction of a section were fished, with part of the net remaining on the net drum. Also, on a few occasions certain mesh sections were put out of commission from accidental ripping on submerged snags, from entanglement with a channel buoy or from being run down by boats in the channel. In addition, the mesh sections farthest from the boat at the buoy end of the net fished longer than the sections near the boat.

Between weekends there were also variations in the time fished, depending on the numbers of fish present, tidal conditions and the number of days fished per weekend.

The weekend catches corrected to a standard fishing time for each boat in 1947 and 1948 show that, in spite of the detailed corrections applied for the time fished by each individual mesh, the relative corrected weekend catches of the two boats are similar to the actual catches. No particular advantage seems to have been gained by converting the catches to a standard fishing time basis.

In the lower graphs of Figure 2 and Figure 3 the average sockeye catch per drift for each boat on each weekend for 1947 and 1948 is shown. The weekend catch per drift is more comparable for the two boats than either the actual catch or the catch per standard fishing time. In 1947 the Uriel and the NBF-1 fished about the same length of time each weekend, but the Uriel made a total of 160 drifts while the NBF-1 made only 119 drifts. The 1947 seasonal catch per drift for the Uriel was 11.4 fish and for the NBF-1 was 10.6 fish. Similarly, in 1948 the catch per drift was comparable for each boat. The number of drifts made by each boat was more nearly equal in 1948 than in 1947 with 113 drifts made by the Uriel and 101 drifts made by the Coastal Chief in 1948. The 1948 seasonal catch per drift was 16.0 fish for the Uriel and 16.1 fish for the Coastal Chief.

It has been demonstrated in the foregoing dissertation that the two boats fishing in the same fishing area over the same time period each day made comparable catches when they made equal number of drifts. Their catches in 1948 are directly comparable without further adjustment, but in 1947 the variation in number of drifts resulted in catch differences which require a conversion to catch per drift for greater accuracy in comparison.

The combined catches of the two boats for all weekends in 1947 and 1948 are shown in Figure 4 and Table III in the three different ways, actual catch, catch per standard fishing time and catch per drift. The amplitude of each weekend catch is shown as the percentage of the seasonal total in each of the three resulting curves. It is noted that in 1948 there is little variation within any weekend for any of the three catch curves. In 1947 variation in the three curves occurs on certain weekends. Although each of the three curves in 1947 shows a fairly consistent picture of the seasonal catch by weekend, the catch per drift has been established previously as the most accurate measure.

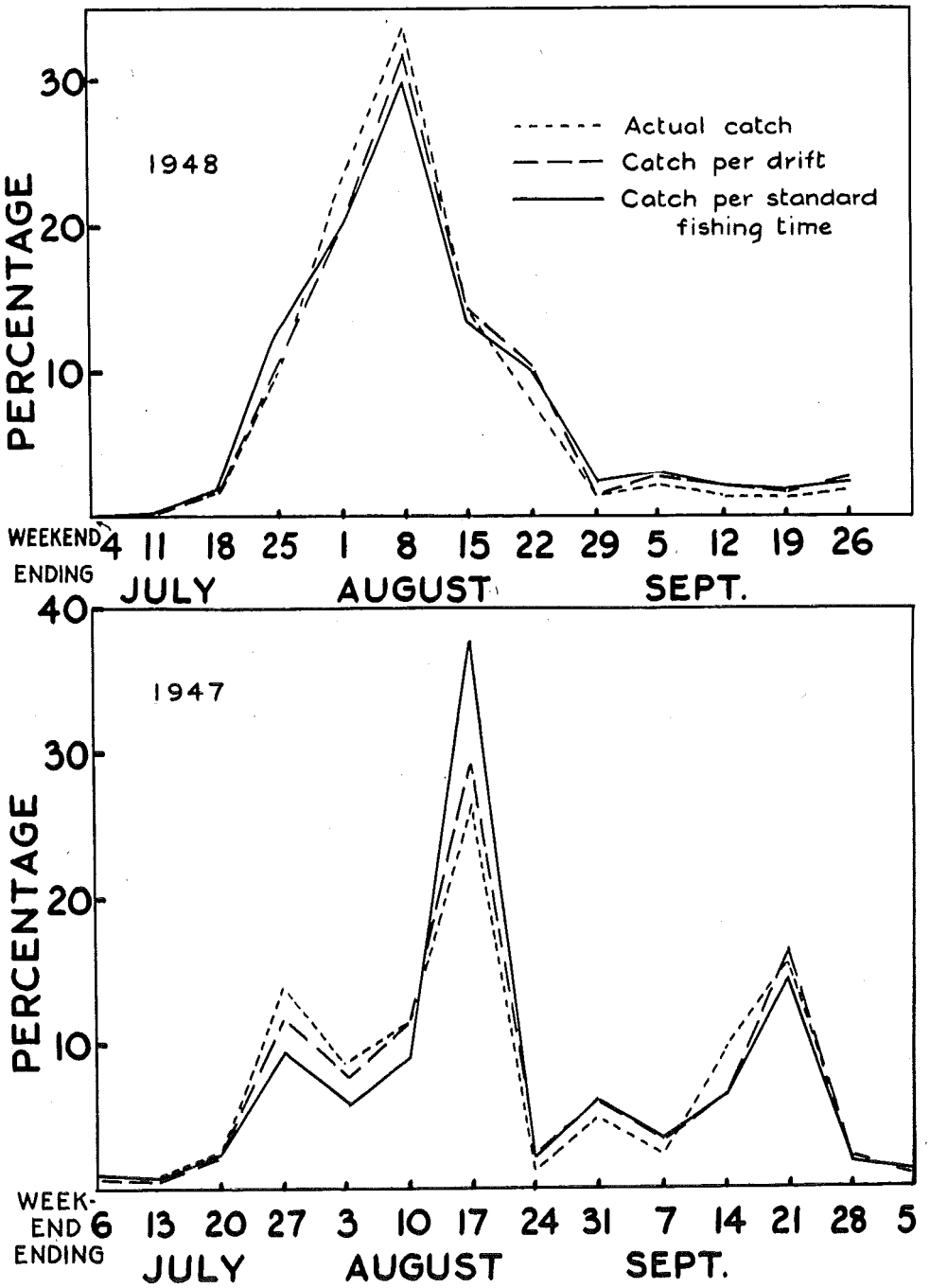

Figure 4. Percentage of Sockeye of the Entire Season's Catch Taken Each Weekend in 1947 and 1948 by Both Boats Combined.

Relation of Mesh Size to Fish Length between Boats

A direct analytical approach to ascertain whether the boats caught similar sizes of fish in comparable mesh sizes would be a statistical comparison of fish sizes taken by duplicated mesh sizes fishing at the same time. However, such duplication of mesh sizes by the boats was not considered necessary to the proper execution of the experiment, and only because one of the mesh sizes (8 1/4 inch) was not available during the first half of 1947 were any duplicate mesh sizes utilized at all. The numbers of fish taken by comparable mesh sizes fished by the boats on particular weekends consisted of small samples. Hence, the validity of any conclusions based on such limited data is believed to be questionable.

In lieu of direct comparisons, the treatment applied to the data was a correlation analysis of mesh size versus fish length with the mesh sizes distributed randomly between the boats. The mean fork lengths (and their respective standard errors) for males and females separately according to mesh size are given for all weekends in 1947 in Tables IV and V and for all weekends in 1948 in Tables VI and VII. Since on many of the weekends in both years the mean lengths were based on small samples (which were in danger of not being representative), it was deemed essential to restrict the statistical analysis only to those weekends when large samples of both sexes were caught. The catches for six weekends in 1947 and for five weekends in 1948 were chosen for further analysis. The sample sizes of each sex for the selected eleven weekends ranged from 86 fish to 594 fish.

Reference will be made to the data of Table VIII, in which is listed the correlation coefficient, sample size, degrees of freedom, slope, y-intercept, mean length, weighted mean mesh size and standard error of estimate for each sex on the various selected weekends. The numbers of fish per standard fishing time were used in determining the correlation coefficients in Table VIII, since the amount of time fished by the individual meshes varied materially on some weekends. Figures 5 to 8, depicting the mean lengths of each sex taken separately by mesh size for each chosen weekend in both years, will also be used to augment the discussion and treatment of the data. The distribution of mesh sizes between the boats has been shown previously in Table I.

Considering first the mesh size to fish length relationship by boat for 1947 males, reference is made to Figure 5 in which is plotted the average length of the males against mesh size for all meshes from 5 1/4 inch to 7 1/2 inch mesh on the selected weekends. It is shown that although the various mesh sizes were fished by two boats, a close relationship exists between the length of male sockeye and size of mesh. For example, on July 26-27, 1947, the average length of males caught by the boat Uriel using the 5 1/4 inch mesh was 58.86 cm. The 5 1/2 inch mesh used by the NBF-1 caught males averaging 59.32 cm. The 5 3/4 inch mesh utilized by the NBF-1 caught males 60.48 cm. in mean length. The 6 inch mesh fished by both boats caught males averaging 61.11 cm. The 6 1/4 inch and 6 1/2 inch meshes used by the Uriel caught males averaging 61.76 cm. and 62.36 cm., respectively. The 7 inch and 7 1/2 inch nets fished by the NBF-1 caught males of respective

TABLE IV

MEAN FORK LENGTH AND STANDARD ERROR IN CENTIMETERS FOR MALE SOCKEYE FOR EACH MESH SIZE BY WEEKEND IN 1947

Mesh Size	5¼"			5½"			5¾"			6"		
Weekend	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error
July 5- 6	1	58.	—	2	58.0	—	1	57.	—	5	60.00	.71
12-13	1	63.	—	3	59.0	—	2	60.0	—	1	61.	—
19-20	5	58.80	1.66	8	60.00	1.08	3	58.3	—	13	60.54	.55
26-27	28	58.86	.43	19	59.32	.37	40	60.48	.49	69	61.11	.31
Aug. 2- 3	10	59.80	1.20	16	60.81	.24	11	61.55	.97	31	61.58	.60
9-10	8	62.00	2.39	18	62.11	.95	14	63.71	1.21	37	63.03	.63
16-17	25	61.72	1.06	16	62.44	.99	45	63.16	.46	33	62.97	.58
23-24	1	66.	—	1	61.	—	3	62.7	—	4	62.00	1.08
30-31	5	59.80	2.27	5	62.80	1.66	4	61.25	2.53	18	64.22	.86
Sept. 6- 7	4	64.75	2.86	3	65.7	—	4	63.25	.50	8	62.38	.78
12-14	6	62.67	1.82	7	60.29	1.88	12	61.17	.52	28	63.61	.55
19-21	32	62.22	.65	10	61.90	.78	54	62.35	.36	38	63.26	.44
26-28	3	56.7	—	1	56.	—	5	63.00	1.41	4	61.50	1.55
Oct. 3- 5	1	58.	—	1	63.	—	1	67.	—	1	66.	—
TOTAL	130	60.92	.38	110	61.11	.36	199	62.06	.23	290	62.37	.19

	6¼"			6½"			7"			7½"		
July 5- 6	3	59.7	—	0	—	—	0	—	—	0	—	—
12-13	1	61.	—	1	63.	—	0	—	—	0	—	—
19-20	5	61.20	.51	7	64.57	1.54	3	68.7	—	0	—	—
26-27	29	61.76	.76	11	62.36	.98	16	66.50	.72	3	67.7	—
Aug. 2- 3	14	64.71	1.09	18	64.67	.75	15	67.20	1.11	24	68.71	.62
9-10	14	64.43	1.13	16	65.56	.72	9	66.89	.92	17	68.53	.43
16-17	46	64.80	.54	96	65.30	.31	44	67.98	.30	58	67.98	.36
23-24	5	63.00	.95	1	63.	—	1	63.	—	0	—	—
30-31	9	65.56	.62	9	63.78	1.01	10	68.70	.60	11	67.91	.77
Sept. 6- 7	10	64.70	.92	7	64.43	1.45	10	64.00	.52	2	65.5	—
12-14	29	62.55	.54	57	63.63	.27	35	65.29	.40	11	66.18	1.05
19-21	25	61.96	.49	42	63.71	.45	45	65.07	.42	18	65.83	.91
26-28	7	63.86	1.22	3	64.0	—	0	—	—	1	69.	—
Oct. 3- 5	0	—	—	1	64.	—	1	63.	—	0	—	—
TOTAL	197	63.39	.25	269	64.42	.18	189	66.33	.21	145	67.72	.25

TABLE V

MEAN FORK LENGTH AND STANDARD ERROR IN CENTIMETERS
FOR FEMALE SOCKEYE FOR EACH MESH SIZE BY WEEKEND IN 1947

Mesh Size	5¼"			5½"			5¾"			6"		
Weekend	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error
July 5- 6	1	57.	—	4	59.50	.65	0	—	—	0	—	—
12-13	2	57.0	—	1	61.	—	2	61.5	—	1	62.	—
19-20	5	57.40	.39	15	58.53	.39	3	58.3	—	9	62.56	.32
26-27	37	59.08	.41	33	59.24	.52	32	59.35	.32	67	61.34	.32
Aug. 2- 3	22	58.50	.56	19	60.21	.68	21	61.00	.79	31	61.64	.50
9-10	14	60.64	.92	44	61.11	.51	30	62.93	.61	54	63.11	.31
16-17	58	60.59	.38	39	60.41	.42	110	62.42	.25	66	61.74	.33
23-24	3	59.7	—	3	57.7	—	3	63.3	—	1	64.	—
30-31	7	60.86	1.19	10	63.40	.88	15	62.40	.67	22	63.00	.45
Sept. 6- 7	4	59.25	.87	3	60.0	—	5	61.00	1.14	12	60.83	.51
12-14	7	59.00	.98	11	59.82	.82	27	60.37	.38	26	60.19	.36
19-21	38	59.21	.29	15	59.00	.46	73	60.64	.26	42	60.24	.35
26-28	5	56.80	.87	4	60.50	1.89	11	59.73	.84	5	60.60	.67
Oct. 3- 5	0	—	—	7	59.71	.80	2	59.0	—	0	—	—
TOTAL	203	59.52	.19	208	60.15	.20	334	61.36	.15	336	61.63	.14

	6¼"			6½"			7"			7½"		
July 5- 6	1	62.	—	0	—	—	0	—	—	0	—	—
12-13	0	—	—	0	—	—	0	—	—	0	—	—
19-20	2	64.0	—	0	—	—	0	—	—	0	—	—
26-27	18	62.72	.62	13	64.00	.49	1	66.	—	1	67.	—
Aug. 2- 3	11	62.36	.72	10	63.80	.58	4	63.25	1.26	1	60.	—
9-10	24	63.54	.47	28	64.39	.48	2	65.5	—	2	64.5	—
16-17	64	63.12	.27	83	64.22	.27	6	65.83	.61	5	63.40	.39
23-24	3	61.7	—	3	65.7	—	0	—	—	0	—	—
30-31	12	63.17	1.02	13	64.69	.47	0	—	—	1	64.	—
Sept. 6- 7	1	61.	—	1	58.	—	0	—	—	0	—	—
12-14	10	61.20	.68	5	62.80	1.25	2	62.5	—	0	—	—
19-21	11	61.45	.63	18	62.17	.69	1	68.	—	5	64.40	1.57
26-28	3	61.7	—	3	64.0	—	0	—	—	0	—	—
Oct. 3- 5	0	—	—	0	—	—	0	—	—	0	—	—
TOTAL	160	62.79	.18	177	63.98	.19	16	64.9		15	63.9	

TABLE VI

MEAN FORK LENGTH AND STANDARD ERROR IN CENTIMETERS FOR MALE SOCKEYE FOR EACH MESH SIZE BY WEEKEND IN 1948

Mesh Size	5¼"			5½"			5¾"			6"		
Weekend	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error
July 10-11	0	—	—	1	57.	—	0	—	—	0	—	—
17-18	4	60.00	.91	12	60.42	.64	3	61.0	—	7	62.43	1.38
24-25	19	57.21	.45	29	59.07	.75	33	59.64	.57	20	60.70	.68
31- 1	60	58.17	.38	48	58.23	.44	114	59.65	.26	70	60.93	.31
Aug. 6- 8	90	57.07	.29	98	58.12	.24	110	59.29	.23	124	60.38	.26
14-15	34	57.12	.57	34	58.71	.52	29	59.55	.40	52	60.90	.24
21-22	14	56.43	1.02	14	56.43	.85	20	60.20	.50	27	60.59	.46
28-29	5	54.20	1.20	1	62.	—	3	63.0	—	2	61.5	—
Sept. 4- 5	5	55.80	.97	5	60.40	2.48	4	58.75	1.04	5	61.00	1.00
11-12	5	54.80	.74	1	58.	—	5	58.80	1.50	5	60.00	.84
18-19	2	59.5	—	7	56.14	.46	6	62.17	2.06	0	—	—
25-26	10	55.10	.48	10	56.30	1.17	5	58.20	1.36	2	60.5	—
TOTAL	248	57.17	.19	260	58.27	.19	332	59.60	.15	314	60.68	.15

	6¼"			6½"			7"			7½"		
July 10-11	0	—	—	0	—	—	0	—	—	0	—	—
17-18	1	61.	—	5	63.40	1.12	0	—	—	2	68.0	—
24-25	25	61.92	.74	16	65.25	.82	17	68.00	.69	14	68.86	1.30
31- 1	45	61.80	.48	40	62.82	.59	26	66.46	.69	16	68.12	.71
Aug. 6- 8	96	61.04	.25	49	63.14	.43	13	65.92	.71	12	66.33	1.35
14-15	35	61.86	.27	38	62.87	.40	9	66.33	.75	8	65.75	1.35
21-22	23	61.35	.38	19	63.63	.54	12	65.67	.80	4	66.50	.96
28-29	2	61.5	—	3	64.7	—	0	—	—	0	—	—
Sept. 4- 5	9	61.56	.93	10	62.40	.52	4	64.75	1.66	1	65.	—
11-12	4	63.25	1.04	3	66.0	—	2	61.5	—	1	66.	—
18-19	11	64.45	.91	1	66.	—	3	66.7	—	0	—	—
25-26	1	62.	—	13	64.38	.57	6	64.83	1.14	2	67.5	—
TOTAL	252	61.62	.14	197	63.38	.21	92	66.27	.33	60	67.42	.46

TABLE VII

MEAN FORK LENGTH AND STANDARD ERROR IN CENTIMETERS
FOR FEMALE SOCKEYE FOR EACH MESH SIZE BY WEEKEND IN 1948

Mesh Size	5¼"			5½"			5¾"			6"		
Weekend	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error	Number	Mean	Standard Error
July 10-11	0	—	—	1	61.	—	1	64.	—	0	—	—
17-18	5	58.60	1.47	8	58.12	.97	2	62.0	—	0	—	—
24-25	40	57.38	.41	30	57.67	.37	28	59.11	.62	12	60.92	.29
31- 1	95	57.75	.63	78	57.86	.24	91	59.14	.21	31	61.13	.58
Aug. 6- 8	169	56.75	.16	169	57.99	.15	86	59.03	.17	65	59.97	.95
14-15	60	57.48	.26	53	58.55	.37	53	60.02	.28	42	59.64	.24
21-22	41	57.37	.27	34	57.35	.33	37	58.92	.28	19	60.05	.44
28-29	11	56.73	.53	4	59.00	.41	9	59.22	.53	5	59.40	.74
Sept. 4- 5	5	57.00	1.34	7	59.57	.53	11	59.27	.43	2	59.5	—
11-12	6	57.00	1.32	6	58.83	.98	10	61.10	.38	3	60.3	—
18-19	2	53.5	—	1	59.	—	8	61.12	.55	2	61.5	—
25-26	2	56.0	—	3	58.3	—	4	59.50	1.50	2	60.0	—
TOTAL	436	57.19	.10	394	58.03	.11	340	59.37	.11	183	60.16	.18

	6¼"			6½"			7"			7½"		
July 10-11	1	62.	—	0	—	—	0	—	—	0	—	—
17-18	0	—	—	0	—	—	0	—	—	0	—	—
24-25	24	63.12	.41	12	63.92	.70	3	66.0	—	2	64.0	—
31- 1	29	60.86	.60	28	62.57	.66	6	64.17	1.83	2	54.5	—
Aug. 6- 8	29	61.45	.55	15	62.53	.93	5	64.20	.67	1	56.	—
14-15	27	60.85	.47	13	62.00	.89	2	64.5	—	0	—	—
21-22	16	60.50	.58	3	60.7	—	1	67.	—	0	—	—
28-29	4	62.00	1.58	2	62.0	—	1	65.	—	0	—	—
Sept. 4- 5	1	58.	—	2	60.5	—	0	—	—	0	—	—
11-12	0	—	—	2	64.5	—	2	68.0	—	0	—	—
18-19	5	64.20	1.16	2	63.0	—	0	—	—	0	—	—
25-26	2	64.0	—	3	63.7	—	0	—	—	0	—	—
TOTAL	138	61.52	.24	82	62.63	.35	20	65.05	.62	5	58.6	

TABLE VIII

CORRELATION BETWEEN SIZE OF MESH AND LENGTH OF SOCKEYE BY WEEKEND FOR EACH "LARGE" WEEKEND IN 1947 AND 1948

Weekend	Actual Sample Size	Adjusted Sample Size *	Degrees of Freedom	r	P	Slope (b)	y-intercept (a)	Mean Length (cm.)	Weighted Mean Mesh Size (inches)	Standard Error of Estimate (cm.)
1947 Males										
July 26-27	215	118.1	213	.611	<.01	4.241	35.777	61.231	6.002	2.827
Aug. 2- 3	140	87.4	138	.604	<.01	4.365	36.350	63.256	6.164	3.418
9-10	133	98.2	131	.450	<.01	3.204	44.427	64.225	6.179	3.870
16-17	364	544.0	362	.568	<.01	3.848	40.665	65.615	6.484	3.239
Sept. 12-14	185	129.3	183	.451	<.01	2.593	47.047	63.673	6.412	2.672
19-21	265	244.9	263	.323	<.01	1.851	51.524	62.993	6.196	2.862
1947 Females										
July 26-27	200	114.5	198	.531	<.01	4.392	34.978	60.465	5.803	2.561
Aug. 2- 3	114	85.4	112	.480	<.01	4.205	36.436	60.926	5.824	2.773
9-10	194	146.6	192	.378	<.01	3.244	43.494	62.650	5.905	2.875
16-17	420	525.7	418	.427	<.01	3.152	43.545	62.262	5.938	2.593
Sept. 12-14	86	62.0	84	.347	<.01	2.594	45.091	60.339	5.878	2.105
19-21	197	182.1	195	.390	<.01	2.711	44.523	60.450	5.875	2.114
1948 Males										
July 24-25	173	204.0	171	.736	<.01	5.761	26.604	61.936	6.133	3.315
31- 1	419	331.4	417	.628	<.01	4.713	32.430	60.416	5.938	2.985
Aug. 6- 8	594	480.6	592	.641	<.01	4.537	32.982	59.827	5.917	2.615
14-15	239	206.1	237	.644	<.01	4.139	35.734	60.638	6.017	2.634
21-22	133	149.0	131	.743	<.01	5.222	28.860	60.975	6.150	2.674
1948 Females										
July 24-25	146	170.0	144	.646	<.01	4.941	31.034	59.588	5.779	2.717
31- 1	352	303.0	350	.594	<.01	3.891	36.741	58.861	5.685	2.184
Aug. 6- 8	533	452.8	531	.543	<.01	4.246	34.415	58.222	5.607	2.227
14-15	248	218.8	246	.448	<.01	3.136	41.170	59.243	5.763	2.258
21-22	150	167.0	148	.606	<.01	2.673	43.244	58.448	5.688	1.232

* Calculated number if each mesh had fished 5.5 hours per weekend; meshes 5¼ to 7½ inch for males, meshes 5¼ to 6½ inch for females.

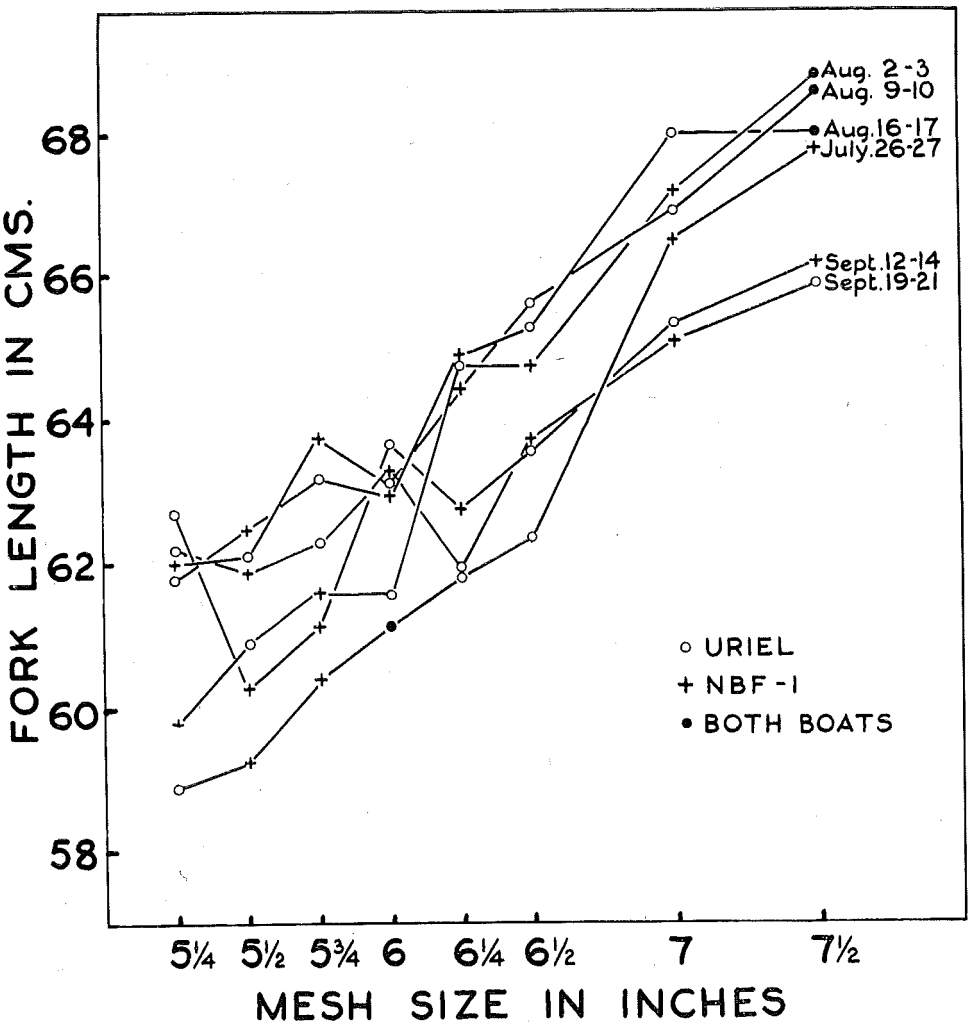

Figure 5. Relation of Average Length of Male Sockeye to Mesh Size by Weekend in 1947.

mean lengths of 66.50 cm. and 67.67 cm. This relationship is approximately linear and as shown in Table VIII has a correlation coefficient of $r = .611$ which by greatly exceeding the 1 per cent level is highly significant.

On August 2-3, 1947, the average lengths of male sockeye caught by the eight mesh sizes from 5 1/4 inch to 7 1/2 inch mesh ranged from 59.80 cm. to 68.71 cm. The NBF-1 used the 5 1/4, 5 3/4, 6 1/2, 7 and 7 1/2 inch mesh sizes and the Uriel utilized the 5 1/2, 6, 6 1/4 and 7 1/2 inch meshes. The "r" value of mesh size versus fish size for this weekend was .604, which exceeded the 1 per cent level and was highly significant. Likewise, "r" values for the lengths of males versus mesh size on August 9-10, August 16-17, September 12-14 and September 19-21 in 1947 were respectively .450, .568, .451 and .323, all of which were highly significant by exceeding the 1 per cent level. The mesh sizes were distributed randomly between the boats in all cases.

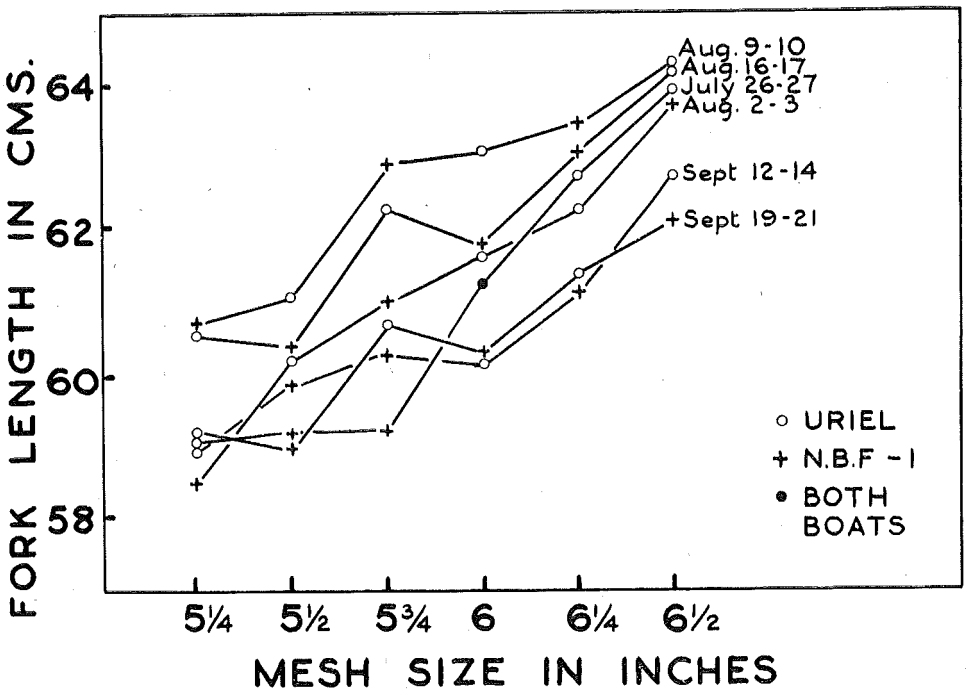

Figure 6. Relation of Average Length of Female Sockeye to Mesh Size by Weekend in 1947.

In Figure 6 a similar direct relationship between mesh size and fish length is shown for the females on the six weekends in 1947 when good samples were caught. The range of mesh sizes which caught significant numbers of females was 5 1/4 inch to 6 1/2 inch. The 7 inch and 7 1/2 inch meshes caught so few females that they have been omitted. On July 26-27 the range in average length of females was from 59.08 cm. to 64.00 cm. for the mesh sizes ranging from 5 1/4 to 6 1/2 inch, respectively. The Uriel fished the 5 1/4, 6, 6 1/4 and 6 1/2 inch meshes, while the NBF-1 fished the 5 1/2, 5 3/4 and 6 inch meshes. The correlation coefficient was $r = .531$ which exceeded the 1 per cent level and was highly significant.

Similarly, on August 2-3 the female average length for the 5 1/4 inch mesh was 58.50 cm., 5 1/2 inch—60.21 cm., 5 3/4 inch—61.00 cm., 6 inch—61.64 cm., 6 1/4 inch—62.36 cm. and 6 1/2 inch—63.80 cm., resulting in a highly significant correlation coefficient of .480. Likewise, on August 9-10, August 16-17, September 12-14 and September 19-21 all individual "r" values for females exceeded the 1 per cent level of significance.

In 1948 the bulk of the fish, dominated by the Chilko River race of sockeye, were smaller and were more uniform in size and sexual development than those caught in 1947. The average lengths of male sockeye by mesh size, designated by boat, are shown in Figure 7. On July 24-25, 1948, the Uriel fished with the 5 1/2 inch, 5 3/4, 6 1/2 and 7 inch meshes, while the Coastal Chief used the 5 1/4 inch, 6, 6 1/4 and 7 1/2 inch meshes. The average length by mesh size for the 5 1/4 inch

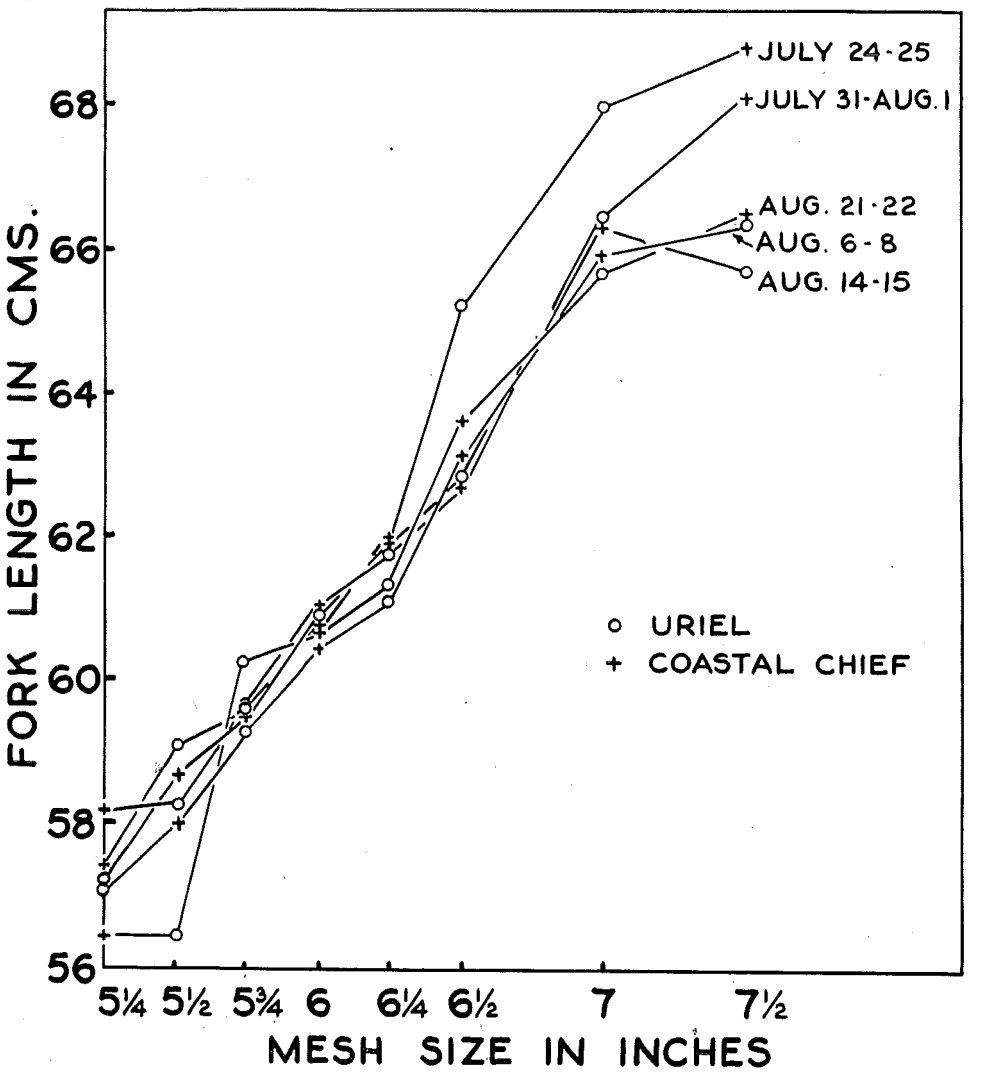

Figure 7. Relation of Average Length of Male Sockeye to Mesh Size by Weekend in 1948.

mesh was 57.21 cm., 5 1/2—59.07 cm., 5 3/4—59.64 cm., 6—60.70 cm., 6 1/4—61.92 cm., 6 1/2—65.25 cm., 7—68.00 cm. and for the 7 1/2 inch mesh—68.86 cm. The correlation coefficient of .736 greatly exceeded the 1 per cent level of significance. Similarly, on July 31 - August 1 the average lengths increased by regular gradations from 58.17 cm. in the 5 1/4 inch mesh to 68.12 cm. in the 7 1/2 inch mesh. The "r" value of .628 was again highly significant. In the same manner on August 6-8 the average lengths of the males ranged from 57.07 cm. to 66.33 cm. in the eight meshes ranging from 5 1/4 to 7 1/2 inch, with a highly significant "r" value of .641. Also, on August 14-15 the average length range for the different meshes was from 57.12 cm. to 65.75 cm., and the highly significant coefficient of correlation was .644. Likewise, on August 21-22, a highly significant "r" value of

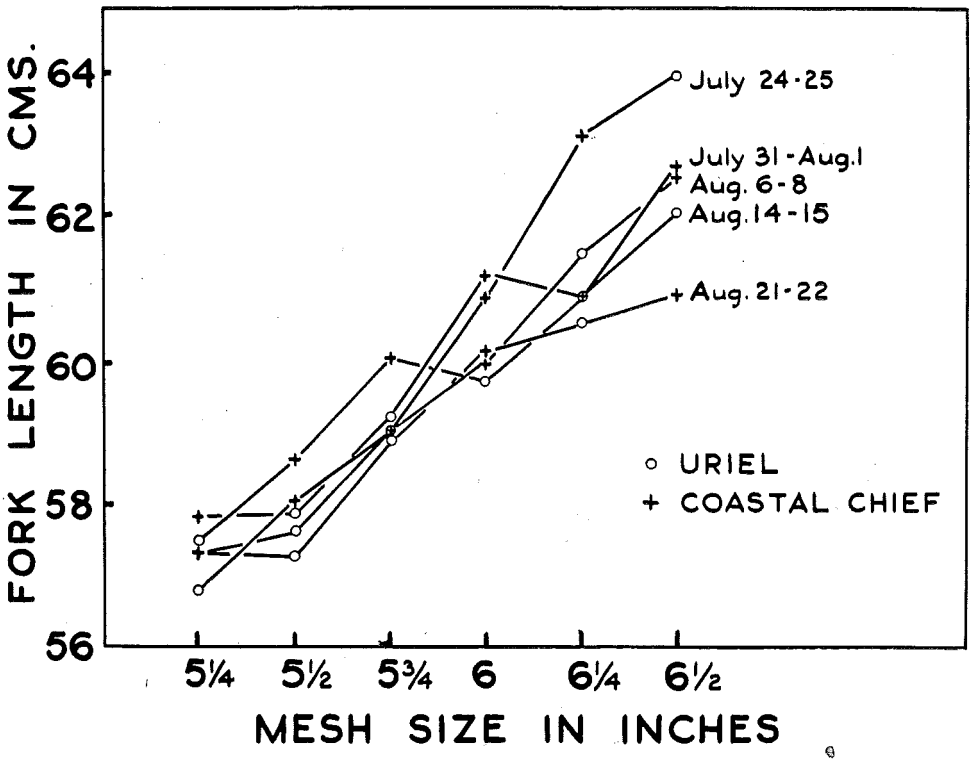

Figure 8. Relation of Average Length of Female Sockeye to Mesh Size by Weekend in 1948.

.743 was obtained on the males ranging from 56.43 cm. to 66.50 cm. in the mesh spread from 5 1/4 to 7 1/2 inch.

The females caught in 1948 on the five weekends of good fishing also indicated without exception the linear relationship between fish length and mesh size. Correlation coefficients were .646, .594, .543, .448 and .606 for the respective weekends and all were highly significant. The female average lengths on the five weekends for meshes 5 1/4 to 6 1/2 inch ranged from 57.38 cm. to 63.92 cm. on July 24-25, 57.75 cm. to 62.57 cm. on July 31 - August 1, 56.75 cm. to 62.53 cm. on August 6-8, 57.48 cm. to 62.00 cm. on August 14-15 and 57.37 cm. to 60.67 cm. on August 21-22, as shown in Figure 8.

The evidence from six weekends of good catches in 1947 and five weekends of good catches in 1948 demonstrates that the relationship of mesh size to length of fish is approximately linear and that probably no significant variability resulted from using the experimental nets on two boats.

Selectivity of Individual Mesh Sizes for Size of Fish

The linear correlation between mesh size and fish length occurred on every weekend of good catches in both years regardless of the length of fish available to the nets. The fish in 1947 were larger than in 1948, and variation in length

occurred also within each of the two seasons. In the eleven weekends of good catches tested statistically the males of August 16-17, 1947, were the group of largest fish, averaging 65.62 cm. (25.8 inches) in length and 7.99 lbs. in weight, while the females of August 6-8, 1948, were the group of smallest fish with a mean length of 58.22 cm. (22.9 inches) and a mean weight of 5.64 lbs. (Average values are based on the catch of all meshes combined.) A difference in length of 7.40 cm. (2.9 inches) and in weight of 2.35 lbs. was present between these two extreme size groups of fish. Although the numbers of fish caught by the respective mesh sizes varied in accordance with the length of available fish, the straight-line relationship of mesh size to fish length was present regardless of the length of available fish.

The seasonal mean lengths of male and female sockeye caught by each mesh size in 1947 and 1948 are shown in Figure 9. The effective range of mesh sizes for catching males was 5 1/4 inch to 7 1/2 inch and for females 5 1/4 inch to 6 1/2 inch in both years. The average lengths of fish caught by the larger meshes, 8 1/4 inch and 8 3/4 inch on males and 7 inch to 8 3/4 inch on females, have not been included in the figure because of the small samples involved and because of the non-selective qualities of these mesh sizes which were too large for the fish. The seasonal length distributions with mean lengths and standard errors for males, females and combined sexes for each year are shown separately in Tables IX to XIV, inclusive.

In Figure 9 it will be noted that the individual mesh sizes caught significantly smaller fish in 1948 than in 1947. Moreover, in each year the females are shown to be smaller than the males for each mesh size. That the mesh size to fish length relationship is approximately linear, regardless of the sex or length of available fish, is demonstrated.

The selectivity of mesh size for size of sockeye has been measured by the depth, width (or breadth), and weight of the fish taken by the individual mesh sizes, as well as by length. The maximum depth distribution and the mean maximum depths are shown for the individual mesh sizes by sex and by year in Tables XV to XIX, inclusive. The maximum width distributions and the mean maximum widths for each mesh size by sex and by year are given in Tables XX to XXIII, inclusive. The weights of the fish were taken throughout both seasons, with the exception of the period in 1947 from July 20 to August 10. The weight distributions and the mean weights of the fish caught by each mesh size are shown by separate sex and by combined sexes for each year in Tables XXIV to XXIX, inclusive.

Every type of measurement made reflecting size of fish, namely fork length, maximum depth, maximum width and weight, showed an approximately linear relation between mesh size and fish size. The mean lengths, depths and widths from males and females separately for both years combined are given for each mesh size in Figure 10. The ordinate scale of the figure is the same for each type of measurement; hence, the various slopes show the relative rate of increase in length, depth and width with increase in mesh size.

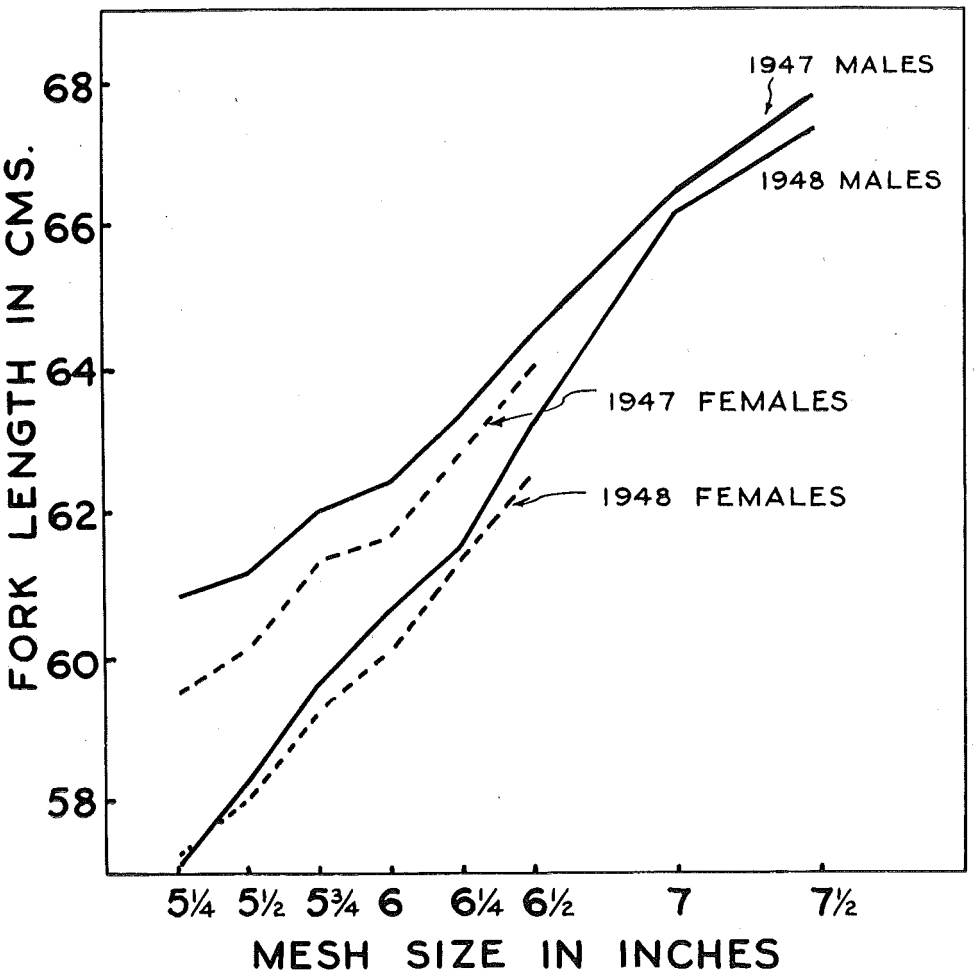

Figure 9. Relation of Mesh Size to Average Length of Male and Female Sockeye in 1947 and 1948.

The lengths show the greatest increments with increasing mesh sizes. The mean depths show a more gradual increase ranging in males from 12.77 cm. to 15.83 cm. for the 5 1/4 inch to 7 1/2 inch meshes, and in females from 12.21 cm. to 14.03 cm. for the 5 1/4 inch to 6 1/2 inch meshes. The mean widths show a small increment with increasing mesh size, ranging from 6.45 cm. in the 5 1/4 inch mesh to 7.42 cm. in the 7 1/2 inch mesh for males, and for females from 6.47 cm. in the 5 1/4 to 7.21 cm. in the 6 1/2 inch mesh.

The size measurement on the fish which would correspond nearest to the actual mesh size (or the perimeter of the mesh) would be the girth measurement. This measurement was not taken because of the difficulty in determining girth accurately. In encircling the fish for measuring girth a constant tension would be required. Such a constant tension is difficult to obtain manually. However, the depth measurements on the fish as related to mesh size show a similarity to

TABLE IX

MALE SOCKEYE LENGTH DISTRIBUTION BY MESH SIZE
FOR THE ENTIRE 1947 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
51	1	1									2
2	2										2
3	2										2
4	1										1
5	6	4	2		1						13
6	5	4	5	4	2		1			1	22
7	8	7	7	4	5	1					32
8	17	9	10	14	3	1					54
9	14	14	17	25	11	4	1	1			87
60	10	15	22	40	16	12	1	2			118
1	10	11	30	47	27	23	6	5			159
2	11	9	23	41	27	43	10	6	2	1	173
3	11	12	21	27	21	33	12	4	2		143
4	8	7	21	23	20	28	23	4	1	1	136
5	2	4	14	17	12	30	21	4	1		105
6	5	3	5	15	11	27	21	9		1	97
7	3	3	9	6	9	22	18	18	1		89
8	5	2	8	7	8	13	24	25			92
9	3	2	1	10	11	20	25	32	1		105
70	5	1	4	8	9	6	15	11			59
1	1			1	1	4	9	13	1		30
2		2		1	3	1	1	8			16
3						1	1	3			5
Total	130	110	199	290	197	269	189	145	9	4	1,542
Mean	60.92	61.11	62.06	62.37	63.39	64.42	66.33	67.72	65.1	62.0	63.61
Standard Error	0.38	0.36	0.23	0.19	0.25	0.18	0.21	0.25			0.10

TABLE X

FEMALE SOCKEYE LENGTH DISTRIBUTION BY MESH SIZE
FOR THE ENTIRE 1947 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
54	1	1									2
5	8	5									13
6	19	13	8	7		2					49
7	20	24	14	8	2	1					69
8	29	27	29	29	4	4					122
9	37	27	40	36	8	4	1	1			154
60	25	26	57	41	17	7	1	1			175
1	11	15	35	39	14	6					120
2	17	21	43	41	22	14		1			159
3	20	17	28	43	23	24	2	1			158
4	8	14	29	45	27	35	2	7			167
5	5	9	23	29	26	28	2	1			123
6	3	6	12	10	15	34	4				84
7		2	12	6	2	10	1	2			35
8		1	2	2		5	3	1			14
9			1			3					4
70			1								1
Total	203	208	334	336	160	177	16	15	0	0	1,449
Mean	59.52	60.15	61.36	61.63	62.79	63.98	64.9	63.9			61.53
Standard Error	0.19	0.20	0.15	0.14	0.18	0.19					0.08

TABLE XI

LENGTH DISTRIBUTION OF ALL SOCKEYE BY MESH SIZE FOR THE ENTIRE 1947 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
51	1	1									2
2	2										2
3	2										2
4	2	1									3
5	14	9	2		1						26
6	24	17	13	11	2	2	1			1	71
7	28	31	21	12	7	2					101
8	46	36	39	43	7	5					176
9	51	41	57	61	19	8	2	2			241
60	35	41	79	81	33	19	2	3			293
1	21	26	65	86	41	29	6	5			279
2	28	30	66	82	49	57	10	7	2	1	332
3	31	29	49	70	44	57	14	5	2		301
4	16	21	50	68	47	63	25	11	1	1	303
5	7	13	37	46	38	58	23	5	1		228
6	8	9	17	25	26	61	25	9		1	181
7	3	5	21	12	11	32	19	20	1		124
8	5	3	10	9	8	18	27	26			106
9	3	2	2	10	11	23	25	32	1		109
70	5	1	5	8	9	6	15	11			60
1	1			1	1	4	9	13	1		30
2		2		1	3	1	1	8			16
3						1	1	3			5
Total	333	318	533	626	357	446	205	160	9	4	2,991
Mean	60.07	60.48	61.62	61.97	63.12	64.25	66.22	67.37	65.1	62.0	62.61
Standard Error	0.19	0.18	0.13	0.12	0.16	0.13	0.20	0.25			0.06

TABLE XII

MALE SOCKEYE LENGTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
50	1										1
1	1	1									2
2	10	1									11
3	18	9								1	28
4	17	15	7	2							41
5	17	15	6			1		1	1		41
6	35	30	16	8	2				2		93
7	41	32	33	15	3	1	1				126
8	28	42	59	29	12	3	1				174
9	36	36	57	53	32	5	1	1	1		222
60	15	34	49	60	43	18					219
1	14	17	41	48	43	23	2	2	1		191
2	8	11	27	43	43	34	6		1	3	176
3	4	5	16	20	34	33	7	3			122
4		4	6	17	15	20	7	2	1	1	73
5		2	5	2	8	17	9	7			50
6	1	2	2	3	5	14	14	4			45
7	1	1	2	4		6	10	8	1		33
8		1	2	3	4	9	12	5			36
9				1	1	6	8	12			28
70			3	3	2	3	7	8			26
1	1	1		2	3	2	3	1	1	1	15
2			1	1	1	1	2	3	1	1	11
3		1			1	1	2	1			6
4								1		1	2
5								1			1
Total	248	260	332	314	252	197	92	60	10	8	1,773
Mean	57.17	58.27	59.60	60.68	61.62	63.38	66.27	67.42	62.3	65.0	60.58
Standard Error	0.19	0.19	0.15	0.15	0.14	0.21	0.33	0.46			0.10

TABLE XIII

FEMALE SOCKEYE LENGTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
51	3	2									5
2	11		1								12
3	9	1		1							11
4	12	11		1	3			1			28
5	40	20	1	1		1		1	1		65
6	73	51	20	5	1	2	1	1			154
7	94	70	28	10	2	6					210
8	98	91	68	20	15	1				1	294
9	50	72	82	37	10	4					255
60	29	43	56	39	24	5		1			197
1	4	12	36	28	15	6					101
2	5	9	23	13	17	10	1			1	79
3	3	3	10	11	15	10	1		1		54
4	4	7	8	5	13	13	4				54
5		1	5	5	12	11	4				38
6	1		2	6	6	7	3		1		26
7				1	4	2	3				10
8					1	3	2	1			7
9							1				1
70		1				1					2
Total	436	394	340	183	138	82	20	5	3	2	1,603
Mean	57.19	58.03	59.37	60.16	61.52	62.63	65.05	58.6	61.3	60.0	58.96
Standard Error	0.10	0.11	0.11	0.18	0.24	0.35	0.62				0.07

TABLE XIV

LENGTH DISTRIBUTION OF ALL SOCKEYE BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Fork Length in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
50	1										1
1	4	3									7
2	21	1	1								23
3	27	10		1						1	39
4	29	26	7	3	3			1			69
5	57	35	7	1		2		2	2		106
6	108	81	36	13	3	2	1	1	2		247
7	135	102	61	25	5	7	1				336
8	126	133	127	49	27	4	1			1	468
9	86	108	139	90	42	9	1	1	1		477
60	44	77	105	99	67	23		1			416
1	18	29	77	76	58	29	2	2	1		292
2	13	20	50	56	60	44	7		1	4	255
3	7	8	26	31	49	43	8	3	1		176
4	4	11	14	22	28	33	11	2	1	1	127
5		3	10	7	20	28	13	7			88
6	2	2	4	9	11	21	17	4	1		71
7	1	1	2	5	4	8	13	8	1		43
8		1	2	3	5	12	14	6			43
9				1	1	6	9	12			29
70		1	3	3	2	4	7	8			28
1	1	1		2	3	2	3	1	1	1	15
2			1	1	1	1	2	3	1	1	11
3		1			1	1	2	1			6
4								1		1	2
5								1			1
Total	684	654	672	497	390	279	112	65	13	10	3,376
Mean	57.18	58.12	59.48	60.49	61.58	63.16	66.05	66.74	62.1	64.0	59.83
Standard Error	0.09	0.09	0.09	0.12	0.14	0.18	0.29	0.54			0.06

TABLE XV

MALE SOCKEYE DEPTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1947 SEASON

Max. Depth in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
11.2	5	1									6
11.7	15	4	4	2							25
12.2	16	16	9	13	4	1	1	1			61
12.7	11	11	20	32	3	2					79
13.2	24	13	34	48	23	8		3			153
13.7	10	19	39	55	35	37	2	3	1		201
14.2	7	13	36	37	36	44	8	3			184
14.7	14	14	22	39	40	62	33	10	2	1	237
15.2	7	6	9	25	22	58	35	22	1	2	187
15.7	7	2	11	16	14	22	54	28	4		158
16.2	5	5	7	8	8	10	27	35	1	1	107
16.7	2		1	2	5	5	8	10			33
17.2					1	2	2	7			12
17.7			1		2		2	4			9
18.2							2				2
18.7						1					1
Total	123	104	193	277	193	252	174	126	9	4	1,455
Mean	13.46	13.64	13.92	13.97	14.45	14.73	15.49	15.73	15.3	15.3	14.44

TABLE XVI

FEMALE SOCKEYE DEPTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1947 SEASON

Max. Depth in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
10.7	2										2
11.2	10	11	1								22
11.7	26	22	20	4	1						73
12.2	44	51	53	39	2	2					191
12.7	35	40	70	61	24	10		2			242
13.2	31	27	75	90	39	22	1				285
13.7	23	26	57	71	45	46	1	4			273
14.2	7	19	28	34	26	52	1	5			172
14.7	1	7	14	12	10	32	5	1			82
15.2	1		3	5	8	5	4	2			28
15.7	1			1	1	2					5
16.2					1						1
16.7											
Total	181	203	321	317	157	171	12	14	0	0	1,376
Mean	12.64	12.79	13.09	13.28	13.64	13.97	14.6	14.0			13.22

TABLE XVII

MALE SOCKEYE DEPTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Max. Depth in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
10.8	7					1					8
11.3	28	10	1	1							40
11.8	58	44	18			2		2			124
12.3	54	75	71	13	1				5	1	220
12.8	38	53	85	61	25	2	2	1			267
13.3	43	33	70	87	60	6		1		1	301
13.8	11	22	34	64	53	26	2	1		1	214
14.3	3	10	18	32	48	46	1			1	159
14.8	2	6	14	26	20	43	11	2	1		125
15.3	2	1	7	13	16	27	18	5	1		90
15.8		3	6	6	10	11	22	13		1	72
16.3		1	2	5	4	10	23	17		1	63
16.8		2	2	2	7	6	6	10	1		36
17.3	1	2	1	3		5	4	4	1		21
17.8			1	3	3		1	4	1	1	14
18.3						1	2	1		1	5
18.8						1					1
Total	247	262	330	316	247	187	92	61	10	8	1,760
Mean	12.43	12.80	13.19	13.76	14.10	14.81	15.79	16.05	14.4	15.2	13.68

TABLE XVIII

FEMALE SOCKEYE DEPTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Max. Depth in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
10.3	5	1									6
10.8	28	10		2	2			1			43
11.3	79	52	6	3	1	3			1		145
11.8	147	96	25	5	2	6					281
12.3	87	101	90	18	8	3					307
12.8	45	58	77	45	15	5		1			246
13.3	22	33	81	49	29	5				2	221
13.8	9	16	30	24	28	7					114
14.3	8	4	16	15	22	18		1	1		85
14.8	2	4	8	8	17	11	5				55
15.3		3	6	6	5	14	6				40
15.8	2	2	2	3	1	6	6		1		23
16.3					2	3	3	1			9
Total	434	380	341	178	132	81	20	4	3	2	1,575
Mean	12.03	12.31	12.95	13.20	13.71	14.16	15.48	13.6	13.8	13.3	12.74

TABLE XIX

DEPTH DISTRIBUTION OF ALL SOCKEYE BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Max. Depth in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
10.3	5	1									6
10.8	35	10		2	2	1		1			51
11.3	107	62	7	4	1	3			1		185
11.8	205	140	43	5	2	8		2			405
12.3	141	176	161	31	9	3			5	1	527
12.8	83	111	162	106	40	7	2	2			513
13.3	65	66	151	136	89	11		1		3	522
13.8	20	38	64	88	81	33	2	1		1	328
14.3	11	14	34	47	70	64	1	1	1	1	244
14.8	4	10	22	34	37	54	16	2	1		180
15.3	2	4	13	19	21	41	24	5	1		130
15.8	2	5	8	9	11	17	28	13	1	1	95
16.3		1	2	5	6	13	26	18		1	72
16.8		2	2	2	7	6	6	10	1		36
17.3	1	2	1	3		5	4	4	1		21
17.8			1	3	3		1	4	1	1	14
18.3						1	2	1		1	5
18.8						1					1
Total	681	642	671	494	379	268	112	65	13	10	3,335
Mean	12.17	12.51	13.07	13.59	13.97	14.59	15.73	15.89	14.22	14.85	13.24

TABLE XX

MALE SOCKEYE WIDTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1947 SEASON

Max. Width in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
5.2	2	1									3
5.7	11	2	11	5	2	3					34
6.2	43	23	47	49	42	43	13	6	3		269
6.7	43	42	84	124	62	100	56	25	3	3	542
7.2	17	30	42	74	55	70	59	42	3		392
7.7	7	4	6	19	28	30	36	44			174
8.2		2	3	5	3	4	7	7		1	32
8.7				1	1	2	3	2			9
Total	123	104	193	277	193	252	174	126	9	4	1,455
Mean	6.54	6.77	6.68	6.83	6.90	6.90	7.13	7.31	6.7	7.1	6.88

TABLE XXI

FEMALE SOCKEYE WIDTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1947 SEASON

Max. Width in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
5.7	10	2	6	1	1						20
6.2	65	46	67	40	10	6		1			235
6.7	71	102	136	133	46	41	1	5			535
7.2	30	43	89	106	84	75	5	5			437
7.7	5	10	23	33	13	47	5	3			139
8.2	1			4	3	2	1				11
Total	182	203	321	317	157	171	12	14	0	0	1,377
Mean	6.58	6.73	6.79	6.92	7.04	7.19	7.4	7.1			6.87

TABLE XXII

MALE SOCKEYE WIDTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Max. Width in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
5.2	2	1									3
5.7	30	12	2	1	1	2			1		49
6.2	101	107	85	36	21	9	5	3	1	1	369
6.7	98	101	170	147	112	58	9	3	5	2	705
7.2	15	34	62	107	93	79	24	16	1	1	432
7.7	3	4	12	18	10	37	33	20		1	138
8.2			1	3	11	9	19	9	1	3	56
8.7		1	1	2	1	3	1	8	1		18
Total	249	260	333	314	249	197	91	59	10	8	1,770
Mean	6.41	6.53	6.71	6.89	6.96	7.15	7.50	7.65	7.0	7.4	6.83

TABLE XXIII

FEMALE SOCKEYE WIDTH DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Max. Width in cms.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
5.2	1	1									2
5.7	27	9	1		2				1		40
6.2	221	169	66	13	7	7					483
6.7	158	176	196	92	47	19		1		1	690
7.2	20	32	61	60	50	24	4	2		1	254
7.7	8	7	15	13	23	19	11		1		97
8.2	1		1	3	4	12	5				26
8.7							1	1			2
Total	436	394	340	181	133	81	21	4	2	2	1,594
Mean	6.43	6.52	6.74	6.93	7.06	7.26	7.77	7.4	6.7	7.0	6.69

TABLE XXIV

MALE SOCKEYE WEIGHT DISTRIBUTION BY MESH SIZE FOR THE 1947 SEASON, OMITTING JULY 20 TO AUGUST 10, INCLUSIVE

Weight in lbs.	Mesh Size in Inches										
	5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
3.781	2	1									3
4.406	8	1	1								10
5.031	12	11	4	3	2			1			33
5.656	10	5	18	20	9	4					66
6.281	12	10	39	27	29	32	4	5	1		159
6.906	11	8	29	39	34	58	13	5	3	1	201
7.531	9	11	15	21	26	54	39	5	2	1	183
8.156	6	4	16	15	18	27	30	10			126
8.781	3	2	7	4	9	25	32	29	1	1	113
9.406	4		2	10	5	12	17	28	2		80
10.031	2				4	2	10	9			27
10.656		1			2	1	1	5			10
11.281						1		2			3
11.906								1			1
Total	79	54	131	139	138	216	146	100	9	3	1,015
Mean	6.48	6.55	6.83	7.03	7.30	7.52	8.25	8.86	7.7	7.7	7.44

TABLE XXV

FEMALE SOCKEYE WEIGHT DISTRIBUTION BY MESH SIZE FOR THE 1947 SEASON, OMITTING JULY 20 TO AUGUST 10, INCLUSIVE

Weight in lbs.	Mesh Size in Inches 5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
4.406	3	3									6
5.031	32	20	8	6							66
5.656	41	24	68	37	3	4		1			178
6.281	22	24	68	62	22	14		1			213
6.906	18	9	46	46	37	26	1	1			184
7.531	6	16	38	19	32	36		4			151
8.156	3	2	13	6	9	33	3	3			72
8.781	1	1	3	1	2	14	4	1			27
9.406			3				1				4
Total	126	99	247	177	105	127	9	11	0	0	901
Mean	5.93	6.14	6.54	6.48	7.08	7.51	8.43	7.47			6.63

TABLE XXVI

WEIGHT DISTRIBUTION OF ALL SOCKEYE BY MESH SIZE IN THE 1947 SEASON, OMITTING JULY 20 TO AUGUST 10, INCLUSIVE

Weight in lbs.	Mesh Size in Inches 5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
3.781	2	1									3
4.406	11	4	1								16
5.031	44	31	12	9	2			1			99
5.656	51	29	86	57	12	8		1			244
6.281	34	34	107	89	51	46	4	6	1		372
6.906	29	17	75	85	71	84	14	6	3	1	385
7.531	15	27	53	40	58	90	39	9	2	1	334
8.156	9	6	29	21	27	60	33	13			198
8.781	4	3	10	5	11	39	36	30	1	1	140
9.406	4		5	10	5	12	18	28	2		84
10.031	2				4	2	10	9			27
10.656		1			2	1	1	5			10
11.281						1		2			3
11.906								1			1
Total	205	153	378	316	243	343	155	111	9	3	1,916
Mean	6.14	6.28	6.64	6.72	7.20	7.52	8.26	8.72	7.7	7.7	7.06

TABLE XXVII

MALE SOCKEYE WEIGHT DISTRIBUTION BY MESH SIZE FOR THE ENTIRE 1948 SEASON

Weight in lbs.	Mesh Size in Inches 5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
3.781	16	2									18
4.406	56	32	2	1				1	1	1	94
5.031	74	84	56	8		4			3		229
5.656	60	71	124	79	27	1	1	1			364
6.281	30	40	76	124	92	22	2	1	1	1	389
6.906	8	17	46	46	74	56	6	1	1	1	256
7.531	3	6	10	32	36	56	17	2	2	1	165
8.156		1	6	11	9	24	11	9		1	72
8.781	1	5	6	7	4	11	17	7			58
9.406		1	1	2	2	10	20	13			49
10.031	1	1	2	4	4	4	11	9			36
10.656			1		5	5	4	6		1	22
11.281		1		3	2	2	3	4	2	1	18
11.906			1	1		2		4			8
12.531							1	1		1	3
Total	249	261	331	318	255	197	93	59	10	8	1,781
Mean	5.24	5.63	6.09	6.56	6.89	7.61	8.76	9.41	7.1	8.5	6.53

TABLE XXVIII

FEMALE SOCKEYE WEIGHT DISTRIBUTION BY MESH SIZE
FOR THE ENTIRE 1948 SEASON

Weight in lbs.	Mesh Size in Inches 5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
3.781	14	3		1							18
4.406	87	26	1	3	3	1			1		122
5.031	210	162	51	7	2	9		1			442
5.656	87	139	131	45	15	6					423
6.281	22	45	102	64	37	4		2		2	278
6.906	3	8	29	35	26	9					110
7.531	3	4	11	13	29	21		1	1		83
8.156	3	4	9	6	16	12	4				54
8.781	3	2	4	8	7	13	10		1		48
9.406					2	5	2				9
10.031		1		1		1	4				7
10.656						1		1			2
Total	432	394	338	183	137	82	20	5	3	2	1,596
Mean	5.13	5.47	6.02	6.43	6.93	7.42	8.97	7.2	6.9	6.3	5.88

TABLE XXIX

WEIGHT DISTRIBUTION OF ALL SOCKEYE BY MESH SIZE
FOR THE ENTIRE 1948 SEASON

Weight in lbs.	Mesh Size in Inches 5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾	Total
3.781	30	5		1							36
4.406	143	58	3	4	3	1		1	2	1	216
5.031	284	246	107	15	2	13		1	3		671
5.656	147	210	255	124	42	7	1	1			787
6.281	52	85	178	188	129	26	2	3	1	3	667
6.906	11	25	75	81	100	65	6	1	1	1	366
7.531	6	10	21	45	65	77	17	3	3	1	248
8.156	3	5	15	17	25	36	15	9		1	126
8.781	4	7	10	15	11	24	27	7	1		106
9.406		1	1	2	4	15	22	13			58
10.031	1	2	2	5	4	5	15	9			43
10.656			1		5	6	4	7		1	24
11.281		1		3	2	2	3	4	2	1	18
11.906			1	1		2		4			8
12.531							1	1		1	3
Total	681	655	669	501	392	279	113	64	13	10	3,377
Mean	5.17	5.53	6.05	6.51	6.90	7.55	8.81	9.23	7.0	8.0	6.23

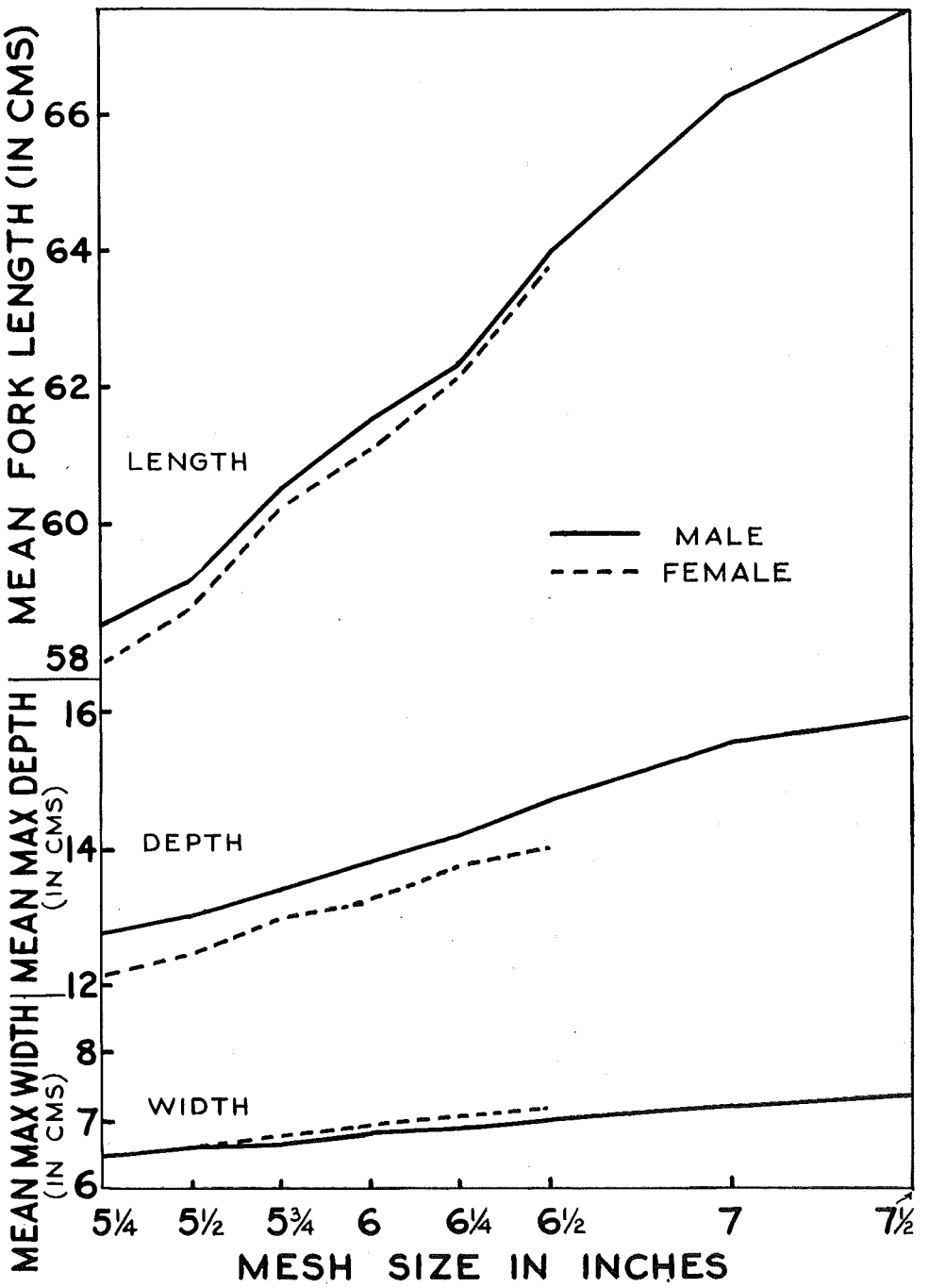

Figure 10. Relation of Mesh Size to Length, Depth and Width of All Sockeye in 1947 and and 1948 Combined.

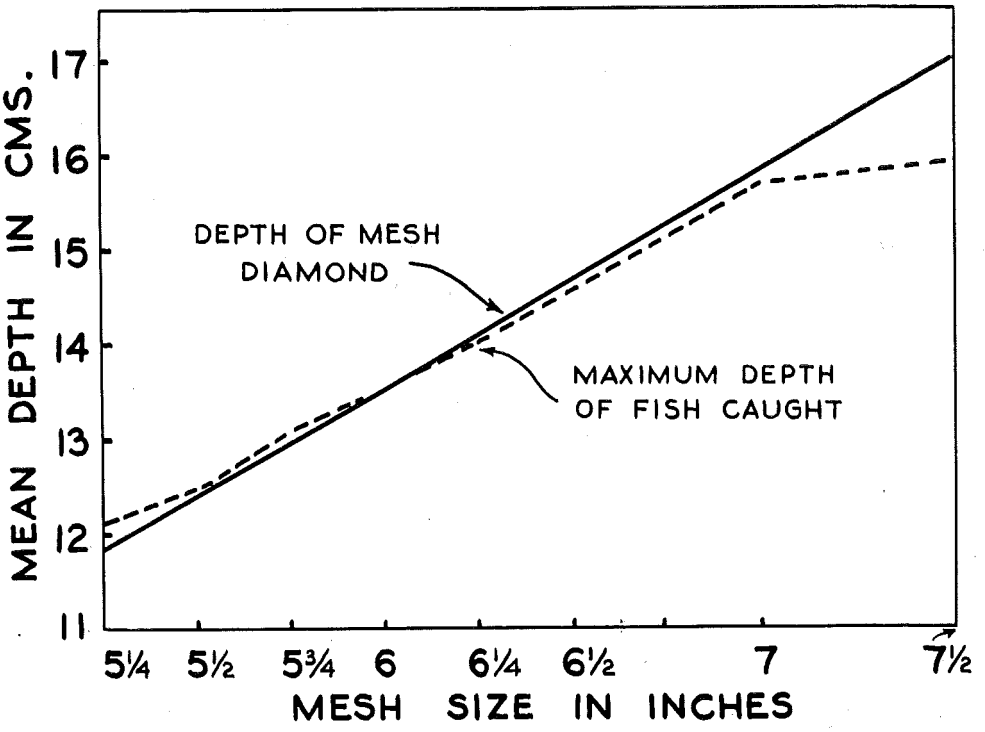

Figure 11. Comparison of Average Maximum Depth of 1948 Sockeye with the Depth of Mesh Diamond According to Mesh Size.

the depth of the mesh "diamond". The actual depth of each mesh diamond, computed on the basis of 88 fathoms of stretched mesh used to make up 40 fathoms of "hung" net for the different mesh sizes is shown below:

	Mesh Size in Inches							
	5¼	5½	5¾	6	6¼	6½	7	7½
Mesh Diamond Depth (cm.)	11.89	12.45	13.00	13.56	14.14	14.71	15.82	16.97
Fish Depth (cm.)	12.17	12.51	13.07	13.59	13.97	14.59	15.73	15.89

Compared above with the mesh diamond depth for each mesh size is the mean maximum depth of both sexes combined taken in the corresponding mesh size in 1948. This comparison is shown to better advantage in Figure 11. It is noted that both sets of data follow similar trends. However, in the smaller meshes the mean depths of fish are slightly larger than the mesh depths, while in the larger meshes the mesh depths are slightly larger. It would be expected that the fish depth measurement would always be the larger, since it is a maximum depth of the fish and is not necessarily taken at the position where the fish was enmeshed.

The indicated differences arise because of the use of *mean* values for determining the fish depths taken by the various mesh sizes. The small mesh sizes catch mainly the small fish but also a scattering of large fish. (The example used refers to fish depths, but a similar circumstance prevails with all the other

size measurements.) The large mesh sizes catch predominantly large fish but also some of the small fish. In the small meshes the asymmetrical distribution is skewed to the larger fish, whereas in the large meshes up to 7 1/2 inch mesh the skewing is to the smaller fish (Table XIX).

In the 5 1/4 inch mesh (Table XIX) the modal value was about 11.8 cm. while the mean was 12.17 cm. On the other hand, in the 7 1/2 inch mesh the mode was about 16.3 cm., while the mean was 15.89 cm. The extreme cases have been deliberately chosen to show the differences in mode and mean. The median (the middle value in the array) was also tried, and whereas it was influenced less by the extremes than the mean, the correction was too slight to be of consequence. It must be realized that the sharp selectivity of particular mesh sizes is somewhat masked by the scattering of "off" sizes of fish which have become entangled in the webbing. These scattered fish of various sizes are, however, too few in number to affect the significance of the mesh size to fish size relationship.

Selectivity of Individual Mesh Sizes for Age of Fish

Scale samples were taken from sockeye caught in the mesh experiment for determination of age. All of the fish could not be aged successfully, especially during the latter part of the season in September when the edges of many scales were deeply absorbed. Most of the fish in both 1947 and 1948 were of the 4_2 and 5_2 age groups. The 4_2 age group with two years of ocean growth was composed of smaller fish than the 5_2 group with three years of ocean feeding.

The numbers of 4_2 and 5_2 fish taken by each mesh size each weekend until the end of August are given for 1947 in Table XXX and for 1948 in Table XXXI. The percentages of 5_2's caught by each mesh size on each of the four weekends in 1947 when substantial samples were aged and for the total 1947 sample are shown in Figure 12. Figure 13 shows the percentage of 5_2's according to mesh size for each of the five weekends of good samples in 1948 and for the 1948 season. It is noted in both years that as the mesh size increased the percentage of 5_2's increased. On a seasonal basis (July and August combined) the percentage of 5_2's in 1947 increased from 32.9 per cent in the 5 1/4 inch mesh by fairly regular gradations through the mesh sizes to 94.4 per cent in the 7 1/2 inch mesh. For the July and August period in 1948 a similar trend occurred, with the percentage of 5_2's ranging from 2.2 per cent in the 5 1/4 inch mesh to 73.6 per cent in the 7 1/2 inch mesh.

The percentages of 5_2's taken by the respective mesh sizes during the 1948 season were substanitally lower than in 1947, because fewer 5_2 sockeye were available to the nets. Only 10.7 per cent of the 4_2 and 5_2 age groups were 5_2's in 1948, whereas in 1947 the sample consisted of 55.8 per cent 5_2's. During the peak of the 1948 Chilko run, August 6-8, only 5.4 per cent of the sockeye were of the 5_2 age group.

The sockeye produced in the Fraser River above Hell's Gate are predominantly four-year-old fish, and in 1948 the dominant race was Chilko. On the other hand, the 1947 sockeye run was that of an "off" year, with no up-river race being present

TABLE XXX

PROPORTION OF 4_2 TO 5_2 SOCKEYE BY MESH SIZE BY WEEKEND IN 1947

Mesh Size (Inches)	5¼		5½		5¾		6		6¼		6½		7		7½	
Age Group	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2
Weekend																
July 5- 6	1	0	4	0	1	0	2	1	4	0						
12-13	2	1	4	0	2	0	1	0	1	0	1	0				
19-20	8	2	20	0	5	1	14	7	4	1	3	4	1	1		
July 26-27	42	7	35	9	52	10	73	34	23	15	8	14	2	11	0	3
% 5_2	14.2		20.4		16.1		31.8		39.5		63.6		84.6		100.	
Aug. 2- 3	3	1	19	7	8	8	23	24	9	11	1	3			0	11
% 5_2	33.3		26.9		50.0		51.1		55.0		75.0				100.	
Aug. 9-10	10	8	21	25	11	19	18	45	7	25	3	35	1	8	1	10
% 5_2	44.4		54.3		63.3		71.4		78.1		92.1		88.9		90.9	
Aug. 16-17	27	27	22	15	36	70	30	39	20	53	23	103	2	36	2	39
% 5_2	50.0		40.5		66.0		56.5		72.6		81.7		94.7		95.1	
Aug. 23-24	0	2	4	1	4	1	2	1	1	3	0	3				
30-31	5	1	0	7	4	3	1	13	1	8	2	11	0	2	1	4
Total	100	49	129	64	123	112	164	164	70	116	41	173	6	58	4	67
% 5_2	32.9		33.2		47.7		50.0		62.4		80.8		90.6		94.4	

TABLE XXXI

PROPORTION OF 4_2 TO 5_2 SOCKEYE BY MESH SIZE BY WEEKEND IN 1948

Mesh Size (Inches)	5¼		5½		5¾		6		6¼		6½		7		7½	
Age Group	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2	4_2	5_2
Weekend																
July 10-11			1	0	0	1			0	1						
17-18	8	1	17	3	2	0	5	2	0	1	2	1			0	3
July 24-25	43	4	44	4	34	13	21	7	21	18	11	14	3	14	1	16
% 5_2	8.5		8.3		27.6		25.0		46.2		56.0		82.4		94.1	
July 31 - Aug. 1	135	3	110	4	173	12	79	18	51	14	34	23	10	14	2	13
% 5_2	2.2		3.5		6.5		18.6		21.5		40.4		58.3		86.7	
Aug. 6- 8	209	2	230	5	160	8	162	7	100	11	42	8	8	5	5	6
% 5_2	0.9		2.1		4.8		4.1		9.9		16.0		38.5		54.5	
Aug. 14-15	81	1	77	3	64	5	76	0	56	4	32	7	3	1	4	1
% 5_2	1.2		3.8		7.2		0		6.7		17.9		25.0		20.0	
Aug. 21-22	43	1	33	0	47	1	39	1	29	1	15	0	10	2	2	0
% 5_2	2.3		0		2.1		2.5		3.3		0		16.7		0	
Aug. 28-29	11	0	3	0	9	0	3	0	5	0			1	0		
Total	530	12	515	19	489	40	385	35	262	50	136	53	35	36	14	39
% 5_2	2.2		3.6		7.6		8.3		16.0		28.0		50.7		73.6	

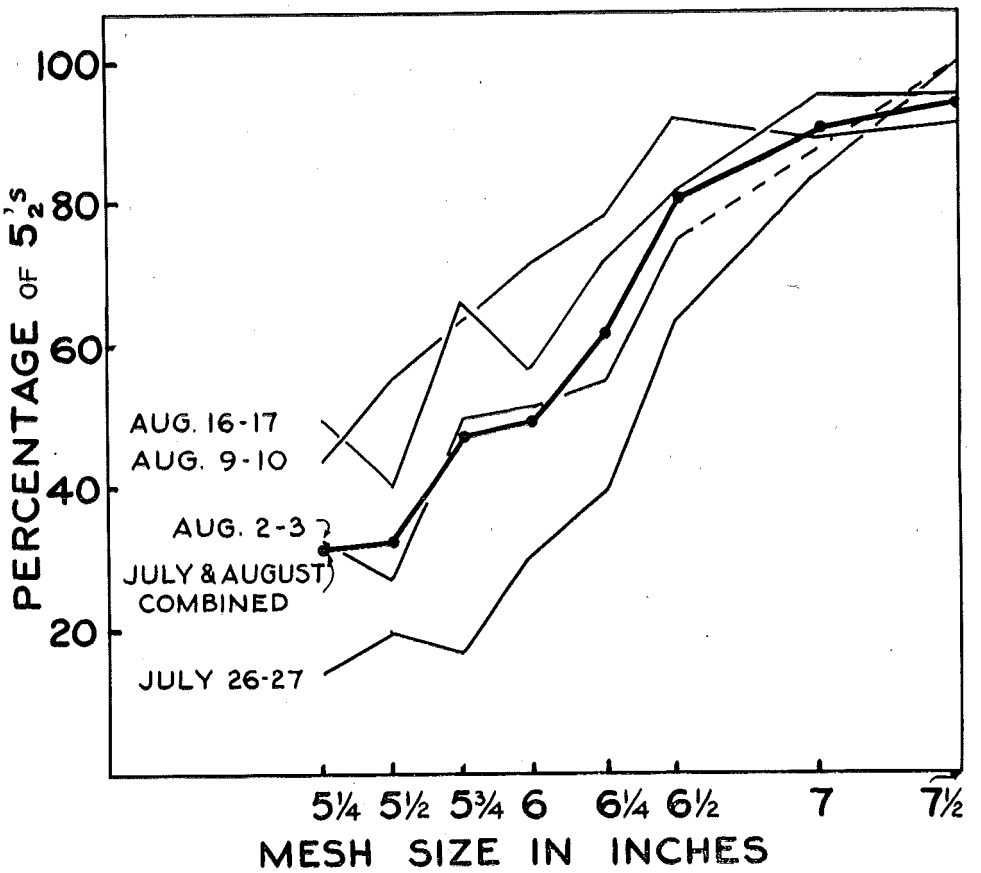

Figure 12. Percentage of 5_2 Sockeye by Mesh Size in 1947.

in large numbers in the July and August catches. A goodly portion of the 1947 catches consisted of fish destined for the lower river spawning grounds of the Pitt River and Birkenhead River races, both of which have high proportions of five-year-old fish in certain years.

A selective action for age of sockeye by the individual mesh sizes occurred in both 1947 and 1948, although the proportion of 4_2's to 5_2's differed greatly in the two years. The smaller mesh sizes caught predominantly four-year-old fish and the larger meshes took mainly five-year-olds. The 4_2's were smaller than the 5_2's, and the selectivity for age of fish merely reflected size selectivity.

Relation of Mesh Size to Sex Ratio

It has been shown previously that individual mesh sizes are highly selective for size of sockeye, with the small meshes taking predominantly small fish and the large meshes catching mainly large fish. Since within a year-class the large fish are mostly males and the small fish are preponderantly female, a definite selective action by mesh size occurs for sex as well as size of the sockeye. The size

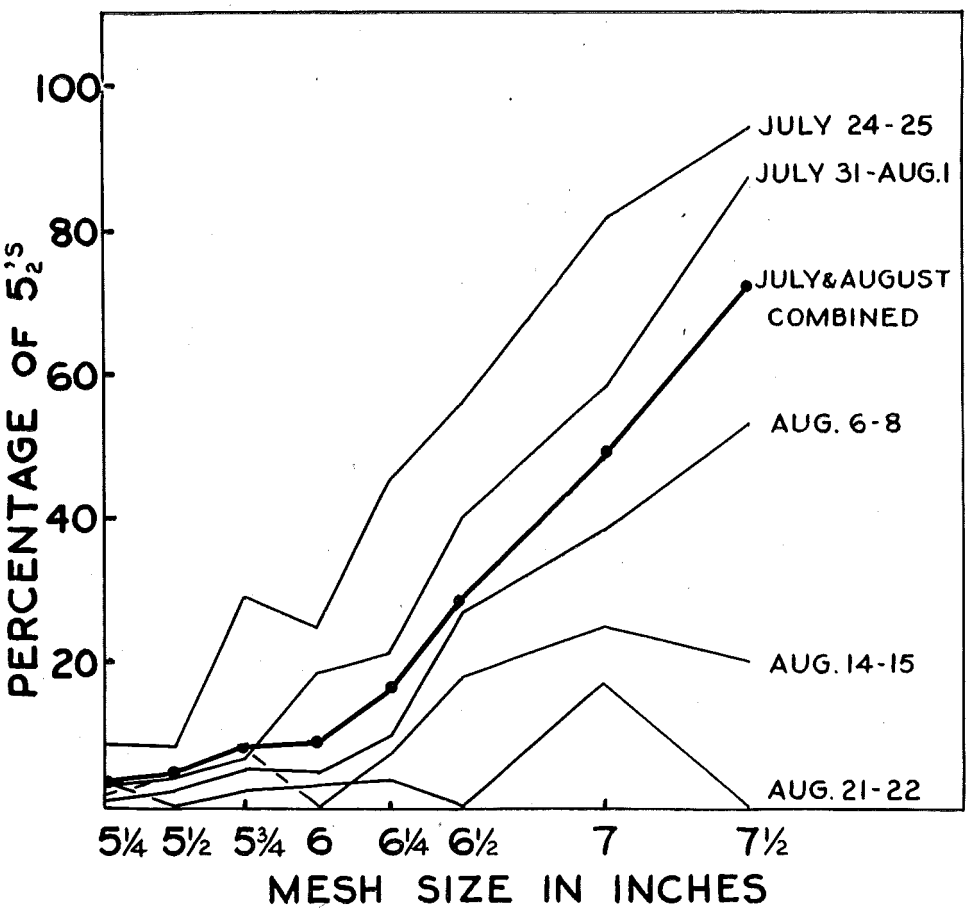

Figure 13. Percentage of 5_2 Sockeye by Mesh Size in 1948.

composition of 4_2, 5_3 and 5_2 males is invariably larger than that of 4_2, 5_3 and 5_2 females from the same races of Fraser River sockeye. That the mean length of the males is greater than the mean length of the females has been shown by Gilbert and Clemens in the British Columbia Fisheries Department Reports and by all Commission records from the commercial fishery, upriver tagging stations and the spawning grounds.

On the other hand, the precocious "jack" sockeye which are mostly 3_2's with some 4_3's and which are predominantly males have a smaller size distribution than 4_2 females. However, the 3_2 and 4_3 "jacks" are seldom caught by the range of mesh sizes used in the gillnet fishery because of their small size, usually less than 50 cm. in fork length, and therefore are not considered in this report.

The numbers of males and females for each weekend of experimental fishing in 1947 according to mesh size are given in Table XXXII. The percentage of males has been computed for each mesh size on the six weekends when large

TABLE XXXII

NUMBER OF MALE AND FEMALE SOCKEYE CAUGHT BY EACH MESH SIZE EACH WEEKEND IN 1947 AND THE PERCENTAGE OF MALES BY MESH SIZE ON THE SIX WEEKENDS OF GOOD FISHING

	MESH SIZE IN INCHES																	
	5¼		5½		5¾		6		6¼		6½		7		7½		8¼		8¾	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
July 5- 6	1	1	1	0	1	0	5	0	3	1	0	0	0	0	0	0	—	—	0	0
12-13	1	2	3	1	2	2	1	1	1	0	1	0	0	0	0	0	—	—	0	0
19-20	5	5	8	15	3	3	13	9	5	2	7	0	3	0	0	0	—	—	0	0
July 26-27	29	37	19	33	41	34	72	67	29	18	11	13	16	1	3	1	—	—	1	0
% Males	43.9		36.5		54.7		51.8		61.7		45.8		94.1		75.0					
Aug. 2- 3	11	22	16	19	11	21	31	31	14	11	18	10	15	5	25	1	—	—	0	0
% Males	33.3		45.7		34.4		50.0		64.0		64.3		75.0		96.2					
Aug. 9-10	8	14	18	44	15	31	39	55	16	25	16	28	9	2	17	2	—	—	0	0
% Males	36.4		29.0		32.6		41.5		39.0		36.4		81.8		89.5					
Aug. 16-17	25	59	16	39	45	112	34	66	46	64	96	84	44	6	58	5	—	—	0	0
% Males	29.8		29.1		28.7		34.0		41.8		53.3		88.0		92.1					
Aug. 23-24	1	3	1	3	3	3	4	1	5	3	1	3	1	0	0	0	0	0	0	0
30-31	6	8	5	10	4	15	18	22	9	12	9	13	10	0	11	1	0	0	0	0
Sept. 6- 7	4	4	3	3	5	5	8	12	11	1	7	1	10	0	2	0	2	0	0	0
Sept. 12-14	6	7	7	11	12	27	29	26	29	11	57	5	35	2	11	0	2	0	1	0
% Males	46.1		38.9		30.8		52.7		72.5		91.9		94.6		100.					
Sept. 19-21	33	38	10	15	54	73	38	42	25	11	42	18	45	1	18	5	4	0	1	0
% Males	46.5		40.0		42.5		47.5		69.4		70.0		97.8		78.3					
Sept. 26-28	3	5	2	4	6	11	4	5	7	3	3	3	0	0	1	0	1	0	1	0
Oct. 3- 5	2	0	1	7	1	2	1	0	0	0	1	0	1	0	0	0	0	0	0	0
Season Total	135	205	111	208	203	339	297	337	200	162	269	178	189	17	146	15	9	0	4	0
% Males	39.7		34.8		37.5		46.8		55.2		60.2		91.7		90.7		100.		100.	

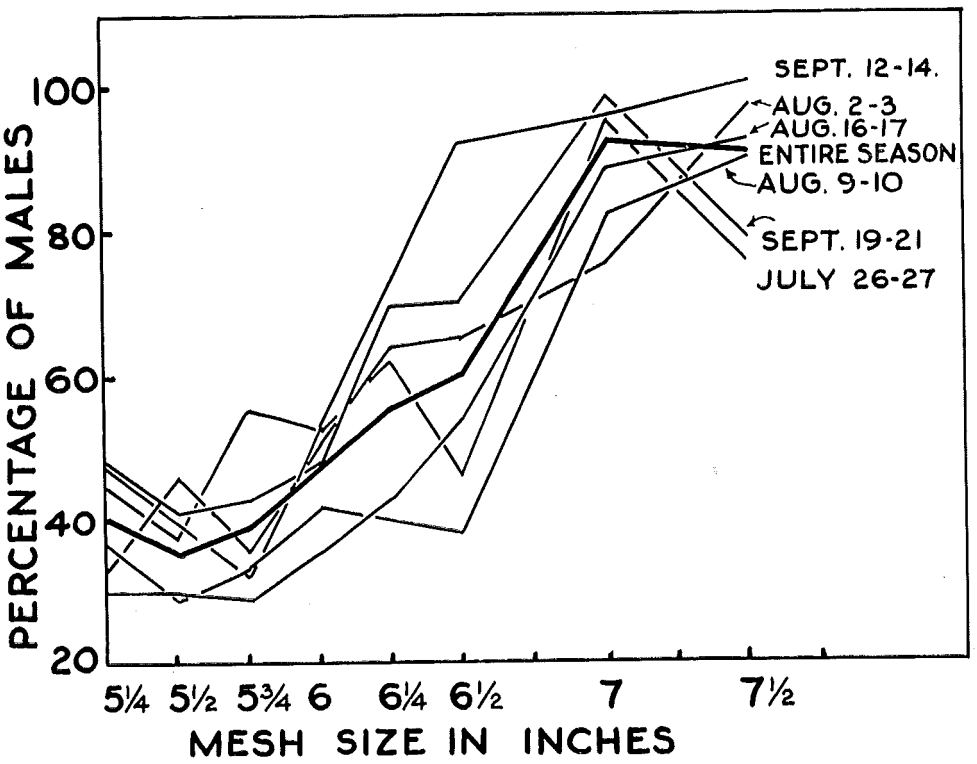

Figure 14. Percentage of Male Sockeye Caught by Each Mesh Size by Weekend and Entire Season in 1947.

samples of fish were caught and also on a seasonal basis. These data have been plotted in Figure 14. A definite relationship between percentage of males and mesh size is noted for each of the six weekends and for the entire season.

Variations occur between weekends in the percentage of males taken by any particular mesh size. These variations are in part due to size of fish, sex ratio of fish and the degree of sexual dimorphism in the available stock of fish.

The mesh size/percentage males relationship for the 1947 season is approximately straight-line over the middle range of mesh sizes. But when the small and large mesh sizes are included, the line tends to follow a sigmoid or drawn-out S-shaped curve. The decline in percentage of males in the 7 1/2 inch mesh is probably the result of the upper size limit of available fish being attained. The higher percentage of males in the 5 1/4 inch mesh over the 5 1/2 inch mesh is probably due to the lower limit of the size range of the fish being reached.

In Table XXXIII the numbers of male and female sockeye caught by the various mesh sizes each weekend in 1948 are given. The percentages of males for each mesh size on the five weekends of good fishing and for the season of 1948 are displayed in Figure 15. There is less deviation of the weekly percentages from the seasonal percentages by mesh size in 1948 than in 1947, mainly due to the

TABLE XXXIII

NUMBER OF MALE AND FEMALE SOCKEYE CAUGHT BY EACH MESH SIZE EACH WEEKEND IN 1948 AND THE PERCENTAGE OF MALES BY MESH SIZE ON THE FIVE WEEKENDS OF GOOD FISHING

	MESH SIZE IN INCHES																	
	5¼		5½		5¾		6		6¼		6½		7		7½		8¼		8¾	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
July 10-11	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
17-18	4	5	12	8	3	2	7	0	1	0	5	0	0	0	2	0	0	0	1	0
July 24-25	19	40	29	30	33	28	20	12	25	24	16	12	17	3	14	2	0	0	1	0
% Males	32.2		49.2		54.1		62.5		51.0		57.1		85.0		87.5					
July 31 - Aug. 1	60	95	48	78	114	91	71	32	47	29	40	28	27	6	16	2	3	0	1	0
% Males	38.7		38.1		55.6		68.9		61.8		58.8		81.8		88.9					
Aug. 6- 8	90	169	100	170	110	87	127	65	97	29	50	15	13	5	13	1	3	3	2	1
% Males	34.7		37.0		55.8		66.1		77.0		76.9		72.2		92.8					
Aug. 14-15	34	60	34	54	29	53	52	42	35	27	38	13	9	2	8	0	0	0	1	0
% Males	36.2		38.6		35.4		55.3		56.4		74.5		81.8		100.					
Aug. 21-22	15	41	14	34	20	37	27	19	23	16	19	3	12	1	4	0	3	0	1	1
% Males	26.8		29.2		35.1		58.7		59.0		86.4		92.3		100.					
Aug. 28-29	5	11	1	4	3	9	2	5	2	4	3	2	0	1	0	0	0	0	1	0
Sept. 4- 5	5	5	5	7	4	11	5	2	9	1	11	2	4	0	1	0	0	0	0	0
Sept. 11-12	5	6	1	6	5	10	5	3	4	0	3	2	2	3	1	0	0	0	0	0
18-19	2	2	7	1	7	8	0	2	11	5	1	2	3	0	0	0	0	0	0	0
25-26	10	2	10	3	5	4	2	2	1	2	13	3	6	0	2	0	1	0	0	0
Season Total	249	436	262	396	333	341	318	184	255	138	199	82	93	21	61	5	10	3	8	2
% Males	36.3		39.8		49.6		63.3		64.9		70.8		81.6		92.4		76.9		80.0	

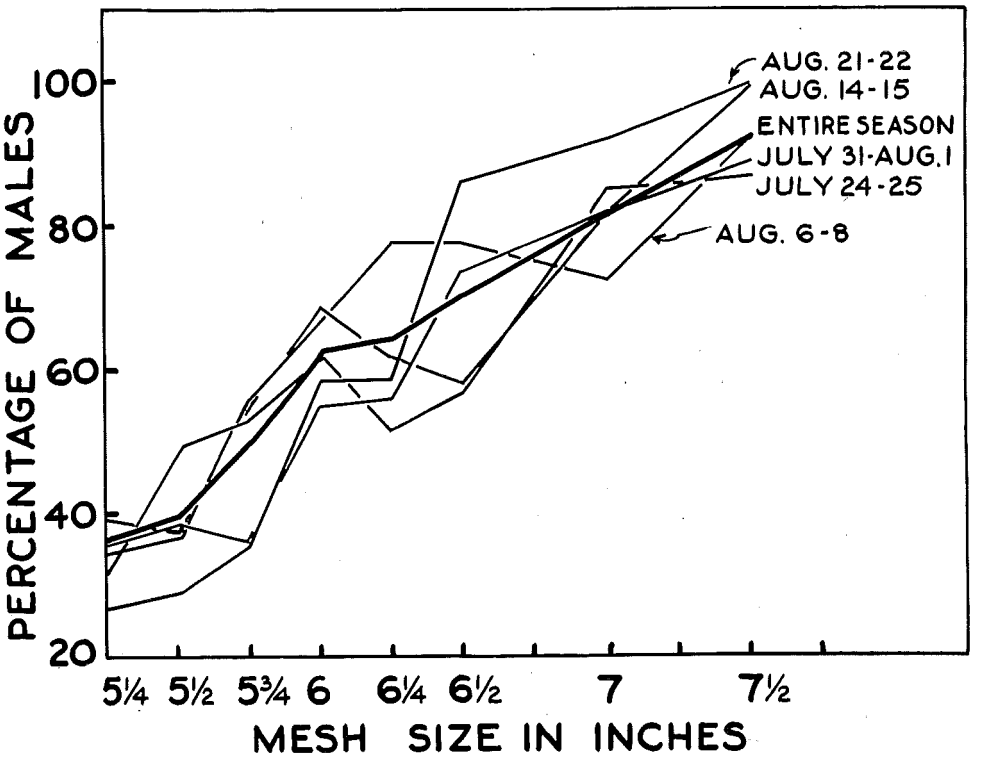

Figure 15. Percentage of Male Sockeye Caught by Each Mesh Size by Weekend and Entire Season in 1948.

presence of the dominant Chilko race composed of mostly four-year-old sockeye. The relationship between mesh size and percentage of males caught is demonstrated to be approximately linear.

When the fish were small as on August 6-8, 1948, the individual mesh sizes up to 6 1/2 inch caught a higher percentage of males than when the fish were large as on August 16-17, 1947. According to the two *seasonal* curves a 50-50 sex ratio was approximated in the 5 3/4 inch mesh in 1948, whereas in 1947 about a 6 1/8 inch mesh would have taken the sexes in even proportions.

Although variations occurred in the percentage of males taken by the individual mesh sizes on the different weekends in both years, the relationship between mesh size and percentage of males is evident. The larger meshes take predominantly male sockeye, whereas the smaller meshes take mainly females.

Mesh Size and Relative Catch

In comparing the numbers of sockeye caught in the mesh experiment by the individual mesh sizes, it is essential that the fishing effort and efficiency of the various nets be fairly consistent. Significant variations in efficiency occurred in 1947 between the two boats, and hence the actual catches by the different mesh sizes were not comparable, as has been indicated previously. When each weekend

TABLE XXXIV

SOCKEYE CATCH PER DRIFT PER 40-FATHOM NET SECTION BY MESH SIZE EACH WEEKEND OF 1947

		Mesh Size in Inches									
		5¼	5½	5¾	6	6¼	6½	7	7½	8¼	8¾
July	5- 6	0.2	0.5	0.1	0.6	0.3	0	0	0	—	0
	12-13	0.2	0.4	0.3	0.1	0.1	0.1	0	0	—	0
	19-20	1.4	1.6	0.8	1.8	0.7	0.5	0.3	0	—	0
	26-27	5.8	5.3	7.6	6.4	4.2	3.2	1.7	0.4	—	0.1
Aug.	2- 3	3.5	3.2	3.6	5.6	2.8	2.8	2.0	1.3	—	0
	9-10	3.1	5.9	6.7	8.6	6.0	4.5	1.2	1.1	—	0
	16-17	10.9	9.2	14.5	16.6	18.3	18.5	11.5	4.3	—	0
	23-24	0.5	0.8	1.0	1.0	1.0	1.0	0.2	0	0	0
	30-31	2.1	1.7	2.7	5.7	3.0	2.8	1.4	1.3	0	0
Sept.	6- 7	1.3	1.0	1.7	3.3	1.5	1.2	1.2	0.3	0.2	0
	12-14	1.0	2.0	5.6	3.5	4.4	4.0	2.3	1.4	0.2	0.1
	19-21	6.5	5.1	11.7	11.4	6.2	8.6	7.1	2.2	0.4	0.1
	26-28	1.1	0.6	1.7	1.5	1.2	0.6	0	0.1	0.1	0.1
Oct.	3- 5	0.2	0.8	1.1	0.1	0	0.1	0.1	0	0	0
Mean		2.64	2.47	4.66	3.97	3.13	3.17	1.62	1.06	0.16	0.03

total catch was converted to a catch-per-drift basis, the catches between the boats appeared comparable. Therefore the catch per drift (Table XXXIV) can be used to compare the catches of the different meshes in 1947.

In 1948 the fishing effort and efficiency of the two boats were much more comparable than in 1947. The actual catch, the catch per standard fishing time and the catch per drift—all showed a consistent pattern in the weekend catches between the two boats (Table III). All three ways of establishing relative catches for the various mesh sizes by weekend will be used in 1948.

Special emphasis will be accorded the 1948 mesh experiment data, since in that year the results can be compared with an operating commercial fishery. In 1947, on the other hand, the fishery was closed for escapement purposes until September 8, except for mesh sizes of 8 inch or greater. The mesh experiment catches in 1948 are also of more value for detailed analysis because of the predominance of the large Chilko race of sockeye. The Chilko fish can be traced through the United States purse seine fishery, the Fraser River gillnet fishery, and through Farwell Canyon on the Chilcotin River to the Chilko spawning grounds, and comparisons of relevant characteristics can be made from the different areas.

The catch per drift figures in 1947 (Table XXXIV) show that especially on two weekends distinctly better catches were made by particular mesh sizes, namely by the 6 1/4 inch and 6 1/2 inch meshes on August 16-17 and by the 5 3/4 and 6 inch meshes on September 19-21. For the entire 1947 season the 5 3/4 inch mesh was the most effective, catching 4.66 sockeye per drift per 40-fathom net section. The 6 inch mesh was second in effectiveness with 3.97 fish per drift, followed by the 6 1/4 and 6 1/2 inch meshes with 3.13 fish and 3.17 fish, respectively, per drift.

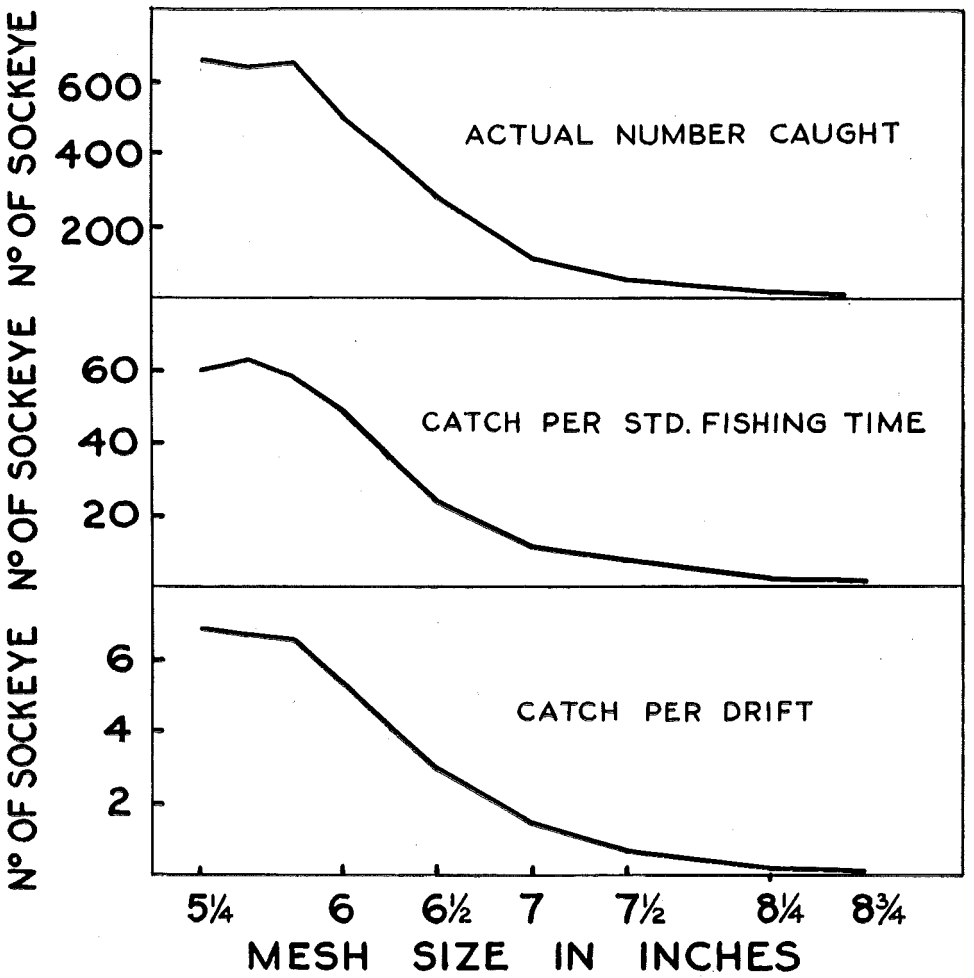

Figure 16. Number of Sockeye Caught by Each Mesh Size during Entire 1948 Season.

The sockeye catch for the entire 1948 season by mesh size is shown in Figure 16. The catch is given in the three ways, (1) actual numbers caught, (2) catch per standard fishing time and (3) catch per drift. The similarity of the three catch curves is apparent. Each of the curves show the best catches in the small meshes, 5 1/4 inch, 5 1/2 and 5 3/4 inch. In the mesh sizes from 6 inch to 8 3/4 inch the catches decline in a consistent manner in all three curves as the mesh sizes become larger.

In Table XXXV is given the percentage of numbers of fish taken by mesh size on each weekend of good fishing in 1948 by each of the three ways. The combined number caught on a percentage basis was computed by taking a combination of the three curves for each mesh size and is shown in Figure 17. Any one of the catch curves would probably have been adequate, but a combination of the three is considered the best estimate.

TABLE XXXV

PERCENTAGE OF NUMBERS OF SOCKEYE CAUGHT BY EACH MESH SIZE FOR EACH WEEKEND FROM JULY 24 TO AUGUST 22, 1948, INCLUSIVE

	Mesh Size in Inches								
	5¼	5½	5¾	6	6¼	6½	7	7½	Total
July 24-25									
Actual No. Caught (%)	17.8	19.3	19.0	9.7	14.8	8.5	6.0	4.8	99.9
No. per Standard Time (%)	18.4	17.5	18.5	11.9	10.8	12.2	6.4	4.3	100.0
No. per Drift (%)	21.3	14.7	14.5	11.7	17.8	9.6	4.6	5.8	100.0
Combined No. Caught (%)	19.2	17.2	17.3	11.1	14.5	10.1	5.7	5.0	100.1
July 31 - August 1									
Actual No. Caught (%)	19.7	16.1	25.9	13.4	9.9	8.6	4.1	2.2	99.9
No. per Standard Time (%)	19.7	22.1	27.6	10.3	7.7	7.3	3.7	1.6	100.0
No. per Drift (%)	19.8	16.1	25.9	13.3	9.9	8.7	4.1	2.2	100.0
Combined No. Caught (%)	19.7	18.1	26.5	12.3	9.2	8.2	4.0	2.0	100.0
August 6-8									
Actual No. Caught (%)	22.6	23.7	17.1	17.1	10.9	5.8	1.6	1.2	100.0
No. per Standard Time (%)	21.4	28.3	18.1	14.0	9.4	4.1	3.6	1.0	99.9
No. per Drift (%)	22.3	23.4	16.9	16.9	10.8	5.7	2.7	1.2	99.9
Combined No. Caught (%)	22.1	25.1	17.4	16.0	10.4	5.2	2.6	1.1	99.9
August 14-15									
Actual No. Caught (%)	19.2	18.2	16.6	19.2	12.6	10.3	2.2	1.6	99.9
No. per Standard Time (%)	18.5	17.3	17.5	21.9	12.8	8.6	2.2	1.2	100.0
No. per Drift (%)	16.2	21.1	19.2	16.2	14.7	8.7	2.6	1.3	100.0
Combined No. Caught (%)	18.0	18.9	17.8	19.1	13.4	9.2	2.3	1.4	100.1
August 21-22									
Actual No. Caught (%)	19.6	16.8	20.0	16.1	13.7	7.7	4.6	1.4	99.9
No. per Standard Time (%)	17.3	20.1	20.6	16.2	11.4	6.0	6.3	2.2	100.1
No. per Drift (%)	21.1	15.8	18.7	17.4	12.9	8.2	4.2	1.6	99.9
Combined No. Caught (%)	19.3	17.6	19.8	16.6	12.7	7.3	5.0	1.7	100.0

TABLE XXXVI

PERCENTAGE OF SOCKEYE POUNDAGE CAUGHT BY EACH MESH SIZE FOR EACH WEEKEND FROM JULY 24 TO AUGUST 22, 1948, INCLUSIVE

	Mesh Size in Inches								
	5¼	5½	5¾	6	6¼	6½	7	7½	Total
July 24-25									
Actual Poundage Caught (%)	14.2	16.5	17.2	9.5	16.1	10.8	8.6	7.1	100.0
Poundage per Standard Time (%)	14.5	14.8	16.6	11.5	11.7	15.4	9.1	6.3	99.9
Poundage per Drift (%)	16.8	12.5	13.0	11.3	19.2	12.1	6.6	8.5	100.0
Combined Poundage Caught (%)	15.2	14.6	15.6	10.8	15.7	12.8	8.1	7.3	100.1
July 31 - August 1									
Actual Poundage Caught (%)	16.8	13.9	24.8	14.3	10.9	10.2	5.9	3.3	100.1
Poundage per Standard Time (%)	17.1	19.5	26.9	11.2	8.6	8.8	5.4	2.4	99.9
Poundage per Drift (%)	16.8	13.9	24.8	14.1	10.8	10.3	5.9	3.3	99.9
Combined Poundage Caught (%)	16.9	15.8	25.5	13.2	10.1	9.8	5.7	3.0	100.0
August 6-8									
Actual Poundage Caught (%)	19.1	21.7	16.9	18.4	12.5	7.3	2.3	1.8	100.0
Poundage per Standard Time (%)	18.2	26.0	18.0	15.1	10.8	5.2	5.2	1.5	100.0
Poundage per Drift (%)	18.8	21.3	16.6	18.1	12.3	7.2	3.9	1.8	100.0
Combined Poundage Caught (%)	18.7	23.0	17.2	17.2	11.9	6.6	3.8	1.7	100.1
August 14-15									
Actual Poundage Caught (%)	15.8	16.8	16.5	20.0	13.7	12.2	3.1	2.0	100.1
Poundage per Standard Time (%)	15.2	16.0	17.3	22.8	13.9	10.2	3.1	1.5	100.0
Poundage per Drift (%)	13.3	19.4	19.0	16.8	15.9	10.3	3.7	1.6	100.0
Combined Poundage Caught (%)	14.8	17.4	17.6	19.9	14.5	10.9	3.3	1.7	100.1
August 21-22									
Actual Poundage Caught (%)	16.6	14.3	19.5	17.0	14.7	9.5	6.3	2.1	100.0
Poundage per Standard Time (%)	14.5	17.1	20.0	17.0	12.1	7.3	8.6	3.3	99.9
Poundage per Drift (%)	17.8	13.5	18.2	18.3	13.8	10.1	5.8	2.4	99.9
Combined Poundage Caught (%)	16.3	15.0	19.2	17.4	13.5	9.0	6.9	2.6	99.9

When comparing the relative efficiency of different mesh sizes, the poundage of sockeye caught by each mesh size must also be considered. From an economic standpoint total poundage is more important than total numbers of fish, because the fishermen are paid on a poundage basis and the canneries utilize a certain poundage of fish to make up a case of canned salmon.

Since the fish caught in the mesh experiment were weighed individually, it is a simple matter to show the percentage of sockeye poundage caught by each mesh size for each of the five weekends of good fishing in 1948. The percent poundage for each mesh size, as in Table XXXV for numbers of fish, is shown in Table XXXVI in the three ways. A combined poundage has been established for each mesh size by combining the poundage per drift, poundage per standard fishing time and poundage actually caught. These combined poundages on a percentage basis for each mesh size have also been plotted in Figure 17 for each weekend and are considered the best estimates of relative poundages caught.

Figure 17 represents the relative catches of the different mesh sizes for each weekend of fishing from July 24 to August 22, 1948, on both a poundage basis and numbers of fish basis. On the weekend of July 24-25, two weeks before the peak of the dominating Chilko race of sockeye, there were apparently two size groups of fish present. The smaller meshes, 5 1/4, 5 1/2 and 5 3/4 inch, caught the most fish, but the 6 1/4 also did well. (On a poundage basis the 5 3/4 inch mesh was best, followed by the 6 1/4 inch mesh.)

Fishing had improved by July 31 - August 1 and the 5 3/4 inch mesh was outstandingly efficient, taking 26.5 per cent of the numbers of fish (25.5 per cent of the poundage). The next two best mesh sizes, 5 1/4 inch and 5 1/2 inch, caught respectively 19.7 per cent and 18.1 per cent of the fish (16.9 per cent and 15.8 per cent of the poundage).

On August 6-8 excellent catches were made on mainly Chilko fish of small size, and the 5 1/2 inch mesh was the most effective, taking 25.1 per cent of the total number of sockeye caught that weekend (23.0 per cent of the poundage). The second best mesh size was the 5 1/4 inch which caught 22.1 per cent of the fish (18.7 per cent of the poundage). The 5 3/4 inch and 6 inch were the next most effective mesh sizes. It is evident that the small meshes were extremely effective on August 6-8.

On August 14-15 the catches dropped considerably from the previous "peak" weekend. The four smaller meshes, 5 1/4, 5 1/2, 5 3/4 and 6 inch, were about equal in effectiveness for numbers of fish caught. Their catches were 18.0 per cent, 18.9 per cent, 17.8 per cent and 19.1 per cent, respectively. (On a poundage basis, the 6 inch mesh was best with 19.9 per cent; the 5 3/4 was next with 17.6 per cent, followed by the 5 1/2 with 17.4 per cent and the 5 1/4 with 14.8 per cent). In the larger meshes there was a general tapering off in catch as the mesh size became larger.

By August 21-22 the catches had decreased further, and the small meshes from 5 1/4 inch to 6 inch were again the best mesh sizes, with 19.3 per cent, 17.6 per cent, 19.8 per cent and 16.6 per cent respectively, of the numbers of

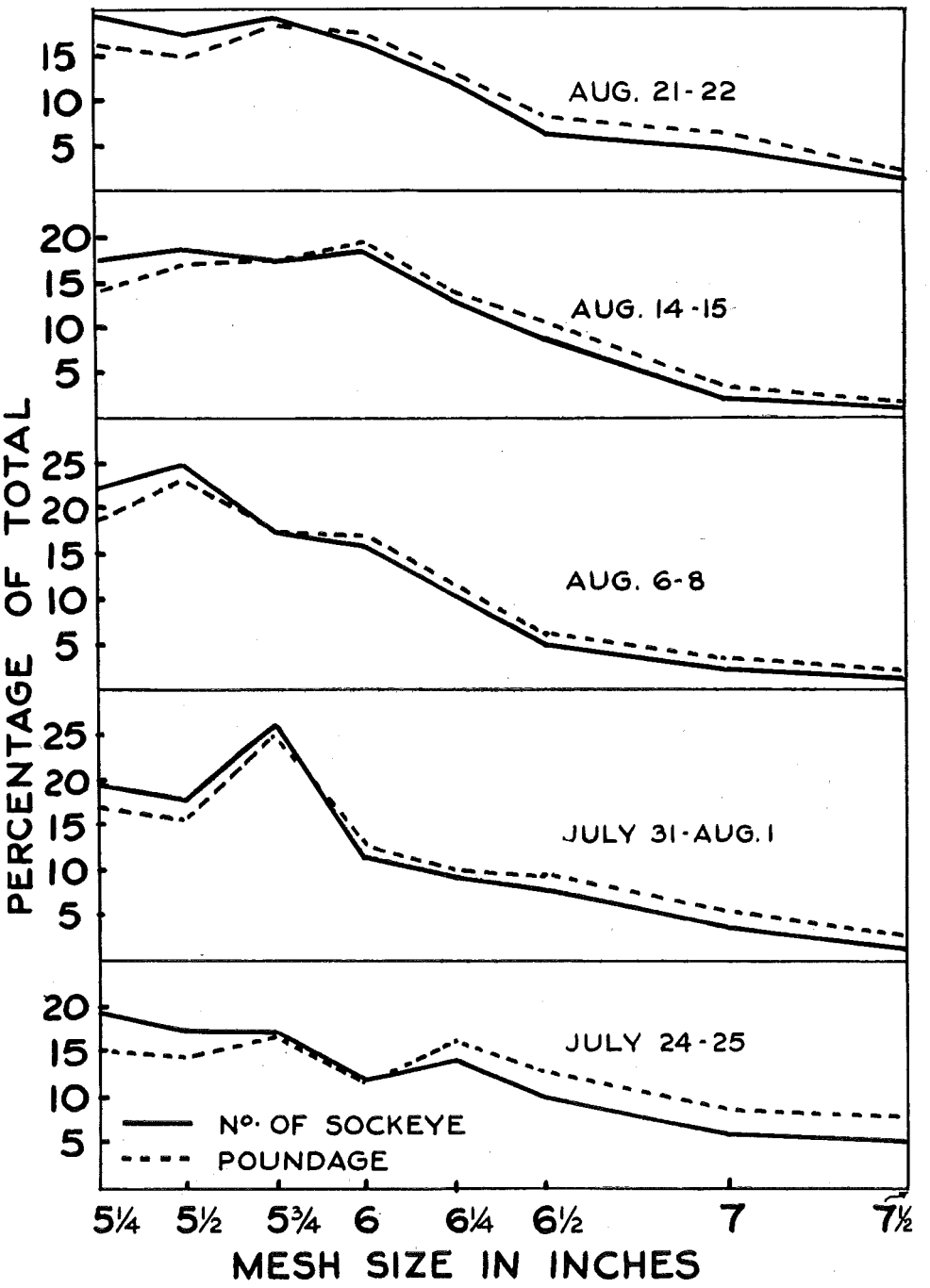

Figure 17. Percentage of Sockeye Caught by Each Mesh Size for Each Weekend from July 24 to August 22, 1948, Inclusive.

fish being taken. (In poundage the percentages caught by the 5 1/4 inch mesh to 6 inch mesh, inclusive, were 16.3, 15.0, 19.2 and 17.4 per cent, respectively.)

The relative effectiveness of the small meshes on August 6-8 compared with the other weekends can be emphasized by combining the catches of the 5 1/4 inch and 5 1/2 inch meshes and by showing them as follows:

	July 24-25	July 31 Aug. 1	Aug. 6-8	Aug. 14-15	Aug. 21-22
Numbers of Fish (%)	36.4	37.8	47.2	36.9	36.9
Poundage (%)	29.8	32.7	41.7	32.2	31.3

It is noted that on August 6-8 the combined 5 1/4 and 5 1/2 inch meshes caught 47.2 per cent of the fish as compared with only 37.8 per cent on July 31 - August 1 and slightly less on the other weekends. (Similarly, in poundage the combined meshes took 41.7 per cent on August 6-8, 32.7 per cent on July 31 - August 1 and less on the other weekends. The poundages are of course represented by smaller figures than the numbers of fish, because the small meshes caught the lighter fish.)

Comparison of Weekend Experimental Catches with Commercial Gillnet Catches

A comparison of the daily commercial gillnet catch below the Pattullo bridge and the mesh experiment daily catch per drift per 200-fathom net for both boats combined for the various weekends through the 1948 season is shown in Figure 18. Both the mesh experiment catches and the commercial fishery catches in 1948 followed a similar distinctive pattern. The respective catches started out low; then increased steadily and reached an apex within the August 5 to 9 period; and then tapered off to very low catches by the end of August, and remained very low all during September. A Chi-square test showed no significant difference between the catch per drift each weekend and the weekly fleet catch. (An average was taken of the catches of the last day of the week and the following Monday for each weekly fleet catch.)

The close agreement between the catch per drift on the weekends and the fleet catch during the fishing weeks suggests the possibility of using test drift catches as indices of the total gillnet catch below the Pattullo bridge. It is noted in Figure 18 that the ordinate for the commercial catch by the fleet is in thousands of fish while that for the mesh experiment catch per drift is in units of fish on a relative scale of 1000:1. As has been indicated, this ratio remained fairly constant throughout the 1948 season.

A similar direct comparison in 1947 between the mesh experiment and commercial fishery catches was possible only after September 8, since the fishery was not opened to sockeye fishing prior to that date. However, gillnets of 8 inch minimum mesh were allowed to fish prior to September 8, and a number of the fishermen used nets of fine twine "hung in" to such an extent that they snagged about 15,000 sockeye during this period. It is possible for the period prior to

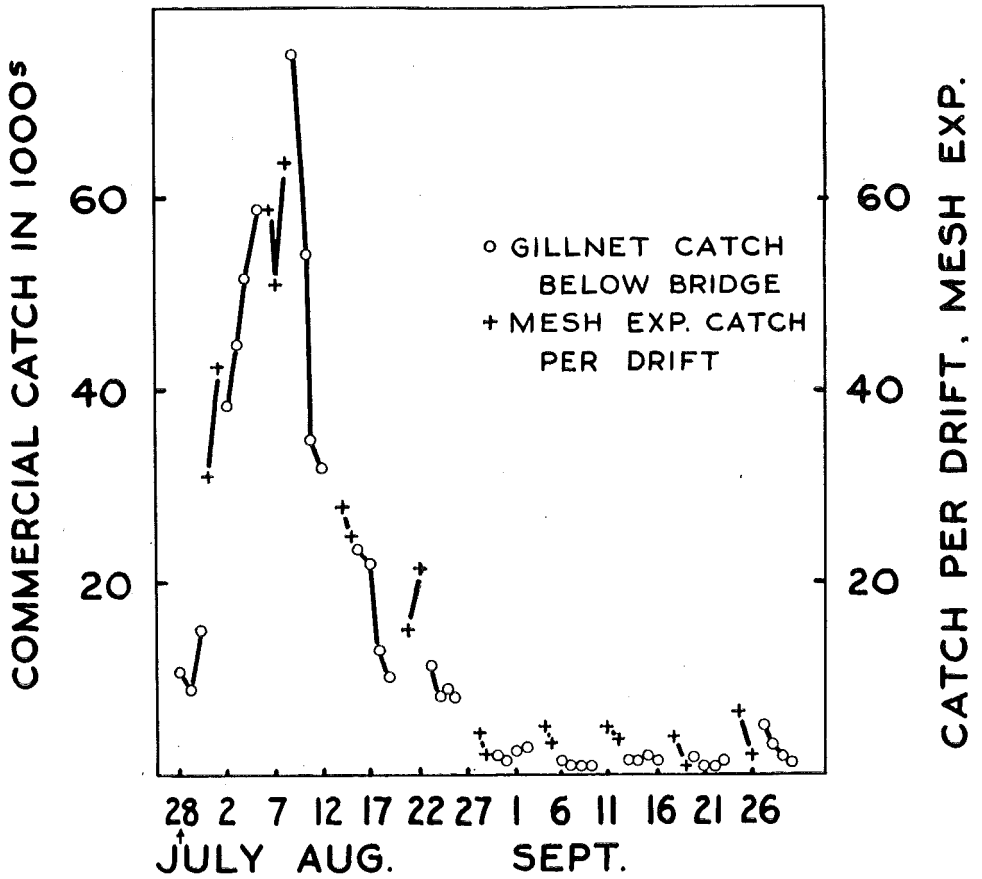

Figure 18. Comparison of Fraser River Gillnet Catch below the Pattullo Bridge and Catch Per Drift from Weekend Mesh Experiment Catches at Steveston in 1948.

September 8 to make a rough comparison of the mesh experiment catches with the reported catches of the "hung in" fine twine 8 inch minimum mesh gillnet catches.

In the upper half of Figure 19 are shown the reported daily fleet gillnet sockeye catches in the Fraser River (all areas) by 8 inch minimum mesh nets and the sockeye catch per drift per 200-fathom net from the mesh experiment during the period July 1 to September 7, 1947 on a relative scale of 1000:30. It is noted that there is a fairly close agreement in the trend between the two catch curves, featured by the sudden formation of a sharp peak on August 17 (Sunday) and August 18 (Monday). The preciseness of the two catch curves which was evident in 1948 was lacking in 1947. The statistics on the 8 inch minimum mesh gillnet catches were not reported as accurately as during a normal sockeye fishing season.

The daily fleet catches below the Pattullo bridge using the full range of mesh sizes and the mesh experiment catch per drift after September 8 in 1947

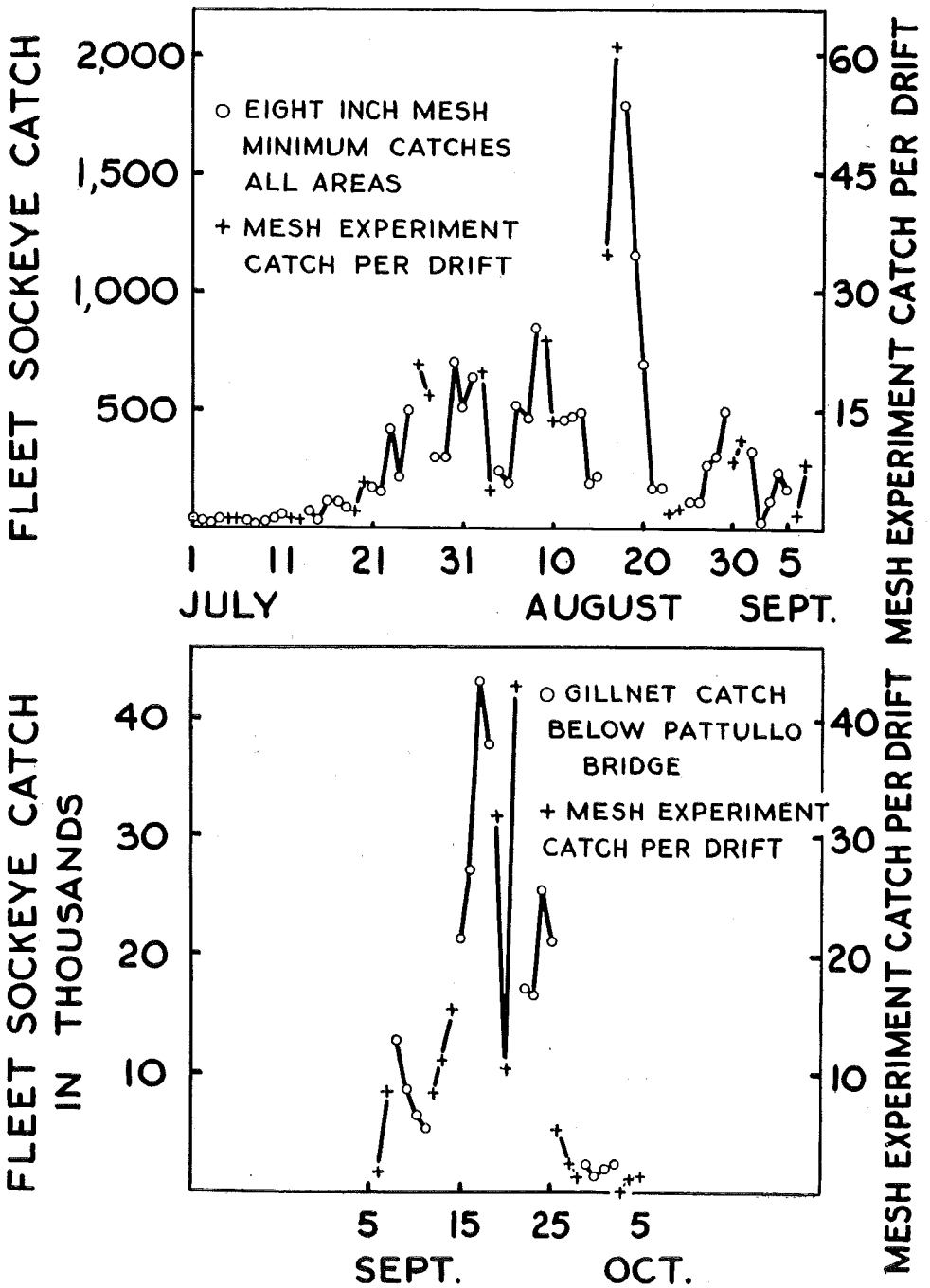

Figure 19. Comparison of Fraser River Gillnet Catch and Mesh Experiment Catch Per Drift in 1947.

are shown in the lower half of Figure 19 on a relative scale of 1000:1. Good sockeye catches were made by the fleet from September 15 to 24, with a peak established on September 17, during an extremely heavy pink salmon run. The best sockeye catches by the mesh experiment boats were made on the weekend of September 19-21, midway between the two best weeks of fishing by the fleet. On this late run a portion of the commercial gillnet catch was made on fish delaying off the Fraser River mouth.

It has been demonstrated that in 1947 and more precisely in 1948 the variations in relative magnitude of the weekend catches are similar to the variations shown in the total Fraser River gillnet catch. The weekend catches followed the same trend as the fleet catches during the fishing weeks.

THE EFFECT OF THE GILLNET FISHERY ON THE SIZE OF SOCKEYE IN THE ESCAPEMENT

In 1946, the first year of regulation by the Commission, the Fraser River gillnet fishery was closed to sockeye fishing (except for nets of 8 inch minimum mesh) until August 8 for escapement purposes. Certain sockeye races were subject to two types of gillnet fishery, (1) a fishery of very light intensity with no gillnets less than eight inch mesh size prior to August 8 and (2) an intense fishery using the full range of sockeye nets after the opening date. The possible effect of any change in size of the escaping fish of these races caused by this change in the fishery has been measured at various upriver points.

The mesh size distribution and the respective catch of each mesh size in the gillnet fishery during the period from August 8 to 30, 1946, has been determined from logbook and personal interview work covering about 20 per cent of the gillnet fleet. In Figure 20 these data are presented as number of sockeye per boat delivery and number of boat deliveries for each mesh size (grouped in quarter inch mesh size intervals).

Figure 20 shows that the mesh size distribution and the average sockeye catch distribution are widely different. The data show the 6 inch mesh (1,657 deliveries) and the 5 3/4 inch mesh (951 deliveries) were used to a much greater extent than the smaller meshes (5 1/2 with 345 deliveries and 5 1/4 with 126 deliveries) or the larger meshes (6 1/4 with 174 deliveries and 6 1/2 with 97 deliveries). The highest average catches were, on the other hand, taken in the 5 1/2 (37.7 fish per delivery) and 5 1/4 (36.4 fish). The larger mesh sizes showed considerably lower average catches (ranging from 23.8 fish per delivery in the 5 3/4 to 11.6 fish in the 6 1/2).

It is indicated from this 20 per cent sample of the gillnet fleet that the mesh sizes used were probably too large for maximum efficiency. Since the smaller mesh sizes made the better catches, it seems reasonable to believe that a greater proportion of the smaller mesh sizes should have been used to avoid size selectivity. Also, it would appear that any escapement through the gillnets was probably composed of mainly the smaller fish, because of the lower fishing intensity by the small meshes.

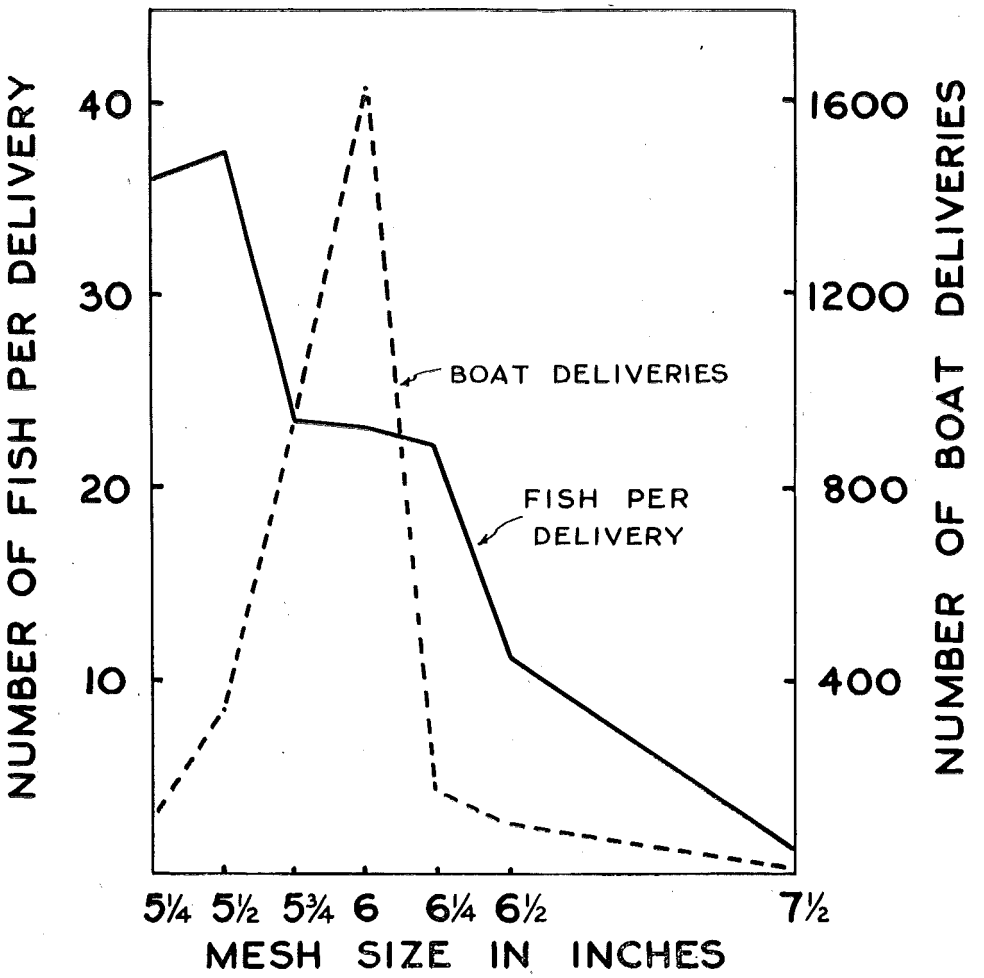

Figure 20. Fraser River Gillnet Sockeye Catch Per Boat Delivery and Number of Deliveries by Mesh Size in August, 1946.

The effect of the mesh size distribution of the gillnet fleet on the size of the fish in the escapement can be observed by referring to Figure 21, which shows the daily average lengths and the percentage of net-marked sockeye at Hell's Gate from August 1 to September 2, 1946. At Hell's Gate, which is about 130 miles above the river mouth (Plate 3), Talbot (1950) has demonstrated that the percentage of net-marked sockeye and the sockeye catch per hour were correlated with the Fraser River gillnet fishery dates in years following the construction of the fishways. Talbot indicated that the time of passage from the gillnet fishery to Hell's Gate was five or six days.

In Figure 21 the gillnet fishing periods have been blocked in and have been advanced five days to correspond roughly to the dates at Hell's Gate (August 8 in the fishery is depicted as August 13 at Hell's Gate). In the period from August 1-12 at Hell's Gate, the Fraser River gillnet fishery was restricted to an eight inch

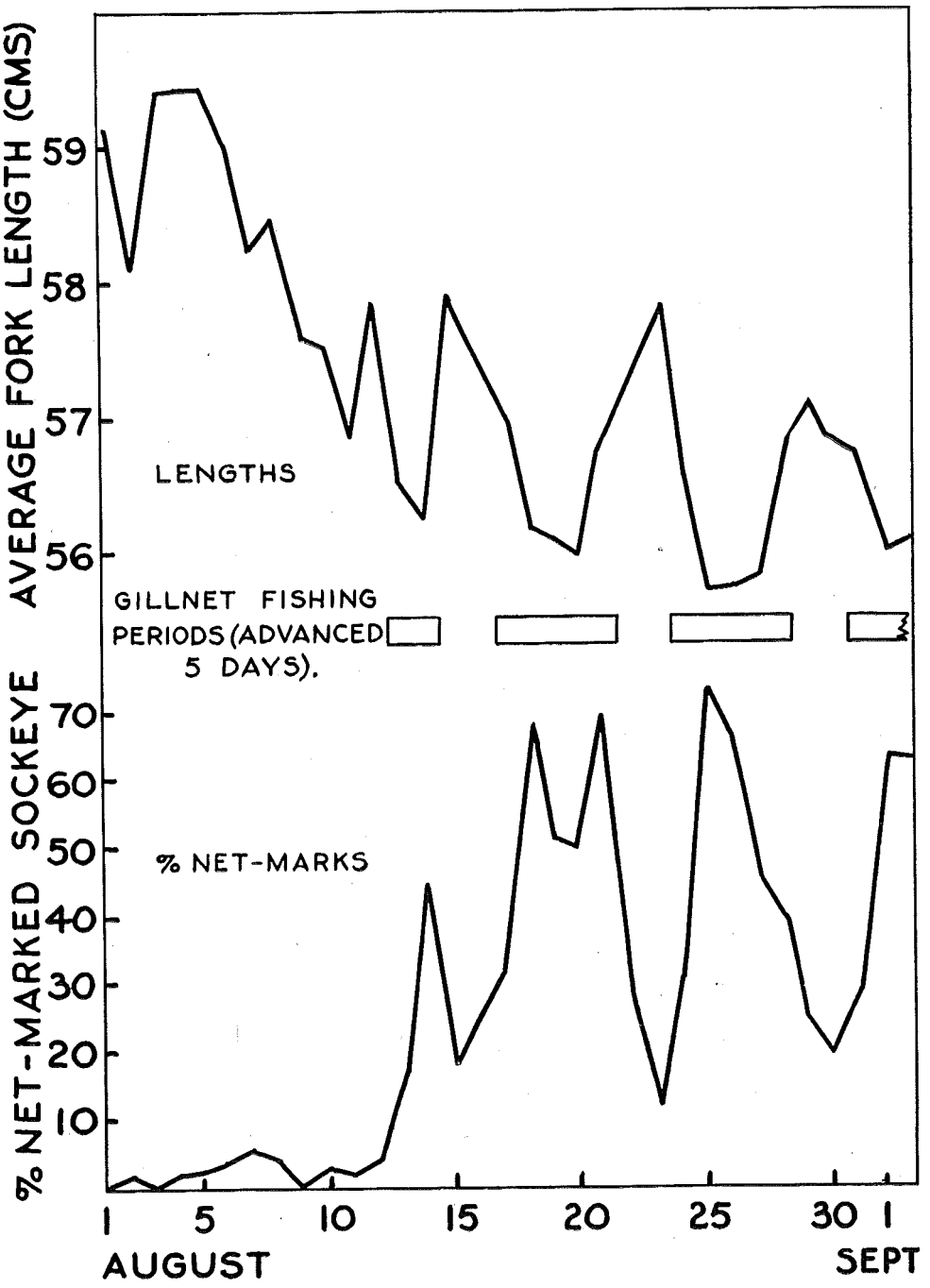

Figure 21. Daily Average Length and Percentage of Net-Marked Sockeye at the Tagging Stations below Hell's Gate in 1946.

minimum mesh size during the sockeye closure. The average lengths of the sockeye at Hell's Gate during this period were comparatively high, averaging about 59 cm. with some fluctuations from August 1 to August 6 and then tapering off to 57.9 cm. between August 7 and August 12. The percentage of net-marked fish during this twelve-day period was practically nil, ranging daily from zero to 4.9 per cent and averaging 2.1 per cent. During the period that the fishery was closed to sockeye fishing, the size of the fish was comparatively large and the proportion of net-marked fish was very small.

With the advent of sockeye fishing by gillnets on August 8 and 9 the average lengths of the fish at Hell's Gate on August 13 and 14 dropped abruptly to 56.5 cm. and 56.2 cm., respectively, whereas the percentage of net-marked fish rose decidedly to 16.2 per cent and 44.1 per cent, respectively. The weekend fishing closure of August 10 and 11 was indicated at Hell's Gate on August 15 and 16 by an increase in average length of the sockeye to 58.0 cm. and 57.5 cm., respectively, and by a decrease in percentage of net-marked fish to 15.9 per cent and 25.0 per cent, respectively.

When the fishery resumed normal operations during the fishing week of August 12-16, the sockeye at Hell's Gate five days later showed a sudden decrease in average lengths and an abrupt increase in percentage of net-marked fish, as Figure 21 shows. The fishing closure of August 17 and 18 was reflected suddenly on August 22 and 23 by increments in fish length and decrements in net-marked sockeye. Conversely, the fish on August 24-28 at the Gate were small and heavily net-marked, relating to the fishing activities of August 19-23. The August 24-25 fishing closure showed correspondingly larger fish with fewer net-marks on August 29-30, followed by smaller fish with a high percentage of net-marks after the weekend closure.

The relationship between the daily average lengths and percentages of net-marked fish was inverse and approximately linear with a highly significant correlation coefficient of $r = -.88$. The relationship of these two variables with the fishing dates in the Fraser River gillnet fishery is also apparent. When the fishery was in operation, the escaping fish were small and heavily net-marked. When fishing closures were in effect, the escapement was composed of larger fish containing fewer net-marks. Any variability in elapsed migration time of the fish from the fishery to Hell's Gate was not of enough consequence to obscure the relationship between the fishing dates and the size and "net-mark" characteristics of the escapement.

It should be pointed out here that the Fraser River sockeye run is composed of a number of different races, each migrating to particular "home" spawning grounds and each exhibiting slightly different characteristics inherent to the particular race. For example, the sockeye from different spawning grounds have shown variations in average size. It might be contended that the change in size of fish at Hell's Gate from early August to late August in 1946 merely indicated a change in racial composition. Further testing of escapement data from a particular single race is required.

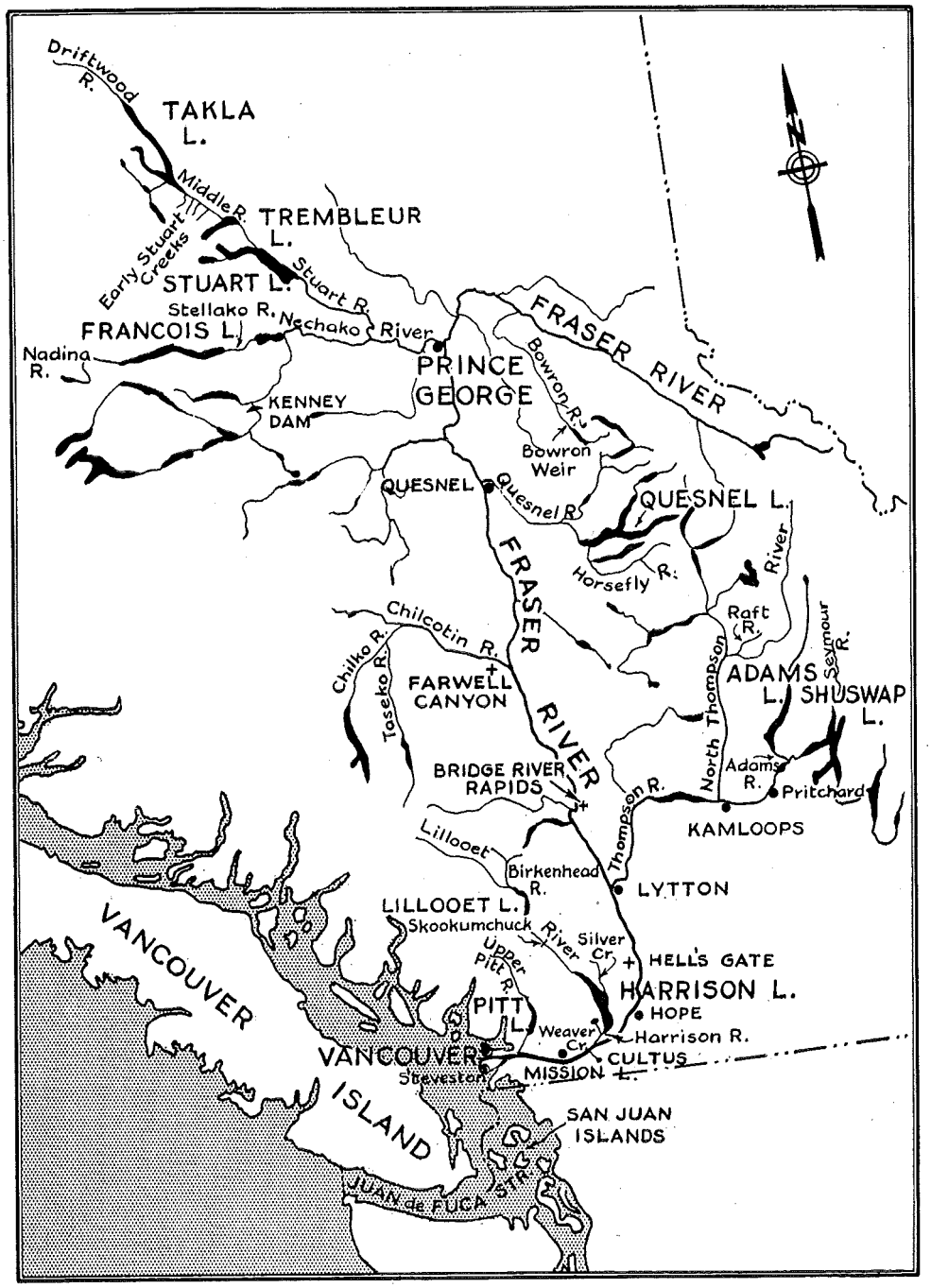

Plate 3. Fraser River Watershed.

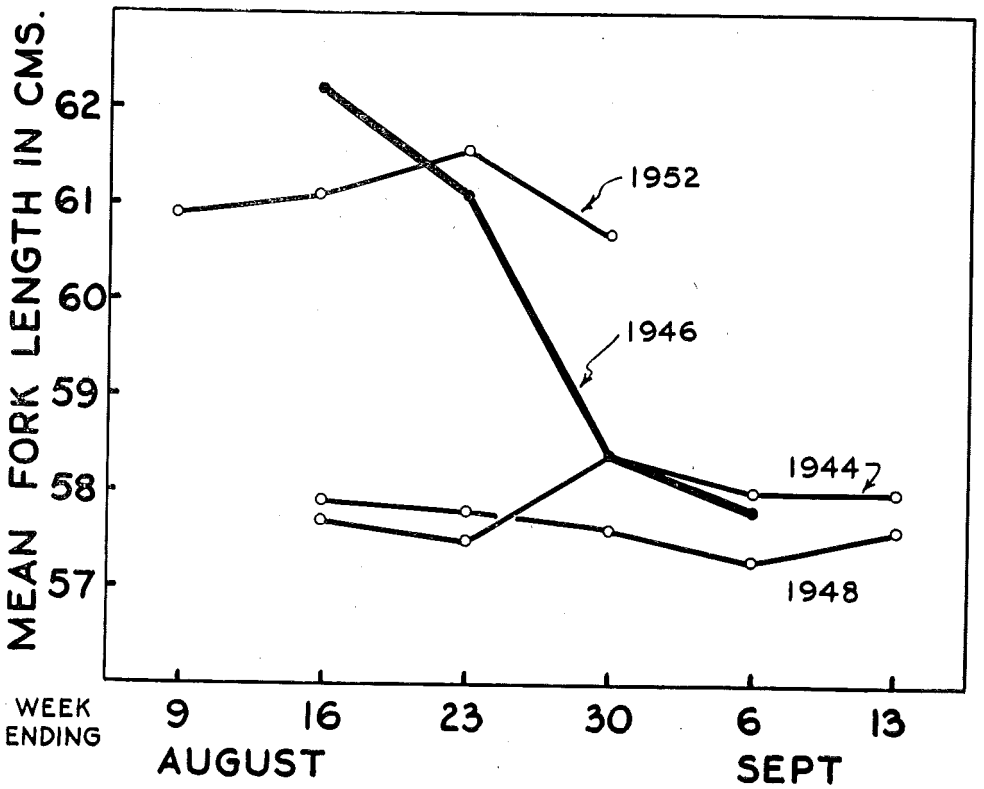

Figure 22. Average Fork Length of Sockeye at Farwell Canyon by Weekly Periods in 1944, 1946, 1948 and 1952.

The Chilko River race of sockeye was chosen for further testing, because its timing through the gillnet fishing area placed it in the fishery both prior to and after the August 8 opening date. The 1946 Chilko run passed through Hell's Gate between July 29 and August 29, based on 86 Hell's Gate tags recovered in the Chilcotin watershed. Allowing a migration time of five days from the gillnet fishery to Hell's Gate, the 1946 Chilko fish probably migrated through the gillnet fishing areas from about July 24 to August 24 or for a period of 15 days prior to the August 8 opening date and 16 days after this date.

At Farwell Canyon, which is situated about 303 miles up the Fraser and Chilcotin Rivers from the mouth of the Fraser River, length measurements taken during daily tagging on a total of 1,762 fish indicated a considerable drop in the size of Chilko fish as the season progressed. The average size of the fish, grouped by weekly periods, declined significantly from 62.2 cm. in the week ending August 16 to 57.8 cm. in the week ending September 6, as is shown in Figure 22. An analysis of variance test on the weekly average lengths indicated lack of homogeneity with an extremely high F value of 130.54.

Contrasted with the decline in size at Farwell in 1946 are length data from three other years, namely 1944, 1948 and 1952, when the size of fish at Farwell

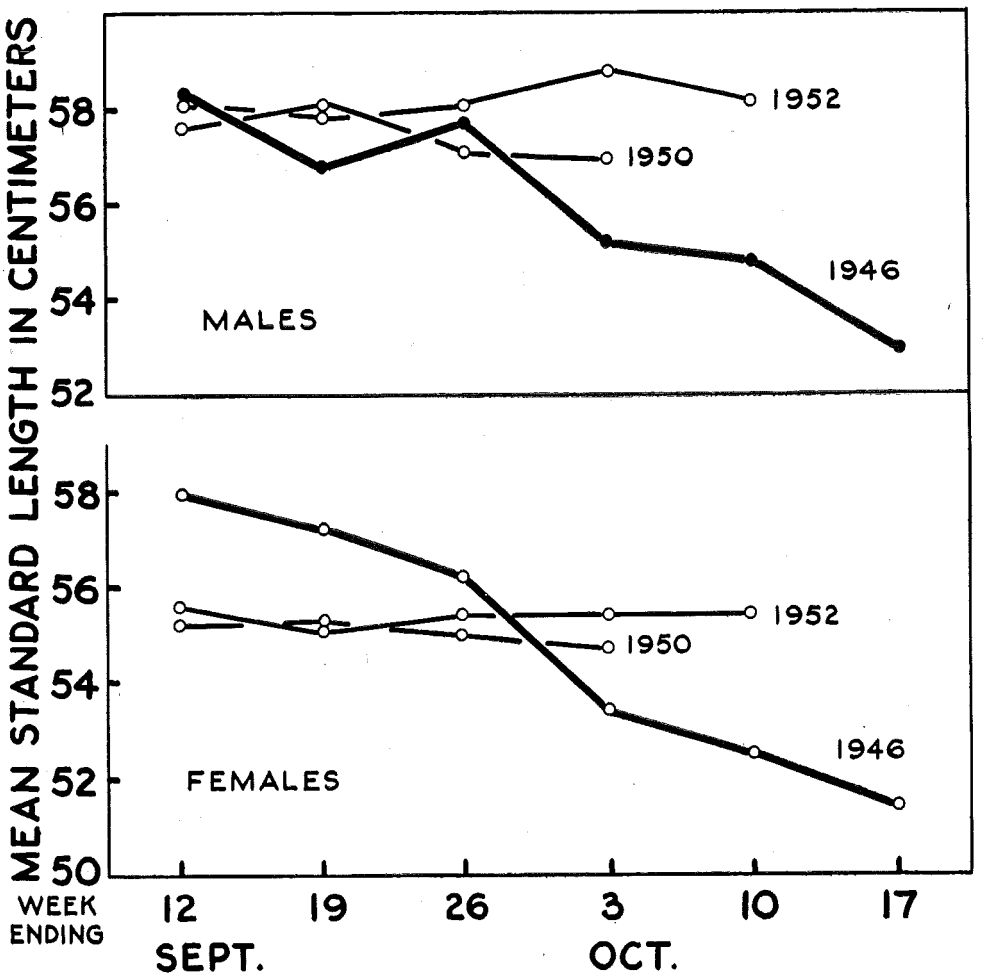

Figure 23. Average Standard Length of Sockeye by Sex at the Chilko River by Weekly Periods in 1946, 1950 and 1952.

did not drop appreciably throughout the season. Figure 22 shows that in the latter three years mentioned the mean weekly lengths remained fairly stable. The total sample sizes in 1944, 1948 and 1952 were 1,748 fish, 6,212 and 5,177 fish, respectively. F values for these years were 4.12, 10.59 and 16.21, respectively, considerably lower than in 1946. While no year showed size homogeneity through the sensitive analysis of variance test, the high F value in 1946 compared with the relatively very low values in the other three years indicated a much greater change in size in 1946. The sockeye gillnet fishery operated throughout the Chilko run in 1944, 1948 and 1952, whereas in 1946 approximately the first 15 days of the run was fished only by 8 inch minimum and the latter 17 days by sockeye nets (disregarding weekend closures).

The decline in the size of the Chilko fish at Farwell in 1946 was not due to a changing sex ratio, because both sexes of sockeye showed this decline (Figure 23). At Farwell the sex of sockeye could not be distinguished accurately, but

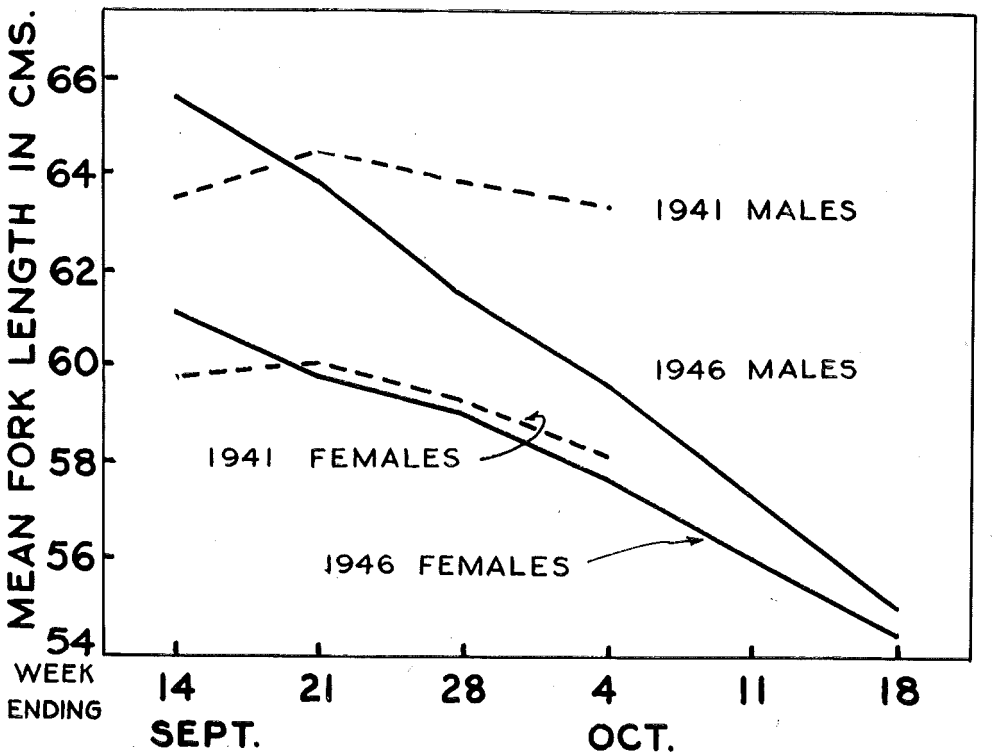

Figure 24. Average Fork Length of Sockeye by Weekly Periods in 1946 and 1941 at the Birkenhead River.

standard lengths from dead fish on the Chilko River spawning grounds in the years 1946, 1950 and 1952 showed a marked decrement in size with progression of the season only in 1946. (The standard length is taken from the tip of the snout to the posterior edge of the hypural plate.)

The Birkenhead River race, which is known to follow the Chilko race but whose delimitation in the gillnet fishing areas is not well defined, also showed a substantial decrease in size throughout the 1946 season on the spawning grounds (Figure 24). In 1941, however, when the gillnet fishery operated throughout the run (except for closed weekends), the males showed no decline and the females a slight decline in size.

The possible effect of the gillnet fishery on the large Chilko run of 1948 (670,000 escapement) was also examined. The Fraser River was opened to sockeye nets on July 28, 1948, with the great bulk of the run occurring in the fishing areas after the opening date. The distribution of mesh sizes used, as shown in Table XXXVII, represents about a 15 per cent sample of the whole fleet obtained from logbook and personal interviews. The data were gathered from about 200 to 275 boats, the number varying during the season. As in 1946, the mesh size distribution is represented by number of boat deliveries rather than number of boats, since all boats did not land fish each day. These boat deliveries have been

TABLE XXXVII

1948 MESH DISTRIBUTION OF FRASER RIVER GILLNETS BY WEEKLY PERIODS EXPRESSED AS NUMBER OF BOAT DELIVERIES PER MESH SIZE

Mesh Size in Inches	July	August				
	28-30	2-5	9-12	16-19	23-26	Total
5-1/8	1	7	10	5	7	30
5-1/4	41	126	141	100	72	480
5-1/2	108	272	275	213	136	1004
5-3/4	223	382	393	325	230	1553
6	165	305	312	277	209	1268
6-1/4	12	30	23	36	30	131
6-1/2	35	64	61	63	69	292
7-1/4	0	5	5	4	1	15
7-1/2	7	0	0	0	0	7
Total	592	1191	1220	1023	754	4780
Mean Mesh Size	5.81	5.76	5.75	5.78	5.81	

TABLE XXXVIII

NUMBER AND POUNDAGE OF SOCKEYE PER BOAT DELIVERY CAUGHT BY EACH MESH SIZE DURING THE TWO PEAK WEEKS OF FISHING IN 1948

Dates	Mesh Size	No. Sockeye	No. Lbs.	Av. Wt.	No. Boat Deliveries	Sockeye per Delivery	Lbs. per Delivery
August 2-5	5-1/4	4003	20,401	5.10	64	62.5	318.8
	5-1/2	7609	40,564	5.33	116	65.6	349.7
	5-3/4	7342	42,846	5.84	151	48.6	283.7
	6	8635	52,637	6.10	212	40.7	248.3
	6-1/4	349	2,245	6.43	19	18.4	118.2
	6-1/2	878	6,294	7.17	44	20.0	143.0
	7-1/4	48	340	7.08	4	12.0	85.0
					610		
August 9-12	5-1/4	5693	28,592	5.02	102	55.8	280.3
	5-1/2	9125	48,490	5.31	170	53.7	285.2
	5-3/4	8967	52,303	5.83	207	43.3	252.7
	6	8518	52,068	6.11	239	35.6	217.9
	6-1/4	333	2,165	6.50	14	23.8	154.6
	6-1/2	643	4,620	7.18	36	17.9	128.3
	7-1/4	33	276	8.36	4	8.2	69.0
					772		

grouped by weekly periods and also according to mesh size by quarter inch class intervals with the 5 1/8 inch mesh being a single exception. The mesh size distributions in Table XXXVII show that the preferred mesh size was 5 3/4 inch, followed by 6 inch and then 5 1/2 inch during each of the five weekly periods from July 28 to August 26, 1948, including the two weeks of "peak" fishing on the Chilko run.

In Table XXXVIII is given the number of sockeye and poundage of sockeye per boat delivery (and average weight) caught by each mesh size during the two

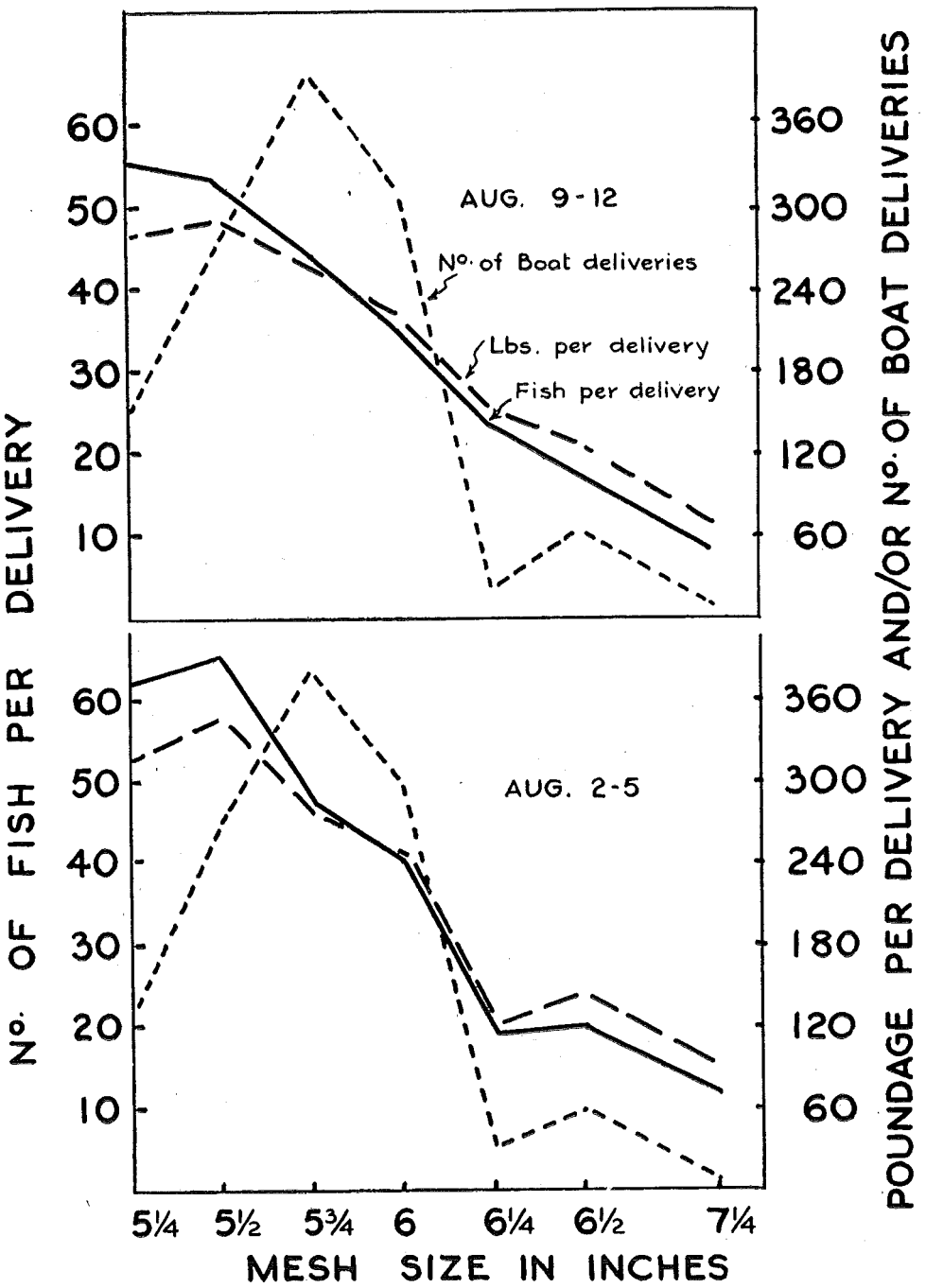

Figure 25. Fraser River Gillnet Sockeye Catch per Boat Delivery and Number of Deliveries by Mesh Size during the Two "Peak" Weeks of Fishing in 1948.

peak weeks of fishing in 1948, namely August 2-5 and August 9-12. Whereas the mesh distributions (Table XXXVII) were determined from 1,191 and 1,220 boat deliveries in the respective weeks, the average catches and average weights were established from smaller samples of 610 and 772 deliveries, respectively. Incomplete data or obvious discrepancies in the numbers and pounds of sockeye resulted in many boat deliveries being omitted in the calculation of average catches and weights. The data therefore presented in Table XXXVIII represent a sample of the mesh distribution sample.

Figure 25 shows the catch per boat delivery and number of deliveries by each mesh size during the two weekly periods of peak fishing on the 1948 Chilko run, as developed from Tables XXXVII and XXXVIII. The catch of each mesh size each week is given in both numbers of fish per delivery and poundage per delivery. It is noted in both weekly periods that although the best catches in both numbers and poundage of fish were made by the small mesh sizes of 5 1/2 inch and 5 1/4 inch, the preferred mesh sizes used by the fishermen were 5 3/4 and 6 inch.

The logbook and personal interview data on relative catches of the different mesh sizes corroborate evidence already shown in Figure 17 from the mesh experiment catches on the peak of the Chilko run. It was noted in Figure 17 that the 5 1/2 and 5 1/4 inch mesh sizes were the most efficient on August 6-8. It is possible that a selective action for the larger sizes of sockeye occurred on the 1948 Chilko run, because of the low fishing effort by the small mesh sizes. More boats fished with the 5 3/4 and 6 inch meshes than the 5 1/2 and 5 1/4 inch meshes.

The 1948 daily average weights from the Fraser River gillnet fishery and the Point Roberts purse seine fishery, which is considered non-selective, were compared to see whether a size difference existed in the two types of fishing gear. The average weights for Point Roberts purse seines were computed from a total sample of 156,000 fish from the fish tickets of two canneries. The Fraser River gillnet average weights were calculated from a total sample of 235,000 fish from the fish tallies of two Steveston canneries for all areas below the Pattullo bridge, where 86 per cent of the gillnet-caught fish were taken. These daily average weights are shown in Figure 26.

The Point Roberts daily purse seine average weights fluctuated around 6.2 lbs. during the first week of fishing when catches were low and then began a steady decline from about 6.1 lbs. to 5.5 lbs. as the Chilko run developed. The Canadian gillnet fishery which opened ten days later than the United States fishery also showed this steady decline, but on any particular day or week caught larger fish than the purse seines, as Figure 26 demonstrates. The weekly average weight for the August 1-6 fishing week from the purse seines was 5.61 lbs. as compared with 5.83 lbs. from the Fraser River gillnets. In the August 8-12 fishing period the purse seine average weight was 5.52 lbs. as compared with 5.76 lbs. from the gillnets.

The difference in average weight in the two fisheries was not the result of a lag in the Chilko fish entering the Fraser River since the Chilko race is known

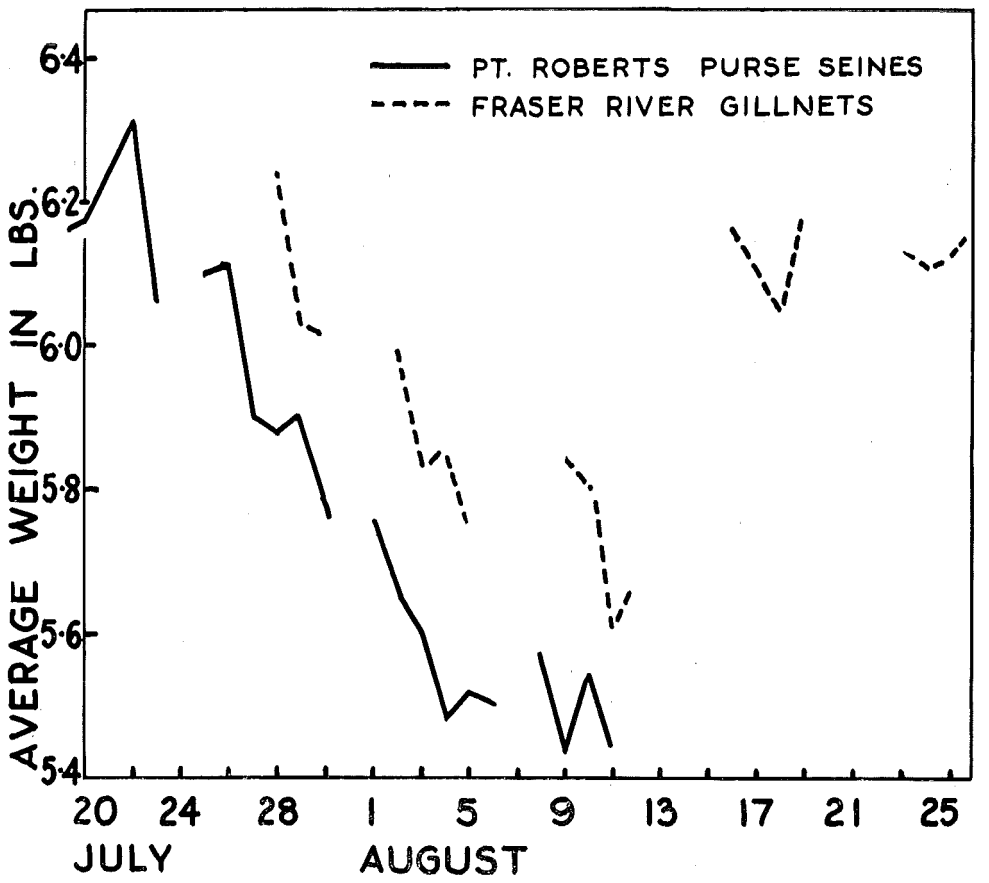

Figure 26. Daily Average Weights of Sockeye in 1948 from Point Roberts Purse Seines and Fraser River Gillnets below the Pattullo Bridge.

to have a speedy migration rate through both fisheries. The elapsed migration time between the two fisheries, without going into detail on pinpointing fishing areas, is probably no greater than two days. As a matter of fact, commercial fishery catches have indicated that in some years the Chilko fish have appeared with only a one day difference in timing between the fisheries.

Nor were the weight differences in the two fisheries the result of small "jack" sockeye being taken by purse seines and missed by gillnets. The size distribution of samples of the purse seine catch measured by Commission observers indicated that the number of jacks was negligible during the 1948 fishing season. It is possible that larger fish were caught by the gillnets than the purse seines, because (as has been indicated) the mesh size composition of the gillnet fleet tended to select the larger fish. However, the evidence necessitates further proof which is available from an examination of the Chilko escapement.

The size of the fish in the 1948 Chilko escapement was determined from length measurements on 6,251 fish from Farwell Canyon on the Chilcotin River. Daily

average fork lengths and the number of sockeye caught per hour each day were obtained, and these data are used to show the size of the fish and the relation to numbers of fish in the escapement. Also, in order to facilitate size comparisons of the Chilko fish at Farwell Canyon with the purse seine and gillnet catches, the average fork lengths have been converted to average weights by use of a length/weight curve determined from 1,130 fish taken on the peak of the Chilko run at Steveston on August 6-8, 1948, by the two mesh experiment boats. The length/weight equation, $\log W = 3.42614 \log L - 4.09667$, in which W = weight in ounces and L = fork length in centimeters, was obtained from the total catch of both sexes combined from all mesh sizes on the August 6-8 weekend.

The mean fork length (tip of the snout to the fork of the tail) of the 6,251 fish at Farwell Canyon with no adjustment made for snout elongation was 57.80 cms. Snout measurements made in 1951 and 1952 during a large-scale sampling program from the Fraser River gillnet fishery and the Chilko spawning grounds indicated that the increase between these locations in snout length is about 2.6 cm. for males and 1.4 cm. for females measuring 57 cm. in fork length in the fishery. For both sexes combined the average increase is about 1.88 cm. from the time the fish are in the gillnet fishery to death on the Chilko spawning grounds. It is estimated that about one third of this increase in snout length (0.63 cm.) has taken place by the time the fish reach Farwell, since the migration time from the fishery to Farwell is about one third of the elapsed time from the fishery to death on the spawning grounds. The fish which averaged 57.80 cm. in fork length at Farwell in 1948 probably averaged about 57.17 cm. in length when they escaped the fishery at Mission. From the length/weight curve the average weight of the Chilko run escaping the gillnet fishery is calculated to be 5.24 lbs.

This average weight is considerably smaller than the Canadian cannery average weights for gillnet-caught fish. During the two-week fishing period from August 2 to August 12 the fish from two canneries averaged 5.80 lbs. The fish in the 1948 Chilko escapement were also smaller than the fish from the U.S. purse seine fishery on the Chilko run. The purse seine fish caught at Point Roberts weighed 5.57 lbs. for the August 1 to August 11 fishing period.

The effect of the gillnet fishery on the size of the fish in the Chilko escapement on a daily basis as measured at Farwell Canyon is shown in Figure 27. The figure shows the total sockeye dipnet catch per hour and the average fork length of all fish for all fishing stations at Farwell daily from August 16 to September 6, 1948. The Fraser River gillnet catch below the Pattullo bridge for a like period of time but 18 days earlier is also shown in the figure. It is suggested from a comparison of the catch per hour curve at Farwell and the Fraser River gillnet catch curve that the average migration time from the below bridge fishery to Farwell Canyon was approximately 18 days in 1948.

The shape of the escapement curve, represented by the catch per hour at Farwell daily, is probably controlled to a great extent by the intensity and efficiency of the Fraser River gillnet fishery and by the weekend closures on this fishery. The abundance curve of an unfished population is possibly altered by all commercial fisheries, but the highly effective river gillnet fishery (nearest to the

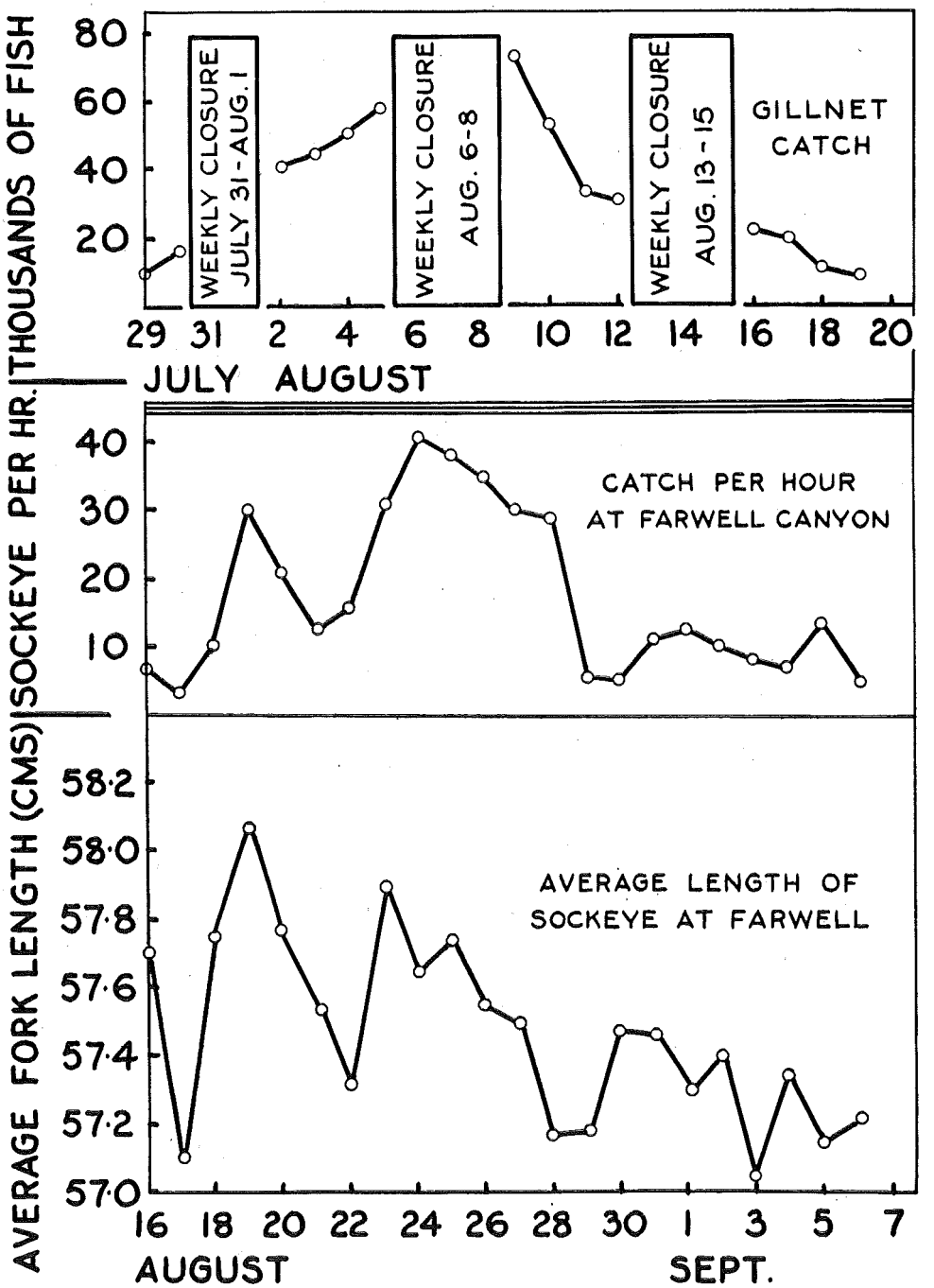

Figure 27. Relation of Fraser River Gillnet Catch to Dipnet Catch per Hour and Average Length of Sockeye at Farwell Canyon in 1948.

escapement) has the greatest influence on the ultimate escapement. If the rate of migration is fairly constant from the gillnet fishery to Farwell Canyon and if the catch per hour at Farwell has a uniform relationship to number of fish passing, the daily catch per hour at Farwell should show an abundance curve related to the escapement from the fishery.

A comparison of the Fraser River gillnet catch curve and the Farwell Canyon catch curve 18 days later indicated that the assumed requirements have been at least partially fulfilled. A third variable, the daily average length of the sockeye at Farwell, also is compared and adds strength to the validity of the assumptions. In the discussion which follows the three variables are compared.

It is noted from the Farwell Canyon catch per hour curve in Figure 27 that the first peak catch occurred on August 19. Similarly, the average fork length of the sockeye was highest on that date, 58.08 cm. This first peak may correspond to the weekend closure of July 31 - August 1. An escapement of fish unselected for size by gillnets on the closed weekend may have resulted in the large size of fish present at Farwell on August 19. The Farwell catches on August 20, 21 and 22 showed a decline from the first peak, and similarly the average lengths showed a decline on these dates. It is suggested that the gillnet fishery operated on this section of the run.

From August 23 to August 28 at Farwell a second peak catch per hour (6 days in duration) occurred, indicating a good escapement during this period. The average lengths also rose abruptly on August 23, then declined gradually over the following four days, dropping abruptly on August 28. The gradual decline in length is the result of a changing sex ratio, starting out predominantly male and ending with a preponderance of females, with males being larger fish than females. The abrupt changes in average length probably are the result of the gillnet fishery selectivity. The long period of indicated escapement probably was the result of a good escapement on the August 6-8 weekend closure of the gillnet fishery with additional escapement before and after this three-day weekend possibly caused by inefficient utilization of the Chilko run by the gillnet fleet. This suggested inefficiency may have been partly the result of using mesh sizes too large for the size of the available fish. The gillnet catch/escapement ratio (usually roughly 2:1 but on the 1948 Chilko run about 1:1) has indicated that the gillnet fishing mortality rate in 1948 was low on the Chilko run.

There is indicated a third peak, minor in amplitude, on August 31 - September 1 in the Farwell catch curve with an abrupt rise in average length on August 30 - 31 which in general but not exactly corresponds to the average length curve. This third minor peak is probably the result of the August 13-15 weekend closure of the gillnet fishery on the latter part of the waning Chilko run.

Figure 27 indicates that the changes in catch per hour and in the average lengths of the fish may have been caused by the operations of the Fraser River gillnet fleet. In spite of the long migration route from the gillnet fishing areas to Farwell Canyon, the numbers and size of the fish indicate a relationship with the gillnet fishery operations. There may have been some mixing of the fish enroute,

with certain fish travelling faster than others, but the dispersion apparently was not of sufficient degree to obscure the trends in numbers of fish and size of fish as measured at Farwell.

A HYPOTHETICAL NON-SELECTIVE MESH DISTRIBUTION

The gillnet fleet probably should have fished with a smaller mesh size composition on the 1948 Chilko run for a normal utilization of the fish stock. What should have been the mesh distribution used by the fleet for the size of available fish? That question (in present tense) confronts the fisherman and cannery manager from the standpoint of efficient utilization of fishing gear and faces the biologist and fisheries "manager" from the standpoint of the character of escaping reproductive stock.

The fleet mesh distribution was shown in Figure 25 to be widely different from the fleet average catch distribution among the mesh sizes for the two weekly periods during the 1948 Chilko run. Similarly, the August 6-8 weekend catch distribution in the mesh experiment on the peak of the Chilko run (Figure 17 and Table XXXV) was widely different from the fleet mesh distribution during the Chilko run. A hypothesis can be advanced that perhaps the mesh distribution should be related to the mesh experiment catch distribution among the various mesh sizes. That is, if a particular mesh size catches 25 per cent of the total fish taken by all mesh sizes in the mesh experiment, why should not approximately 25 per cent of the fleet fish with that mesh size? Likewise, perhaps all the other mesh sizes should be fished in accordance with the percentages caught by these meshes. (In the mesh experiment all mesh sizes were fished with approximately equal effort. Hence, the catches by the respective mesh sizes are directly related. Also, these catches were made on the closed weekends to fishing when the effect of competition from other boats was either lacking or at a bare minimum.)

If the fleet mesh distribution corresponds throughout its entire range to an accurate catch distribution predetermined from experimental fishing, it is possible that a maximum fleet would operate at top efficiency as far as mesh size is concerned, theoretically catching everything and allowing no escapement during the fishing week. The fish present in the river at the time of a closure theoretically would have undergone no screening action from gillnets, since all size groups of fish in the population would have been fished equally. The only escapement would be on the closed weekends and the average size of the fish would be unchanged. The average catch theoretically would be the same for each mesh size, and all available fish would be caught. The hypothesis requires testing with the limited data at hand.

The plan involves the weighting of the catches of the different mesh sizes in the mesh experiment by a hypothetical mesh distribution corresponding to the mesh experiment catch distribution. The average weight of the fish from all weighted mesh sizes combined can then be computed and compared with the average weight of the purse seine catch at Point Roberts, which is nearest to the gillnet fishery. This has been done and is shown in Figure 28 for the three weekends during the build-up, "peak", and tapering off of the Chilko run in 1948, namely July 31 - August 1, August 6-8 and August 14-15. For each weekend is

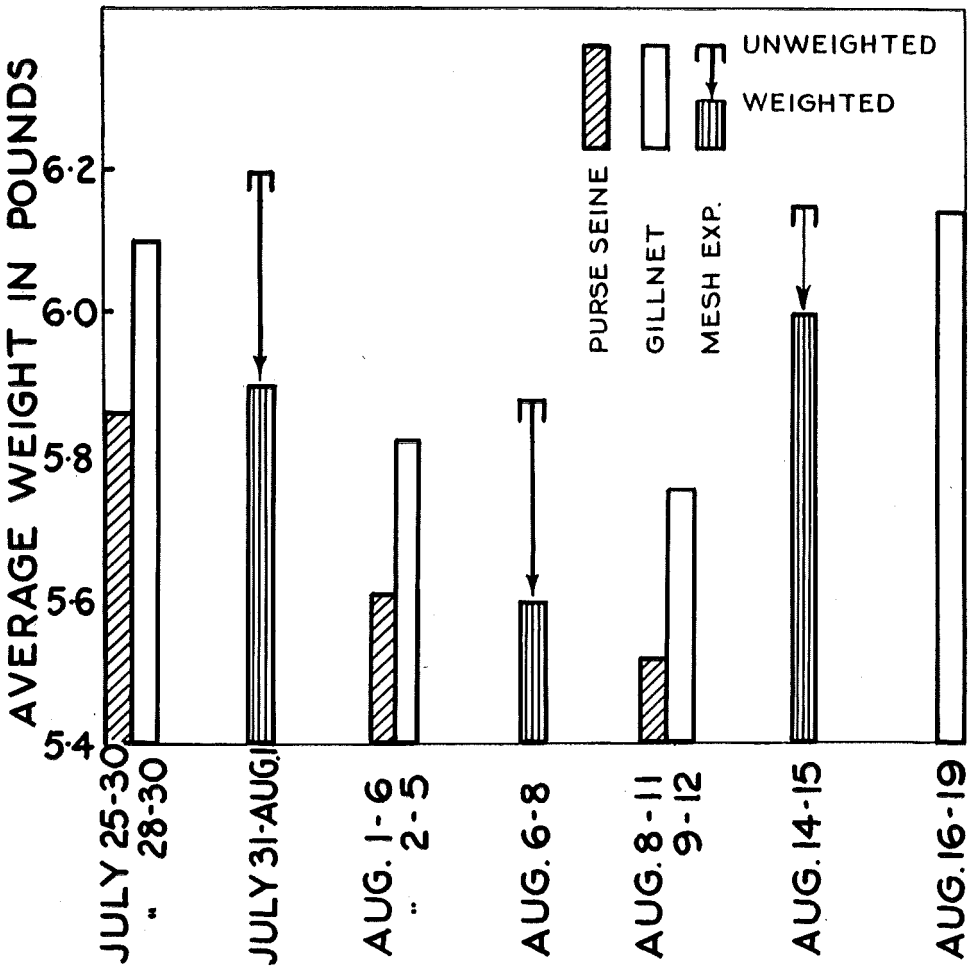

Figure 28. Sockeye Average Weights in Point Roberts Purse Seine Catch, Fraser River Gillnet Catch and Mesh Experiment Catch (Unweighted, and Weighted by Hypothetical Mesh Distribution) in 1948.

shown the average weight of the fish for all meshes combined as actually fished in what might be termed a "flat" mesh distribution (all mesh sizes fishing with approximately equal intensity). Also given is the average weight for the combined meshes adjusted to a hypothetical mesh distribution equal to the catch distribution. Comparisons are made with the Point Roberts purse seine catch during the three weekly periods of fishing from July 25 to August 11 and with the gillnet catch from below the Pattullo bridge for the four weekly periods from July 28 to August 19.

For the week of July 25-30 the purse seine average weight was 5.86 lbs. as against 6.10 lbs. from the gillnet fishery. In the mesh experiment on July 31 - August 1 the average weight of 6.20 lbs. was changed to 5.90 lbs. when weighted by a mesh distribution equal to the catch distribution.

During the August 1-6 fishing week the sockeye average weight from the purse seines was 5.61 lbs. as compared with 5.83 lbs. from the Fraser River gillnets. The mesh experiment average weight of August 6-8 was 5.88 lbs. for the combined mesh sizes when fished in approximately equal intensity, but when adjusted to a mesh distribution the same as the catch distribution the average weight became 5.60 lbs.

In the August 8-12 fishing period the purse seine average weight had declined to 5.52 lbs., and fishing was stopped on August 11 to aid in balancing the catch between Canada and the United States. The Fraser River gillnet average weight during this same period was 5.76 lbs. By August 14-15 in the mesh experiment the size of the fish had increased to 6.15 lbs. unadjusted, or 6.00 lbs. when weighted by the mesh distribution equal to the catch distribution. The fleet gillnet catch of August 16-19 also showed this increase in size with an average weight of 6.14 lbs.

It is observed that the mesh experiment average weights prior to adjustment, although following a similar trend to the commercial fishery weights, were much higher than from the purse seine fishery. However, after weighting each mesh size with a theoretical mesh distribution equal to the mesh experiment catch distribution, the average weights are brought nearly into alignment with those from the purse seine fishery.

The adjusted mesh experiment average weight of 5.60 lbs. on the peak of the Chilko run (August 6-8) was very close to the average weights from the Point Roberts purse seine fishery for the week prior to and the week following this August 6-8 weekend. On the other hand, the commercial gillnet average weights on the two adjacent fishing weeks to the August 6-8 weekend were higher than the 5.60 lbs. in the mesh experiment.

In review, it is believed that the Fraser River gillnet sockeye catch during the Chilko run would have been of smaller size composition if the fishermen had used a mesh distribution approximating the mesh experiment catch distribution with the 5 1/2 and 5 1/4 inch mesh sizes predominating. Instead, the fleet (according to the logbook and interview findings) preferred to use mesh sizes between 5 3/4 and 6 inch. As a result the average weights from the gillnet catch were higher than from the purse seines or from the adjusted mesh experiment mesh sizes.

It would seem desirable for the gillnet fleet to fish with a mesh distribution properly synchronized with the size distribution of available fish. This distribution should sample all sizes of sockeye adequately and should therefore have maximum efficiency. The great majority of the gillnet fishermen apparently favor sockeye mesh sizes within a very narrow range from 5 3/4 to 6 inch meshes regardless of the size of available fish. It may not be economically feasible for each gillnetter to own several sockeye nets of different mesh sizes or for the canneries to have large stocks of all mesh sizes in their net lofts. Also, even if the mesh sizes are available, the apportionment among the fleet would be difficult. However, if more gillnetters would fish with 5 1/2 and 5 1/4 inch mesh sizes when the fish are "small", the condition would be considerably improved. When the proper mesh

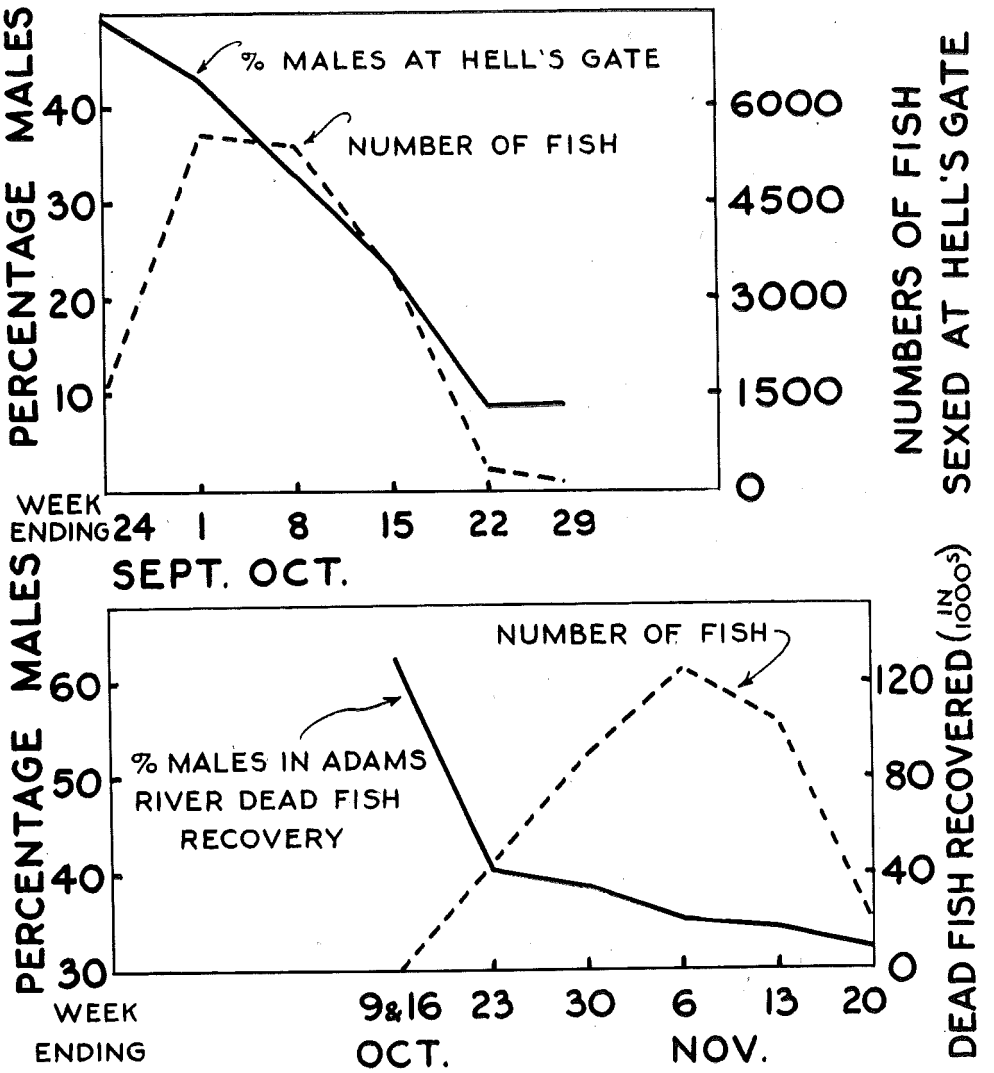

Figure 29. Number of Sockeye and Percentage of Males (Jacks Omitted) in Hell's Gate Dipnet Catch and in Adams River Dead Fish Recovery in 1946.

distribution is used, selectivity should be negligible and the gillnet catch should be at a maximum. The major escapement unscreened by gillnets would occur only during the weekly closed periods and the special fishing closures.

THE EFFECT OF THE GILLNET FISHERY ON THE SEX RATIO IN THE ESCAPEMENT

Some Factors Affecting Sex Ratio in the Gillnet Catch

The size composition of particular sockeye races has been shown previously to remain reasonably stable within a season, except under circumstances such as in 1946 when the latter segment of the run was subjected to the selective action of a gillnet fishery (Figures 21, 22 and 23). This approximate uniformity in size

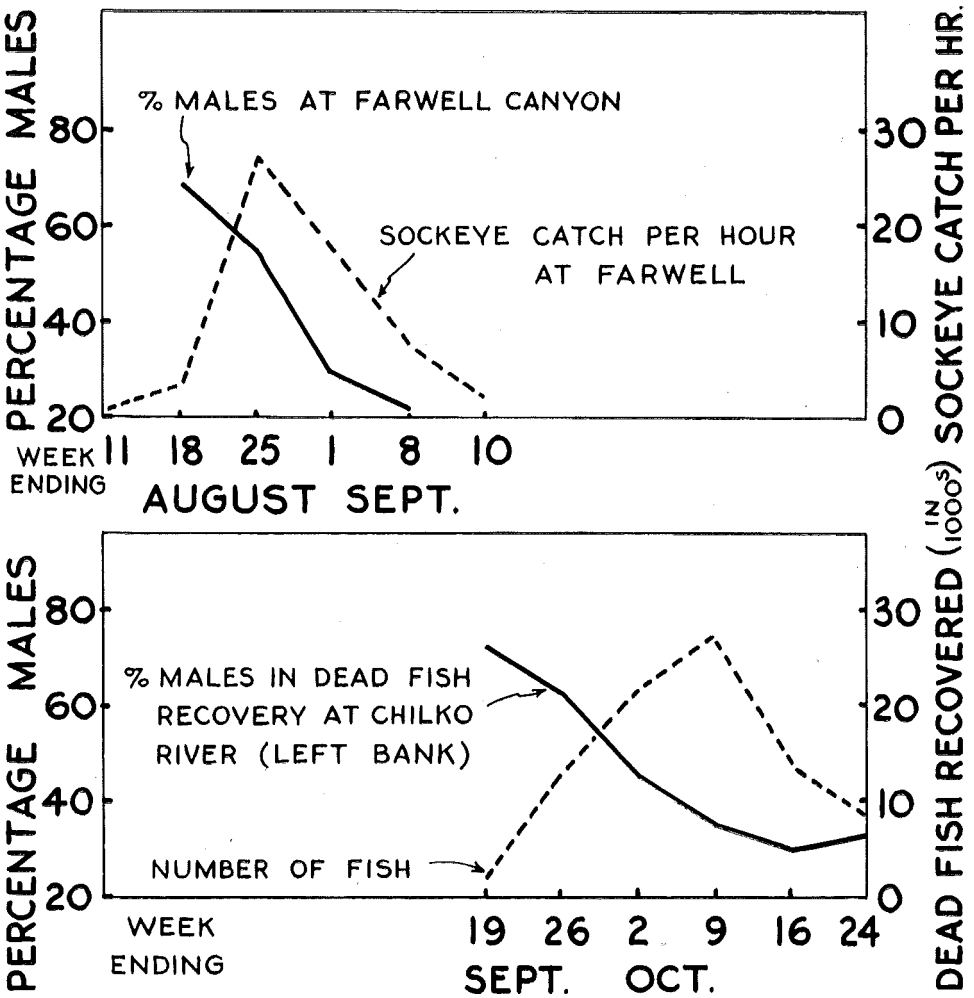

Figure 30. Number of Sockeye and Percentage of Males (Jacks Omitted) in Dipnet Catch at Farwell Canyon (Determined from Farwell Tags Recovered on the Spawning Grounds) and in Dead Fish Recovery at Chilko River in 1948.

of fish has been noted at other major Fraser River spawning grounds as well as those referred to in the examples cited. On the other hand, the proportion of the sexes shows a marked change intraseasonally, as is demonstrated in Figures 29 to 33, inclusive. The vanguard of a sockeye race is predominantly male and the percentage of males tapers off throughout the season, with the latter part of the race composed of mainly females. This changing sex ratio is a natural phenomenon and has occurred at all major sockeye spawning grounds in the Fraser River watershed.

It is noted that this pattern of the changing sex ratio occurs both during the migration period and on the spawning grounds. Figure 29 shows the changing sex ratio of the 1946 Adams River run both at Hell's Gate and after death on the

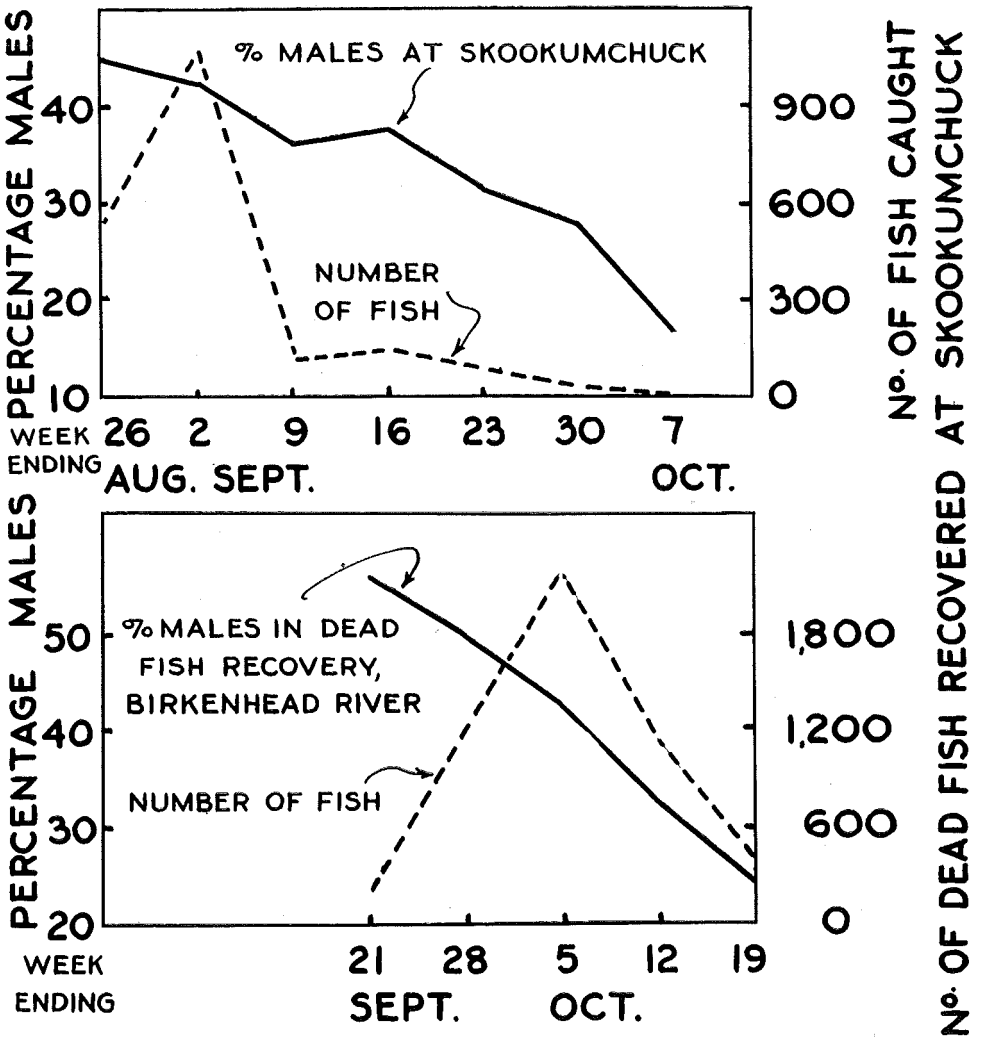

Figure 31. Number of Sockeye and Percentage of Males (Jacks Omitted) in Catch at Skookumchuck and in Birkenhead River Dead Fish Recovery in 1940.

spawning grounds. Figure 30 demonstrates the pattern of males preceding females in the 1948 Chilko run both in the tagged fish at Farwell Canyon and after death on the redds. In Figure 31 is shown the changing proportion of the sexes in the 1940 Birkenhead run on migrating fish at Skookumchuck and dead fish after spawning on the redds. Figure 32 shows a similar phenomenon occurring in the 1938 Cultus Lake run at the Sweltzer Creek weir and after death on the grounds at the head of the lake, as indicated by Howard (1948). Likewise, during the 1950 Adams River run the live fish at the mouth and the dead fish on the spawning grounds (Figure 33) exhibited the changing sex ratio.

The pattern of males preceding females on each of three succeeding races (Chilko, Stellako and Adams) in 1946 at Hell's Gate is shown in Table XXXIX, as determined from Hell's Gate tag recoveries at the spawning grounds.

TABLE XXXIX

SEX RATIO OF CHILKO RIVER, STELLAKO RIVER AND ADAMS RIVER SOCKEYE RACES AT HELL'S GATE BY WEEKLY PERIODS IN 1946, AS DETERMINED FROM TAG RECOVERIES ON THE SPAWNING GROUNDS

Date at Hell's Gate Week Ending	Chilko River Recoveries Male	Female	% Male	Stellako River Recoveries Male	Female	% Male	Adams River Recoveries Male	Female	% Male
Aug. 4	5	4	56	3	5				
11	3	8	27	32	27	54			
18	3	5	37	22	41	35			
25	1	5	17	29	58	33			
Sept. 1	1	4	20	84	154	35			
8				33	80	29			
15				29	93	24			
22				4	6				
29				0	1		221	318	41
Oct. 6							381	733	34
13							208	540	28
20							20	105	16

There have also been general indications that this changing sex ratio exists in the commercial fishery. Sex ratios taken from samples of the United States purse seine catch have shown an intraseasonal decline in the percentage of males for the Adams River race in its dominant cycle, namely in 1938, 1946 and 1950 (not measured in 1942). In 1938 and 1946 the highest percentage of males was present one week before the peak fishing and in 1950 two weeks before the peak.

A second factor affecting the sex ratio of the gillnet catch is the development of the secondary sexual characteristics of the fish. Average snout lengths taken on male and female sockeye throughout the season from the gillnet fishery in 1950, 1951 and 1952 indicated an increase in snout length with progression of the season (Figure 34). The males invariably had longer average snout lengths than the females, and the increase by time was greater in the males than the females. Whereas in July the male snout lengths were 0.54 cm. to 0.66 cm. greater than the female snout lengths in the years shown, in September the difference ranged between 1.42 cm. and 1.76 cm. This elongation of the snout is characteristic of sockeye approaching sexual maturity and is most pronounced in the males.

Another secondary sexual characteristic present in mature male sockeye is a well-developed cartilaginous hump which reaches its greatest height immediately anterior to the dorsal fin. From 1947 mesh experiment data (Figure 35) the male sockeye are shown to increase in depth in relation to the females as the season progressed. The male sockeye in September were 1.69 cm. deeper than the females as compared with a difference in maximum depth of 0.62 cm. in July.

It has been demonstrated that the sexual dimorphism between the sexes is more pronounced on the late races of sockeye in the September fishery than earlier in the season. The males essentially become larger fish in relation to the females

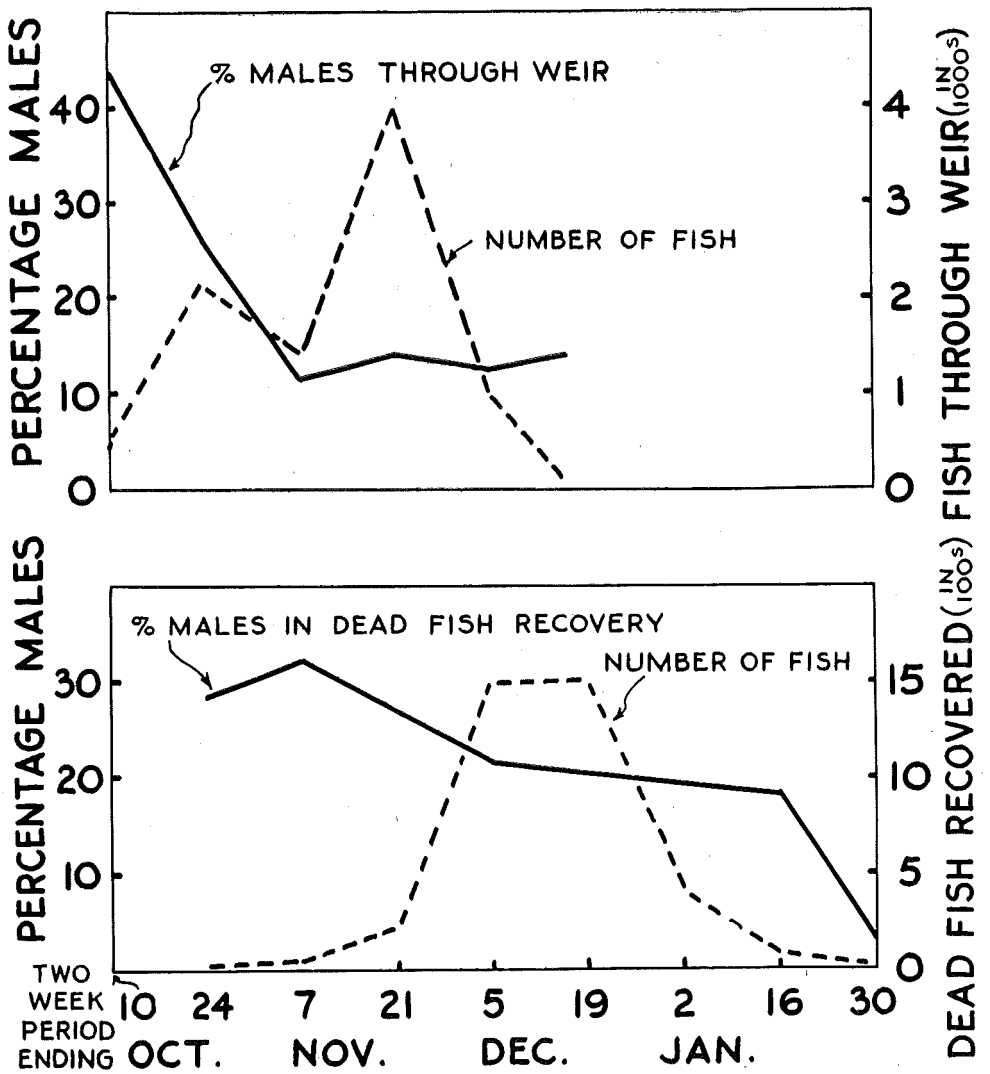

Figure 32. Number of Sockeye and Percentage of Males (Jacks Omitted) through Weir and in Dead Fish Recovery at Cultus Lake in 1938.

because of their well-developed humps and snouts. Related to this development of males are gillnet catch data in 1947, 1948 and 1951 when higher percentages of males were taken in the September fishery than in July and August. In 1951 from large samples of the Fraser River gillnet catch the September catch was composed of 52.3 per cent males as compared with 47.5 per cent males in July and August. Similarly, in the mesh experiment catch of 1947 a high percentage of males was taken in September as compared with earlier in the season. The ten mesh sizes caught 60.7 per cent males in September as compared with 48.0 per cent males in July and August. In the 1948 mesh experiment catch a similar trend was noted. The data suggest that higher percentages of males are taken in September by

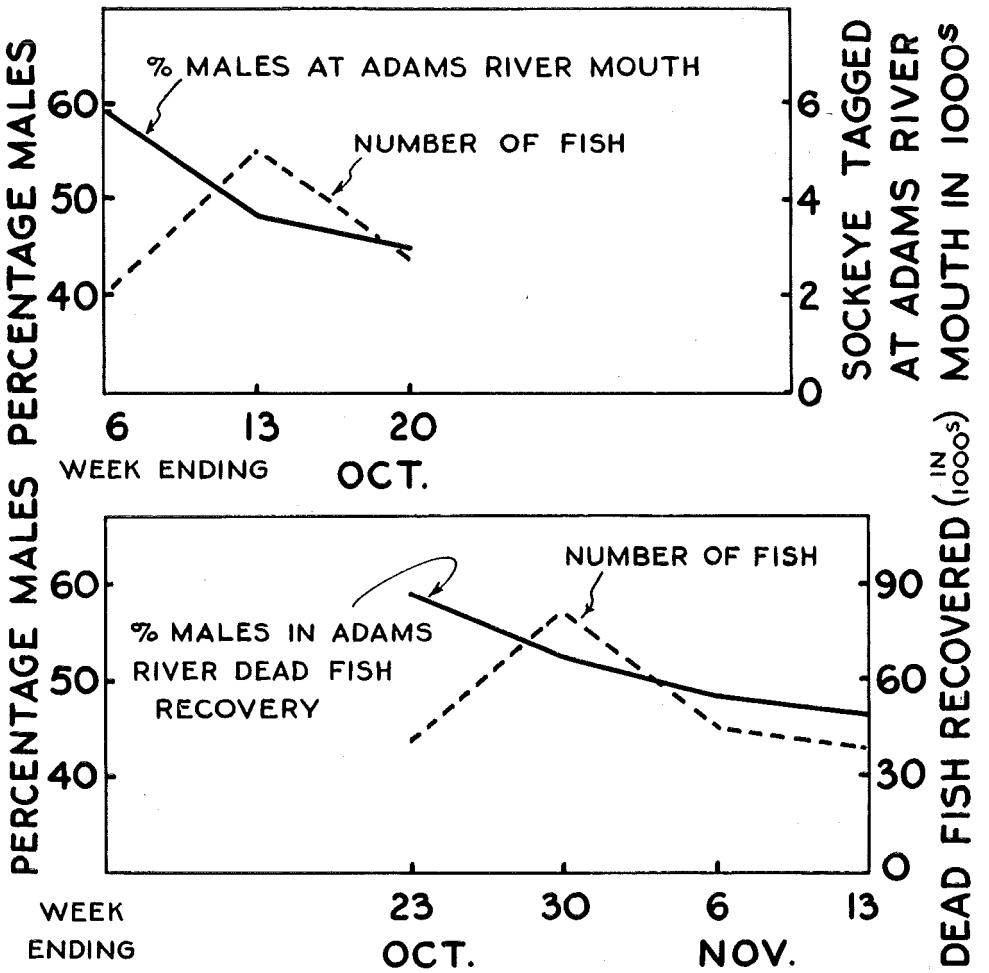

Figure 33. Number of Sockeye and Percentage of Males (Jacks Omitted) in Tagging Experiment at Adams River Mouth and in Dead Fish Recovery at Adams River in 1950.

gillnets than earlier in the year because of this accentuated hump and snout development. The females because of their rounded form and smaller size probably escape through the gillnet meshes more successfully than the males.

Factors Involved in Determining Spawning Ground Sex Ratio

Three methods have been used by the Commission for determining the proportion of males to females on the Fraser River spawning grounds, namely (1) direct weir count, (2) examination of a sample of the fish which have died after spawning and (3) calculating the population of each sex separately, using the ratio of tagged to untagged fish in the dead fish recovery and the number of tags affixed to each sex.

All three methods are subject to some error. It would seem that the direct weir counts would be infallible, but it has been found in at least one area (Early

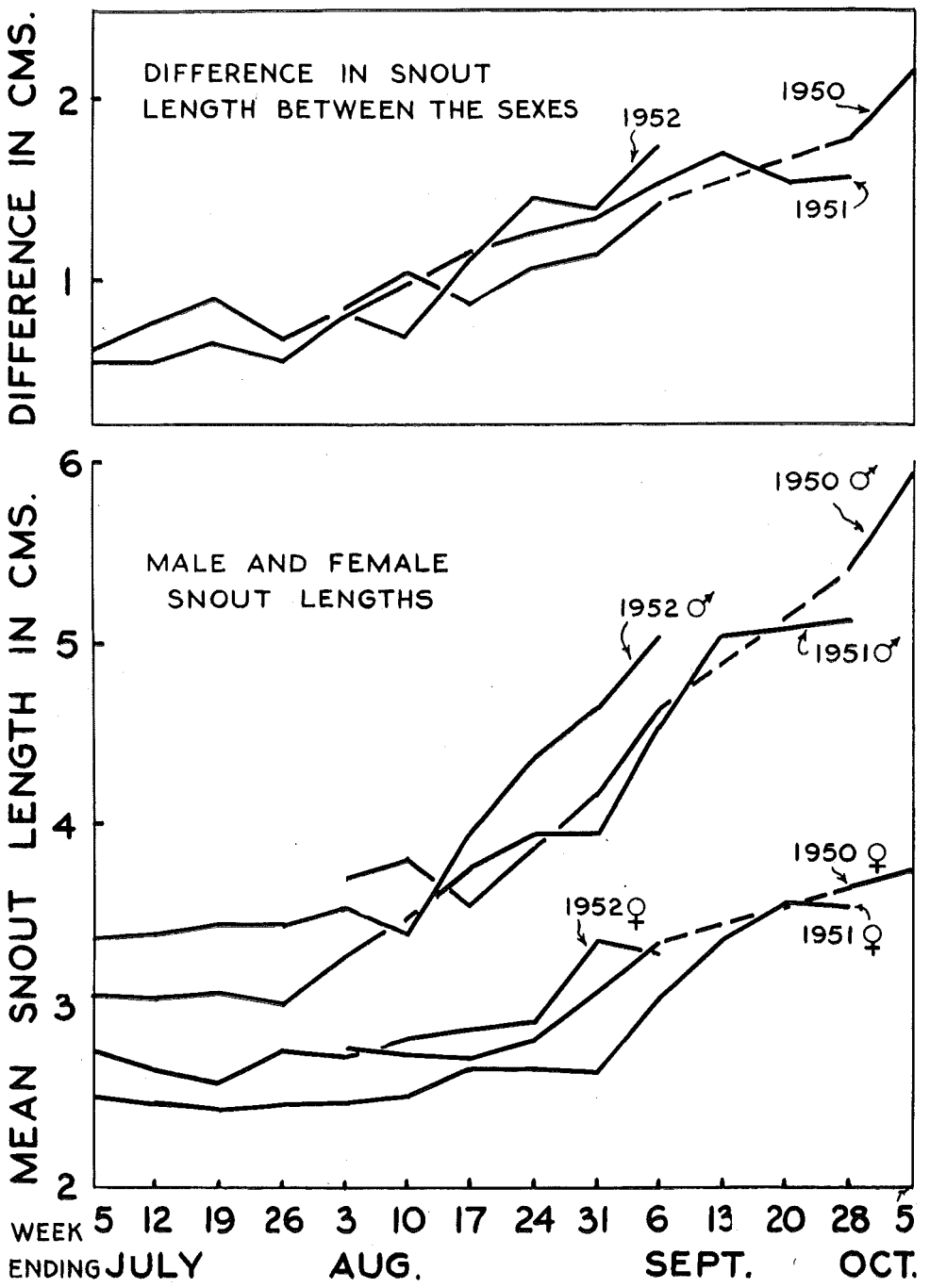

Figure 34. Comparison of Male and Female Sockeye Snout Lengths from the Fraser River Gillnet Catch by Weekly Periods in 1950, 1951 and 1952.

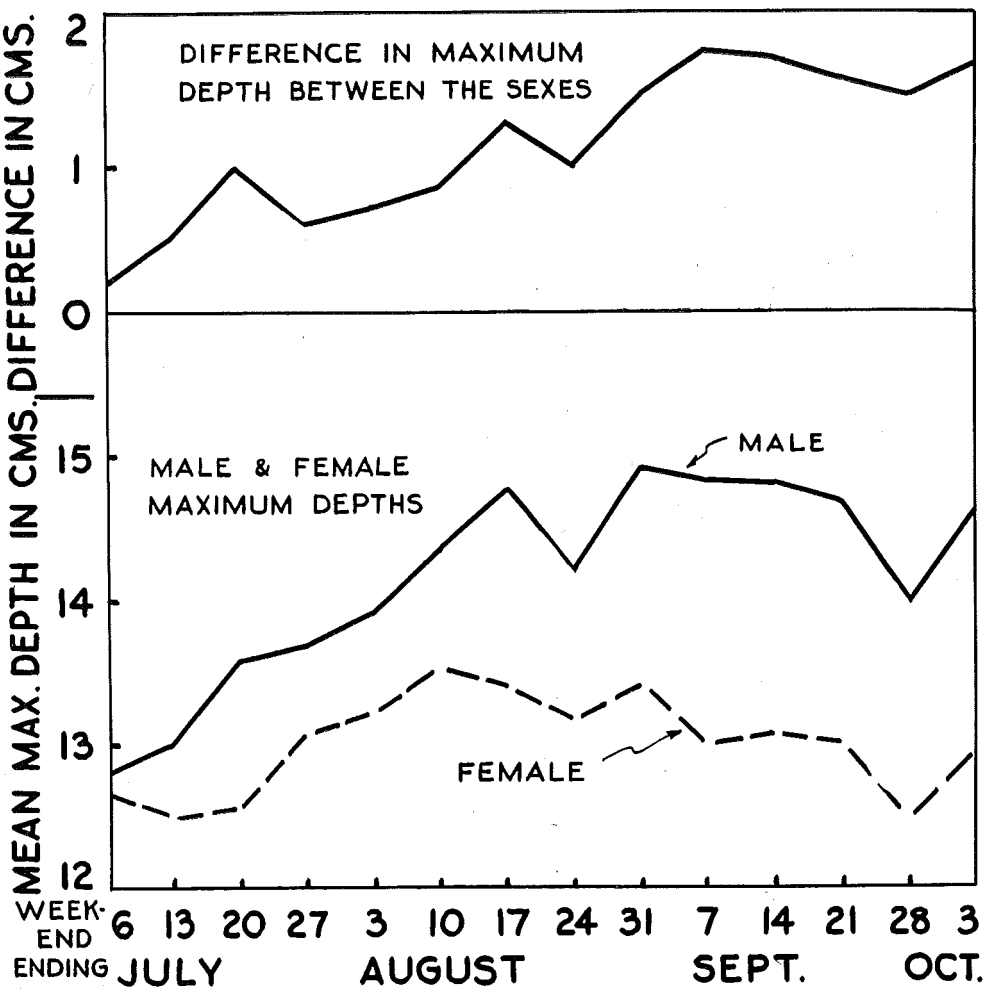

Figure 35. Comparison of Male and Female Sockeye Maximum Depths by Weekend in the 1947 Mesh Experiment Catches.

Stuart creeks, 1946) that the fish cannot always be sexed accurately from external appearance at the weir. Also, weirs are impractical for most spawning grounds.

The second method, the examination of the dead fish, also would appear sound, especially since the recovery rate is usually high (ranging in most cases from about 20 per cent to 50 per cent of the entire population) and the recoveries are reasonably uniform as to time (hence, are not greatly affected by the intra-seasonal change in sex ratio). However, in certain examples (which will be shown) the availability of the two sexes, based on the percentage recovery of tagged males and females in the dead fish recovery sample, differs. Females tend to remain close to their nests after spawning is completed and are recovered dead nearby, whereas males at completion of spawning tend to wander or may be carried by the current into areas where recovery is difficult.

The third method, the calculation of the male and female populations from tagging, also would seem to be sound, especially when the number of tags recovered and the "dead fish pickup" (dead fish recovery) of each sex are samples of significant size. However, especially in the tagging experiments on small populations of sockeye, the experiments are through necessity confined to small numbers of fish. The limits of confidence on the maximum likelihood estimate of sockeye populations based on small samples are broad and therefore are not as adaptable for determining sex ratio. Whereas the tags can be used for estimating the total population, as described by Howard and Chapman (1948) and Schaefer (1951), they may not be as applicable for calculating the male and female populations separately since the samples in the latter are smaller than in the total.

The sex ratios as published in the Commission Annual Reports (1938 to 1952, inclusive) are for the most part based on the proportion of males to females in the dead fish recovery. Exceptions are at the Bowron River, Cultus Lake, and in certain years the Raft River and the tributary creeks of Middle River in the Stuart Lake area, where direct weir counts were used. In addition, there were four instances where the sex ratios were determined by calculating the male and female populations separately from tagging data.

It is essential in evaluating the relationship between sex ratios as estimated from the dead fish pickup and the "calculated separate populations" that the availability of the two sexes be known. The percentage recovery of tagged males and of tagged females are indicative of this availability, if based on significant sample sizes. If the percentage recoveries (recovery rates) of the two sexes are accurate and are significantly different, it would seem advisable to correct the sex ratio of the dead fish pickup for this difference in availability. The variation in availability of the two sexes can be measured by the ratio of the percentage of tagged females recovered to the percentage of tagged males recovered. For want of a better term, this ratio is called the "availability factor". When females are more available than males, the factor is greater than one. When the availability is the same in both sexes, the factor is equal to one. And when females are less available than males, the factor is less than one.

The availability factors have been computed from 33 Commission tagging experiments on which complete data were collected and on which at least 50 tagged fish of each sex were recovered. In Table XL from the 33 experiments are shown the percentage recovery of male and female tagged fish in the dead fish sampling. Also given are the availability factors for each experiment. In addition, the percentage of males from the dead fish recovery and the percentage of males from the calculated separate populations are shown. Jack sockeye have been omitted.

The maximum likelihood estimate of a salmon population has been shown by Chapman (1948) to be $N = \frac{nt}{s}$, in which N = the estimated total number of fish in the population, n = number of fish in the recovery sample, t = number of tagged fish released and s = number of tagged fish subsequently recovered. This

TABLE XL

RECOVERY RATES OF TAGGED MALES AND FEMALES, AVAILABILITY FACTORS, AND PERCENTAGES OF MALES FROM DEAD PICKUP AND FROM CALCULATED SEPARATE POPULATIONS FROM 33 SPAWNING GROUND TAGGING EXPERIMENTS

Area and Year	% Tagged Males Recovered	% Tagged Females Recovered	Availability Factor	% Males in Dead Pickup	% Males from Calculated Separate Populations
Early Stuart					
1950	44.91	46.88	1.044	50.3	51.4
1951	60.94	51.74	0.849	42.9	39.0
1952	73.67	66.87	0.908	48.7	46.3
Upper Pitt					
1950	18.62	19.27	1.035	54.6	55.4
1952	25.79	29.36	1.138	49.6	52.8
Silver Creek					
1952	43.05	44.93	1.044	52.6	53.7
Seymour					
1951	21.19	22.56	1.065	49.5	51.1
Chilko					
1948	25.34	27.03	1.067	39.9	41.5
1949	36.55	38.08	1.042	40.1	41.1
1951	30.72	37.97	1.236	41.0	46.2
1952	32.77	31.37	0.957	47.3	46.2
Raft					
1951	42.43	43.78	1.032	48.8	49.6
1952	39.70	44.51	1.121	47.7	50.6
Stellako					
1946	40.45	47.27	1.169	37.9	41.6
1947	34.41	44.80	1.302	43.9	50.5
1950	20.25	22.79	1.125	40.7	43.6
1951	23.15	24.96	1.078	42.9	44.8
1952	42.56	53.14	1.249	43.7	49.2
Birkenhead					
1941	18.11	31.16	1.721	24.5	35.8
1946	31.85	49.26	1.547	23.3	32.0
1947	21.94	25.04	1.141	36.6	39.7
1949	27.00	34.43	1.275	36.7	42.5
1952	24.81	28.67	1.156	35.6	39.0
Adams					
1946	24.27	21.17	0.872	34.2	31.2
1946*	20.43	21.29	1.042	34.2	35.1
1947	16.07	16.95	1.055	35.7	36.9
1950	17.62	15.88	0.901	50.9	48.3
1951	14.13	18.00	1.274	40.0	45.9
Weaver					
1941	55.95	54.43	0.973	29.4	28.8
1948	46.02	47.86	1.040	23.4	24.1
1952	75.56	74.55	0.987	45.2	44.9
Cultus					
1938	49.50	42.20	0.853	21.0	18.5
1939	13.10	13.04	0.995	31.2	31.1

* Pritchard tagging.

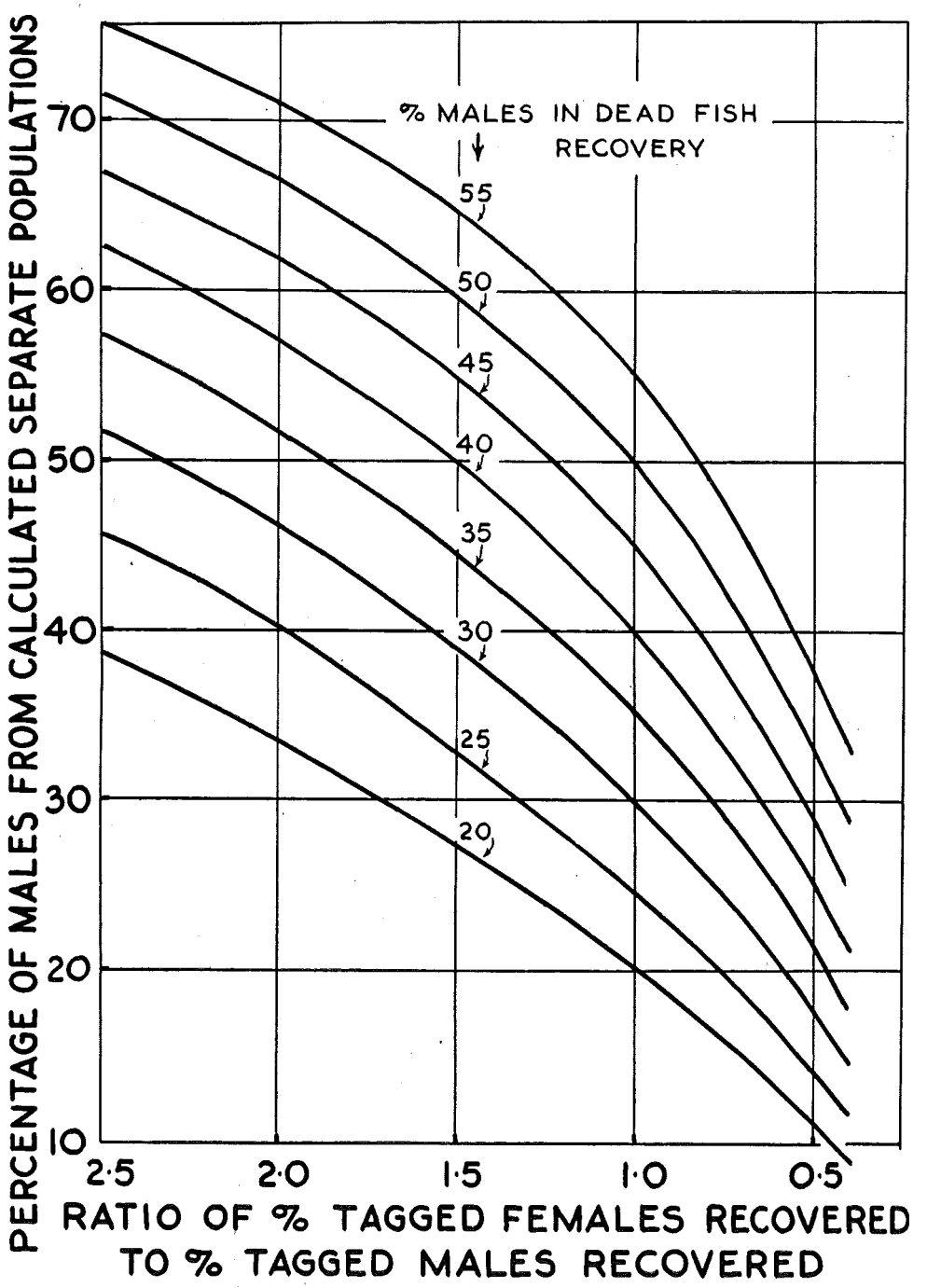

Figure 36. Relation of Sockeye Sex Ratio in the Dead Fish Recovery to Sex Ratio Determined from the Calculated Separate Populations with Various Availability Factors.

TABLE XLI

AVAILABILITY FACTORS FROM 33 TAGGING EXPERIMENTS AT VARIOUS FRASER RIVER SPAWNING GROUNDS

Spawning Grounds	Availability Factor 0.85	0.95	1.05	1.15	1.25	1.35	1.45	1.55	1.65	1.75	Mean
Early Stuart	1	1	1								0.93
Upper Pitt R.			1	1							1.09
Silver Cr.			1								1.04
Seymour R.			1								1.06
Chilko R.		1	2		1						1.08
Raft R.			1	1							1.08
Stellako R.			1	2	1	1					1.18
Birkenhead R.				2	1			1		1	1.37
Adams R.	1	1	2		1						1.03
Weaver Cr.		2	1								1.00
Cultus L.	1	1									0.92
Total	3	6	11	6	4	1		1		1	

formula can be used for calculating the male and female populations separately but may also be simplified to one which determines the calculated proportion of males from the availability factor and the proportion of males in the dead pickup. New notations are required, and they are as follows:

A = availability factor,

M = percentage of males in the dead pickup, and

M′ = percentage of males from the calculated separate populations.

By derivation, the new formula is $M' = \frac{AM \times 100}{AM + (100 - M)}$. Applying an example, a dead pickup of 45 per cent males and an availability factor of 1.2 results in a value of 49.5 per cent males for M′, the percentage of males from the calculated separate populations.

Figure 36 shows a family of curves giving the percentage of males from the calculated separate populations as determined from sex proportions in the dead pickup ranging from 20 per cent males to 55 per cent males and from availability factors ranging from 0.40 to 2.50. The greatest availability factor was 1.721, while the smallest was 0.849 in the 33 experiments (Table XL). The greatest percentage of males in the dead fish recovery was 54.6 per cent, while the smallest was 21.0 per cent in the 33 experiments. The family of curves covers the full range of conditions to be expected.

Using Figure 36 or the formula, with a dead fish recovery of 50 per cent males and availability factors ranging from 0.85 to 1.35 the percentage of males from the calculated separate populations range from 45.9 per cent to 57.4 per cent males, respectively. Similarly, a dead pickup of 30 per cent males and availability factors ranging from 0.85 to 1.35 results in calculated percentages of males ranging from 26.7 per cent to 36.6 per cent males, respectively.

In Table XLI the availability factors from the 33 tagging experiments have been grouped by 0.10 class intervals according to spawning grounds. Seventeen other tagging experiments were eliminated because small numbers of tags were

recovered (less than 50 of each sex). The "small sample" tagging experiments showed greater variability in the availability factors than is shown in Table XLI, and it was deemed arbitrarily that less than 50 tag recoveries of either sex was in danger of not being representative.

The distribution of the availability factors and the mean availability factor are shown for eleven different spawning grounds. The Stellako, Birkenhead and Adams are each represented by five experiments. Chilko is shown for four years; Weaver and Early Stuart for three; Upper Pitt, Raft and Cultus for two; and Silver Creek and Seymour for one year.

The mean availability factors for nine of the eleven spawning grounds did not differ greatly from 1.0 and therefore the percentage of males calculated from the separate population would not vary substantially (2.3 per cent or less) from the percentage of males established from the dead fish recovery. Cultus had a mean availability factor of 0.92, Early Stuart 0.93, Weaver Creek 1.00, Silver Creek 1.04, Seymour 1.06, Adams 1.03, Chilko 1.08, Raft 1.08 and Upper Pitt 1.09. The sex ratio determined from the dead fish recovery at each of these spawning grounds is considered the best estimate (except where accurate weir counts were made).

The Stellako, however, is represented by a mean availability factor of 1.18, and an increase of about 3.6 to 4.1 in percentage of males over the dead fish pickup percentage of males would be evident by using the population of each sex separately for the sex ratio. At the Birkenhead the high mean availability factor of 1.37 would result in a percentage of males 8.0 to 9.0 per cent higher from the calculated separate populations than from the dead fish recovery. It was deemed advisable to correct the Birkenhead and Stellako dead fish recoveries by their respective mean availability factors for the best estimates on sex ratio.

Sex Ratios in the Escapements to the Various Spawning Grounds

In Table XLII the best estimates of the percentage of males (jacks omitted) from the various Fraser River spawning grounds for the years, 1945 to 1952, inclusive, are given. Most of the values shown are based on the proportion of males to females in the total dead fish recoveries in the respective areas (with exceptions noted) and some of these values differ slightly from the published figures in the Annual Reports of the Commission.

The various spawning grounds are listed in Table XLII in a chronological order approximating the time of passage through the Fraser River gillnet fishing areas, according to best estimates. The general order of passage of some of the runs is well known. For example, the Early Stuart run is first, followed by the Bowron, Chilko, Stellako and finally Adams, as ascertained from saltwater and Hell's Gate tagging experiments, scale readings and commercial fishery catches. The order of the other runs is not well-defined, but certain lower-river runs including those destined for Weaver Creek, Harrison River and Cultus Lake are present in the gillnet fishery late in the season. The Adams River run is known to delay off the mouth of the Fraser River, and the three lower-river runs mentioned above also appear to be subject to a period of delay.

TABLE XLII

BEST ESTIMATES OF THE PERCENTAGE OF MALES IN THE ESCAPEMENT (JACKS OMITTED) FROM THE VARIOUS FRASER RIVER SPAWNING GROUNDS, 1945 - 1952, INCLUSIVE.

Spawning Grounds	1945	1946	1947	1948	1949	1950	1951	1952
Early Stuart Creeks	51	43	50	a	50	48	44	49b
Bowron River	53	47	46	47	46	49	49	48
Seymour River	a	48	46	a	51	54	49	49
Upper Pitt River	a	c	c	c	a	55	50	50
Silver Creek	a	a	a	52	a	a	a	53
Chilko River	47	44	44	40	40	44	41	47
Raft River	49	45	46	41	41	47	50b	48
Stellako River (d)	47	42	48	46	47	45	47	48
Birkenhead River (d)	40	29	48	36	44	38	39	43
Adams River	34e	34	36	25	31e	51	40	33
Weaver Creek	36	36	30	23	36	45	37	45
Harrison River	35	32	22	44	a	45	23	29
Cultus Lake (b)	35	36	33	44	34	34	24	32

Notations:

a. No adequate sex ratio established.
b. Sex ratio determined from weir count.
c. Recorded sex ratios based on lower recovery rates from sub-areas than normally used for establishing sex ratio.
d. Stellako and Birkenhead dead fish recoveries corrected by mean availability factors of 1.18 and 1.37, respectively.
e. Population mainly jacks.

TABLE XLIII

COMPARISON OF THE PERCENTAGE OF MALES IN THE ESCAPEMENTS OF THREE MID-SEASON RUNS WITH FOUR LATE-SEASON RUNS IN YEARS WHEN THE GILLNET FISHERY WAS OPEN TO SOCKEYE FISHING

	1945	1946	1947	1948	1949	1950	1951	1952	Average
Chilko River	47	—	—	40	40	44	41	47	43.2
Raft River	49	—	—	41	41	47	50	48	46.0
Stellako River	47	42	—	46	47	45	47	48	46.0
Adams River	34	34	36	25	31	—	40	—	33.3
Weaver Creek	36	36	30	23	36	—	37	—	33.0
Harrison River	35	32	22	44	—	—	23	—	31.2
Cultus Lake	35	36	33	44	34	—	24	—	34.3

Note: Values are given only for years when adequate sex ratio data were obtained from races which had been intensively fished by sockeye gillnets.

Among the runs which are ill-defined in timing through the gillnet fishing areas, the Upper Pitt River run appears to precede and overlap the Chilko run. The Birkenhead run is later than Chilko and overlaps the Stellako considerably. The Seymour, Silver and Raft runs probably are in the gillnet fishery at approximately the same time as the Chilko run.

Special effort has been given to listing the various races in approximate chronological order in the gillnet fishing areas in order to examine the relationship between the time of passage through the fishing areas and the percentage of males in the escapement of the different races. The percentage of males in the escapement of the early runs (Early Stuart and Bowron) is approximately 50 per cent, whereas in the late runs (Adams, Weaver, Harrison River and Cultus) in

most years the percentage of males is on the average about 33 per cent. Also, the percentage of males in the escapement of the mid-season runs is somewhat lower than that of the early runs.

The percentage of males in the Birkenhead River is on the average lower than in the other mid-season runs. This population notably is composed of at least three size groups annually, the proportions in each group fluctuating from year to year. The three- and four-year-old male jack population is represented in all years by at least fair numbers and in some years by considerable numbers of fish. The precocious migration of jacks in considerable numbers from the Birkenhead population at sea may have an effect on the ultimate sex ratio of the combined four-year-olds and five-year-olds remaining in the ocean. This "loss" of male jacks from the population would tend to lower the percentage of males in the four- and five-year-old age groups.

No adjustment, however, has been attempted on the percentage of males in the Birkenhead escapement for the loss in jack males from the spawning population. The problem is complicated by the indefinite delimitation of the year classes and by the differences in efficiency of purse seines and gillnets in the taking of jacks. Gillnets rarely catch jack sockeye because of their small size. Hence, the fishing mortality is lower on jacks than on the older fish, and the proportion of jacks in the escapement is distorted.

Referring to Table XLII and to the percentage of males in the escapements of the various races by year and cycle, it is noted that in general there is a decrease in percentage of males from the early runs to the late runs. Most of the discrepancies from this trend can be related to special closures of the Fraser River gillnet fishery.

In 1945 the Early Stuart and Bowron escapements had high percentages of males, 51 per cent and 53 per cent, respectively. Chilko, Raft, Stellako and Birkenhead had lower percentages of males, namely 47 per cent, 49 per cent, 47 per cent and 40 per cent, respectively. Adams, Weaver, Harrison and Cultus had still lower percentages of males, namely 34 per cent, 36 per cent, 35 per cent and 36 per cent, respectively. No special closures of the gillnet fishery were effected aside from the regular weekly closures. The fishery operated throughout the season on all of the sockeye races listed.

In the following cycle year, 1949, the picture was much the same as in 1945 with high proportions of males on the early runs, lower percentages of males on the mid-season runs, and still lower percentages on the late runs. The opening date for sockeye fishing by gillnets in the Fraser River was delayed until July 25 for escapement purposes (see Table XLIV), although 8 inch minimum mesh sizes were allowed prior to July 25.

In the 1946 - 1950 cyclic years, the percentage of males was slightly higher on the early runs than the mid-season runs. In 1946 the escapements of the late runs were composed of low percentages of males, whereas in 1950 only Cultus Lake was low. The Fraser River gillnet fishery was closed on September 7 in 1950 to allow for escapement of the Adams River run, but in 1946 this special

TABLE XLIV

CLOSED PERIODS IN FRASER RIVER GILLNET SOCKEYE FISHING SEASON (EXCLUDING WEEKLY CLOSURES), 1938 - 1952, INCLUSIVE

Year	Closed Periods
1938	September 10 to October 2, inclusive.
1939	September 18 to September 24, inclusive.
1942	September 17 to September 30, inclusive, with partial curtailment on September 16, due to regulatory closure and strike of fishermen.
1946	June 1 to August 8 opening date, except for 8 inch minimum. September 25 to October 2, inclusive, except for 8 inch minimum. October 3 to October 14, inclusive.
1947	July 1 to September 8 opening date, except for 8 inch minimum. October 3 to October 13, inclusive.
1948	July 1 to July 28 opening date, except for 8 inch minimum.
1949	July 1 to July 25 opening date, except for 8 inch minimum. September 30 to October 11, inclusive.
1950	July 1 to July 31 opening date, except for 8 inch minimum. September 7 to September 17, inclusive, except for 8 inch minimum. September 18 to September 24, inclusive.
1951	Long weekly closures beginning September 20.
1952	July 21 to July 24, inclusive, and September 8 to October 19, inclusive, due to strike action by fishermen.

closure was not effected until September 25 (see Table XLIV for closure dates in the various years). The escapements at Adams River, Weaver Creek and Harrison River consisted of 34 per cent, 36 per cent and 32 per cent males, respectively, in 1946, while in 1950 these escapements were composed of 51 per cent, 45 per cent and 45 per cent males, respectively. The higher percentages of males on the late runs in 1950 were directly related to the earlier closing date, as compared with 1946. This finding will be discussed in detail in the section of the report to follow.

In 1947 the escapement of the early and mid-season runs had high percentages of males ranging from 44 per cent to 50 per cent and averaging 47 per cent males. The four late runs, on the other hand, had percentages of males ranging from 22 per cent to 36 per cent and averaging 30 per cent males. Only the late runs were fished intensively by the gillnets, since the sockeye fishing did not commence until September 8.

In 1951 no decrease in the percentage of males was apparent from the early to the mid-season runs. The late runs, however, had lower percentages of males than earlier in the season. The sockeye fishing season for Fraser River gillnets opened on July 2 and no special closures were effected except for extension of the weekly closures commencing on September 20. The fish were unusually "large" in 1951, averaging 7.3 lbs. in the United States purse seine catch.

In the 1948-1952 cyclic years considerable variations occurred in the sex ratios at the different spawning grounds, and the trend to a lower percentage of males on the later runs was not as evident as in the other years previously mentioned. In 1948 Adams River and Weaver Creek had low percentages of males, 25 per cent and 23 per cent, respectively, but at Harrison River and Cultus

Lake the percentages of males were much higher, 44 per cent in both areas. It is believed that the Adams and Weaver runs move through the gillnet fishery at about the same time (in September), with the Harrison River run somewhat later and the Cultus run also on the average later. With 1948 being an "off" year for pink salmon and the "white spring" runs being practically over by October, a lowered fishing effort on the Harrison and Cultus runs may have resulted.

In 1952 the percentage of males in the early and mid-season runs averaged 48.3 per cent males, with the Birkenhead (43 per cent males) showing the greatest deviation from the average. The fish in 1952 were "large" (averaging 7.1 lbs.), while in 1948 the fish were "small". The Chilko and Raft escapements consisted of 47 per cent and 48 per cent males, respectively, in 1952, as compared with 40 per cent and 41 per cent males, respectively, in 1948. The late season fishery was almost completely closed from September 5 (including the weekly closed period) to October 20 due to strike action by the fishermen's union. Only the Weaver Creek escapement appeared to reflect this closure, with 45 per cent males in the escapment. The small Adams River run had an escapement of 33 per cent males, as compared with 25 per cent males in 1948. The Harrison and Cultus escapements also had low percentages of males, 29 per cent and 32 per cent respectively in 1952.

In Table XLIII is compared the percentage of males in the escapements of three mid-season runs with four late-season runs in the years during the 1945 to 1952 period when the gillnet fishery was open to sockeye fishing. It is noted that the percentages of males from Chilko, Raft and Stellako averaged between 43.2 per cent and 46.0 per cent. The late runs, Adams, Weaver, Harrison and Cultus, had escapements composed of much lower average percentages of males, ranging between 31.2 per cent and 34.3 per cent.

In most instances it is possible to relate the sex ratios of the escapements to the operations of the gillnet fishery. In general it has been shown that the late-run escapements have low percentages of males as compared with the earlier runs. The pronounced development of the hump and snout in the males of the late runs in the fishery (Figures 34 and 35), resulting in a higher proportion of males being caught, is believed to be the main factor causing the scarcity of males in the late-run escapements. Also, the mesh sizes of 6 1/2 inch and greater used during October and November for taking other species of salmon would tend to select male sockeye.

Relation of the Sex Ratios in Two Late-Run Escapements to the Gillnet Fishery Regulations

In Table XLV is shown the number of males and females examined, omitting jacks, in the dead fish recoveries of the Adams River and Weaver Creek escapements for the years 1938 to 1952, inclusive. It is noted that at Adams River large samples of dead fish were recovered annually in the "big-year" cycle, 1938-1942-1946-1950, and reasonably large samples were observed in the 1939-1943-1947-1951 cycle years. In the other two cycles, 1940-1944-1948-1952 and 1941-1945-1949 only small numbers of dead fish (excluding jacks) were observed from small "off-year" runs. Sex ratios have been computed from the dead fish pickups

TABLE XLV

NUMBER OF MALES AND FEMALES AND PERCENTAGE OF MALES (JACKS OMITTED) IN THE DEAD FISH RECOVERIES AT THE ADAMS RIVER AND WEAVER CREEK SPAWNING GROUNDS, 1938 - 1952, INCLUSIVE

	ADAMS RIVER				WEAVER CREEK			
Year	No. Males	No. Females	Total	% Males	No. Males	No. Females	Total	% Males
1938	13,290	12,083	25,373	52.4	1,604	1,315	2,919	54.9
1939	552	1,159	1,711	32.3	96	304	400	24.0
1940	103	326	429	24.0	2,170	5,638	7,808	27.8
1941				*	1,461	3,509	4,970	29.4
1942	98,269	120,228	218,497	45.0	3,918	5,278	9,196	42.6
1943	1,463	4,172	5,635	26.0	246	1,280	1,526	16.1
1944	21	74	95	21.3	1,620	4,372	5,992	27.0
1945	90	178	268	33.6	850	1,499	2,349	36.2
1946	174,996	337,142	512,138	34.2	4,448	7,785	12,233	36.4
1947	11,703	21,080	32,783	35.7	344	844	1,188	29.0
1948	274	874	1,148	24.9	2,093	6,861	8,954	23.4
1949	42	93	135	31.1	2,185	3,796	5,981	36.5
1950	137,813	133,006	270,819	50.9	3,776	4,621	8,397	45.0
1951	9,625	14,103	24,033	40.0	1,274	2,170	3,527	36.1
1952	355	715	1,070	33.2	9,514	11,526	21,040	45.2

* Only 50 jacks reported at Adams River as a result of the 1941 Hell's Gate blockade.

for all years (except 1941, when only 50 jacks were reported on the spawning grounds), although the reliability of the off-year samples is questionable.

At Weaver Creek the number of fish in the dead fish samples did not have the extreme variation between years as at Adams River. The 1939 sample was very small and the 1943 and 1947 samples were fairly small. In all the other years from 1938 to 1952, inclusive, good samples of dead fish were recovered. The percentage of males is shown for all years, regardless of the sample size on which the percentage is based.

In Figure 37 is graphed the percentage of males for the Adams River and Weaver Creek escapements for all years from 1938 to 1952, inclusive (except Adams, 1941). Also given are the "no fishing" periods in September of the various years, either due to special regulatory closures or to fishermen's strikes. These closed periods are in addition to the regular weekly closures. Royal in the International Pacific Salmon Fisheries Commission Annual Report for 1950 (1951) has indicated that the Adams River run, after a delay of two weeks or more off the mouth of the Fraser River, migrates upstream in great volume beginning on September 16. The Weaver Creek run apparently moves through the gillnet fishing areas at about the same time or possibly slightly later. Schaefer (1951) in his Figure 41 showed the 1940 Weaver Creek run "peaking" at the Harrison Bay trapsite on October 1 and October 8, and in 1941 (his Figure 42) on October 9. The main bulk of the Adams River run passes Hell's Gate from September 21 to about October 2, according to Commission records.

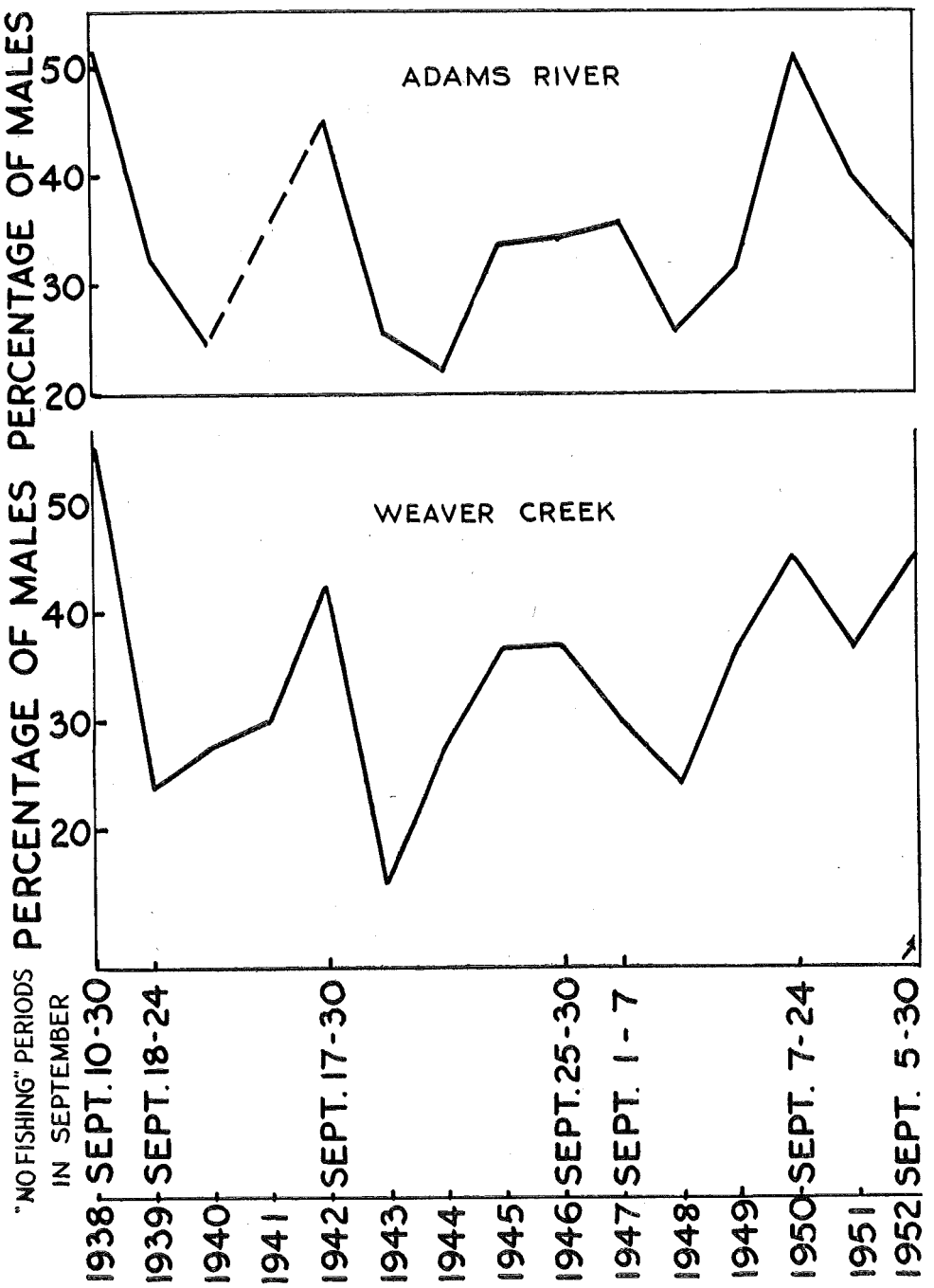

Figure 37. Annual Percentage of Male Sockeye (Jacks Omitted) in the Adams River and Weaver Creek Escapements, 1938-1952, Inclusive, with September Closures of the Gillnet Fishery Indicated.

It is noted in Figure 37 that there is a remarkable agreement between the sex ratio curves at Adams River and Weaver Creek during the years 1938 to 1952, inclusive. There are three coinciding high points in the two curves in the years 1938, 1942 and 1950, respectively. On this big-year cycle at Adams River, the percentages of males were, respectively, 52 per cent, 45 per cent and 51 per cent males, whereas at Weaver Creek for the same years the respective percentages were 55 per cent, 43 per cent and 45 per cent. In the one other "big year" at Adams River, namely 1946, the percentage of males was down to 34 per cent, with a correspondingly low figure of 36 per cent at Weaver Creek.

The closed periods to fishing, with the exception of the regular weekly closures, during the migration of the Adams River and Weaver Creek runs are shown in Table XLIV and Figure 37. The special September closures and the percentages of males at Adams River and Weaver Creek in the Adams River big-year cycle are shown in the following summary:

Year	September Closure	% Males, Adams	% Males, Weaver
1938	Sept. 10-30	52	55
1942	Sept. 17-30	45	43
1946	Sept. 25-30	34	36
1950	Sept. 7-24	51	45

Early closing dates in 1938 (September 10) and 1950 (September 7) can be related to high percentages of males at Adams River and Weaver Creek. In 1942 the percentages were slightly lower when the closure was later (September 17). In 1946 the percentages of males were considerably lower, when the fishery was not closed until September 25. The Adams River and Weaver Creek escapements consisted of low percentages of males with the late 1946 closure.

The special closure in 1939 was of short duration. The closure in 1947, when fishing did not commence until September 8, had a very minor effect on the late runs. The 1952 "strike" closure apparently affected the Weaver Creek run by allowing a comparatively high percentage of males (45 per cent) to escape but was not reflected on the very small run to Adams River. In the years of no special September closures (1940, 1941, 1943, 1944, 1945, 1948, 1949 and 1951), aside from extended weekly closures, the percentages of males were low at both Adams River and Weaver Creek.

It has been shown previously in this report that sexual dimorphism is more pronounced in the fish present in the Fraser River gillnet fishery in September than earlier in the season. The males have well-developed humps and snouts in the late-season fishing. It has also been indicated that the gillnets tend to take a higher percentage of males in September than earlier in the season, mainly resulting from the increased effectiveness of the nets in catching the large well-developed males. The effect on the sex ratio of these late runs has been indicated. When no restrictive fishing closures are effected, the ratio of males to females is approximately 1:2. When the "peak" portion of the run is allowed to escape by closing the gillnet fishery the male to female sex ratio approaches 1:1, which approximates the natural sex ratio for the Fraser River sockeye salmon populations.

SUMMARY

1. The two main fishing gears used for the capture of Fraser River sockeye salmon are purse seines in United States Treaty waters and drift gillnets in the Treaty waters of Canada. The gillnet fleet, which takes almost half of the total catch by both nations, uses sockeye mesh sizes ranging from about 5 1/4 to 6 1/2 inch mesh with the most preferable sizes ranging between 5 3/4 and 6 inch mesh.

2. The methods and results from mesh experiments conducted in 1947 and 1948 to determine whether the sockeye mesh sizes used by the gillnet fleet were selective for size, age, sex ratio and numbers of sockeye are presented.

3. Ten different mesh sizes ranging from 5 1/4 to 8 3/4 inch mesh were experimentally fished on the closed weekends of 1947 and 1948 in the Steveston area near the Fraser River mouth from two chartered gillnet boats. A total of 6,521 sockeye were caught by all mesh sizes. Lengths, depths, widths, weights, sex and scales were taken from the sockeye caught by the different mesh sizes. Mesh measurements were taken to determine shrinkage and exact mesh sizes used.

4. The average shrinkage varied in the different meshes from 1/32nd to 4/32nds of an inch. Practically all shrinkage occurred during the first three weekends of fishing when small numbers of sockeye were taken. The stabilized mesh sizes after shrinkage measured the same as the factory labelled sizes in most cases. The discrepancies have been indicated.

5. The weekend sockeye catches between the two boats were compared to determine the relative efficiency of the two boats. It was demonstrated that the boats fished with approximately equal efficiency each weekend of 1948. In 1947 one boat made more drifts and caught more fish than the other, but the respective boat catches were similar each weekend when converted to catch per drift.

6. A direct approximately straight-line relationship between mesh size and fish length was demonstrated. Highly significant correlation coefficients between mesh size and fish size were noted for each of six weekends in 1947 and five weekends in 1948 when "good" catches were made. Small mesh sizes caught mainly small fish and large meshes took predominantly large sockeye.

7. It was shown that the proportion of five-year-old to four-year-old sockeye increased with increase of mesh size. Few "jacks" were taken.

8. The sex ratio data demonstrated that a direct relationship between mesh size and the proportion of the sexes existed. The large mesh sizes caught predominantly males and the small meshes took mostly females.

9. The relative catches of the various mesh sizes by weekend in 1947 and 1948 are shown, with special emphasis given to the 1948 catches over the fishing period on the dominant Chilko River race of sockeye. The small mesh sizes, 5 1/2, 5 1/4 and 5 3/4, were most effective on the Chilko sockeye in 1948 on either a poundage or numbers basis. The Chilko sockeye were "small", averaging about 5.57 lbs. in the United States purse seine catch.

10. A comparison of the weekend mesh experiment catches with the Fraser River gillnet catches indicated that the experimental catches were reasonably representative samples of the catch of the entire gillnet fleet.

11. During August, 1946, from about a 20 per cent sample of the gillnet fleet it was noted that the preferred mesh sizes used were 6 and 5 3/4 inch (by quarter inch groupings), while the best catches were made by the 5 1/2 and 5 1/4 inch meshes. The mesh distribution appeared too large for maximum utilization of the run.

12. The size of sockeye in the escapement as measured in 1946 at Hell's Gate, Farwell Canyon, Chilko River and Birkenhead River indicated that larger fish escaped when the sockeye gillnet fishery was closed than when the fishery was operating. Also, an inverse linear relationship between daily recorded length of fish and percentage of net-marked sockeye at Hell's Gate was highly significant.

13. The mesh distribution as fished by a 15 per cent sample of the fleet on the Chilko run in 1948 indicated that the preferred mesh sizes were 5 3/4, 6 and 5 1/2, in that order, whereas the 5 1/2 and 5 1/4 inch meshes made the best catches. In the mesh experiment a "flat" mesh distribution was utilized with all mesh sizes fishing approximately equal in effort. The 5 1/2 and 5 1/4 inch meshes in the mesh experiment also made the best catches on the Chilko fish.

14. In 1948 the gillnet fleet took fish of larger average size than the United States purse seines. Also, larger fish were caught by the mesh experiment boats than by the gillnet fleet.

15. Sockeye in the 1948 Chilko run measured at Farwell Canyon appeared smaller than the fish in either the gillnet or purse seine fishery. A relationship between the size and numbers of fish at Farwell and the closed periods in the gillnet fishery 18 days earlier was noted. When the fish were relatively "large" and good catches were made at Farwell, the fishery was closed 18 days earlier. When the fish were "small" and poor catches were made, the gillnet fishery was operating. "Good" escapement through the gillnet fishing areas on the "peak" of the Chilko run from August 5 to August 10, inclusive, is indicated, although the closed weekly period extended from only August 6 to August 8, inclusive. It is theorized that the mesh distribution used by the gillnet fleet allowed a greater escapement of small fish.

16. The possible non-selective qualities of a hypothetical mesh distribution corresponding to the mesh experiment catch distribution was presented. The average weight of sockeye from all mesh sizes combined weighted by the hypothetical mesh distribution approximated the average weight taken by Point Roberts purse seines on the Chilko fish, whereas the average weight taken by the gillnet fleet was larger. A mesh distribution equal to the catch distribution is considered to be non-selective, and theoretically no escapement would occur with a maximum fleet in operation. The catch would theoretically be a maximum, and escapement of sockeye mainly unfished by gillnets would be confined to the weekly closed periods and to special closures.

17. An intraseasonal decline in the proportion of males to females, noted on the migrating fish at upriver tagging stations and at all major spawning grounds, is a natural phenomenon occurring in the Fraser River sockeye salmon runs.

18. It is shown that in the late-season fishery in September the males have well-developed humps and snouts and sexual dimorphism is pronounced. It is indicated that the gillnets take a greater proportion of males in September than earlier in the season mainly as a result of sexual dimorphism.

19. Three methods of determining spawning ground sex ratios have been used by the Commission staff, namely direct weir count, dead fish recovery and the calculation of the populations of each sex separately by use of sample tag ratios. The proportion of the sexes in the dead fish recovery was the most widely used method.

20. The ratio of the percentage recovery of females to the percentage recovery of males was defined as the "availability factor". When the factor is above one, females in the dead fish recovery are apparently more available than males. When the factor is less than one, the opposite is true. An examination of the pertinent data from 33 tagging experiments indicated that mean availability factors were high only at the Birkenhead River (1.37) and Stellako River (1.18) and were reasonably close to one at all other areas. The unadjusted dead fish recoveries or the weir counts were used in all areas for determining sex ratio except at the Birkenhead and Stellako where an adjustment was made utilizing the availability factor. A formula was developed for computing sex ratio from two variables, namely the availability factor and the sex ratio of the dead fish recovery.

21. The percentage of males at the various spawning grounds listed in approximate chronological order indicated that the early escapements were composed of approximately 50 per cent males while the late escapements (when fished by gillnets) only had about 33 per cent males. Apparently, due mainly to sexual dimorphism, larger percentages of males were caught by the gillnets on the late runs than on the early runs.

22. The similarity of the sex ratio curves on two late-run escapements, Adams River and Weaver Creek, during the years 1938 to 1952, inclusive, was noted. The percentages of males at the two spawning grounds were related to operations of the gillnet fishery and to closures on that fishery. In the "big-year" cycle of the Adams River run, namely 1938, 1942, 1946 and 1950, the escapements to Adams consisted of 52 per cent males, 45 per cent, 34 per cent and 51 per cent males, respectively. Relatively similar figures were obtained from Weaver Creek. Early closures in 1938 (September 10) and 1950 (September 7) were related to a high percentage of males. In 1942 with a September 17 closure the percentage of males was still reasonably high. But in 1946 with a late September 25 closure, the percentage of males was low.

23. In the late run escapements when no restrictive fishing closures were effected, the ratio of males to females approximated 1:2. However, when the "peak" portion of the run was allowed to escape by closure of the gillnet fishery, it was indicated that the sex ratio in the escapement approached 1:1.

ABSTRACT

Results from gillnet mesh experiments conducted at the mouth of the Fraser River in 1947 and 1948 demonstrated conclusively that the individual mesh sizes from 5 1/4 inch to 7 1/2 inch mesh were highly selective for size, age-group and sex ratio of sockeye salmon. The smaller meshes took mainly the small fish with females predominating, whereas the larger meshes caught mostly the larger sockeye with males in the majority. The relationship of mesh size to fish length was shown to be approximately linear.

Using the experimental evidence as a model, the analysis was expanded to include a study of the variations in fish size and sex ratio of sockeye escapements and the relationship of these variations with the operations of the Fraser River gillnet fishery and fishing closures on that fishery.

Indicated selectivity for the larger sizes of sockeye by the gillnet fleet in 1946 and 1948 from the Chilko River population was apparently related to the mesh size distribution fished by the fleet. The mesh sizes used most extensively were 5 3/4 inch and 6 inch (1/4 inch groupings), whereas the best average catches were made by the 5 1/2 and 5 1/4 inch meshes. Also, the gillnets caught larger fish than those taken by purse seines, which are considered non-selective.

A hypothesis was advanced that the fleet mesh distribution on the 1948 Chilko run possibly should have been similar to the mesh experiment catch distribution by mesh size to avoid size selectivity. Testing the hypothesis, the calculated average weight of sockeye caught during the peak of the Chilko run by a theoretical mesh distribution equal to this catch distribution was shown to be similar to the average weight taken by purse seines.

A comparison of the sex ratios of the escapements to the various Fraser River spawning grounds demonstrated that the percentage of males was much lower in the late-run escapements when fished by gillnets than in the earlier escapements. It was also shown that the development of the secondary sexual characters, namely snout and hump, was well-advanced in the late-run males in the gillnet fishing area. Adams River and Weaver Creek escapements approximated a 1:1 sex ratio when protected by early special closures of the gillnet fishery, but were unbalanced to about a 1:2 ratio in favor of females when intensively fished by gillnets.

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