PACIFIC MARINE FISHERIES COMMISSION

Bulletin 2

THE CALIFORNIA SALMON TROLL FISHERY

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THE OCEAN SALMON TROLL FISHERY OF OREGON

—•—

RESEARCH REPORT ON THE WASHINGTON STATE OFFSHORE TROLL FISHERY

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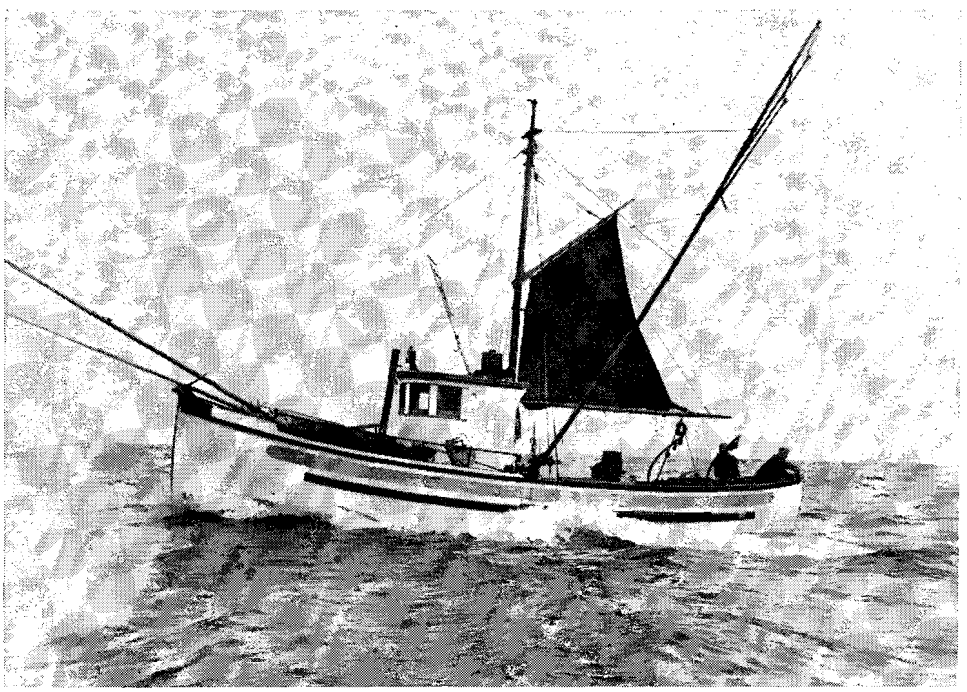
OBSERVATIONS ON
TROLL-CAUGHT SALMON OF THE WEST COAST
OF VANCOUVER ISLAND, 1949

—•—

Portland, Oregon
1951



Salmon troller operating along the Pacific Coast.

FOREWORD

The Pacific Marine Fisheries Commission was created in 1947 when the States of Washington, Oregon, and California entered into a compact with the consent of the 80th Congress of the United States.

The objectives of this tri-state agreement are set forth under Article I of the Compact as follows:

> "The purposes of this compact are and shall be to promote the better utilization of fisheries, marine, shell, and anadromous, which are of mutual concern, and to develop a joint program of protection and prevention of physical waste of such fisheries in all of those areas of the Pacific Ocean over which the states of California, Oregon and Washington jointly or separately now have or may hereafter acquire jurisdiction."

In order to achieve these purposes, the Commission is directed, among other things, under Article IV:

> "The duty of the said Commission shall be to make inquiry and ascertain from time to time such methods, practices, circumstances and conditions as may be disclosed for bringing about the conservation and the prevention of the depletion and physical waste of the fisheries, marine, shell and anadromous, in all of those areas of the Pacific Ocean over which the states of California, Oregon and Washington jointly or separately now have or may hereafter acquire jurisdiction."

The Commission has no regulatory powers, but is essentially an investigating and research body with authority to submit specific recommendations to the respective States.

One of the first undertakings of the Commission was the collection of all available research data, statistics, and other facts pertinent to the marine fisheries of the Pacific Coast of the United States. This material when assembled was published as Bulletin 1 of the Commission. It was used as a basis for recommended regulations for several of the fisheries and as a guide in the formulation of a coordinated research program.

Based on the data thus collected, the Commission in 1948 made the following recommendations for the regulation of the ocean troll fishery which operates chiefly on king (chinook) and silver (coho) salmon:

1. No king salmon less than 26 inches, measured from the tip of the snout to the tip of the tail, should be taken by trollers. No king salmon less than 26 inches taken incidentally by other gear should be permitted to be sold.
2. The king salmon fishing season should be from March 15 to October 31. Any state could set a shorter season within that period.
3. The silver salmon season should be from June 15 to October 31. Any state could set a shorter season within that period.
4. It was deemed by the Commission that California's alternate proposal for troll silver salmon regulations consisting of a 25 inch minimum size limit (tip to tip) and a fishing season from May 1 to September 30 would be an acceptable substitute for the recommended regulation of a June 15 to October 31 fishing season.

These recommendations, designed to develop the conservation and better utilization of these resources, were subsequently adopted in substance by the States of California, Oregon, and Washington, and the Territory of Alaska.

The preliminary nature of these regulations was recognized by the Commission which also recommended that research be continued in this field in order to obtain more complete data on which to base such additional regulations for the management of the ocean salmon troll fishery as should prove necessary. Recognizing the magnitude and importance of the problems involved in this research, the fishery agencies of Canada and Alaska are actively cooperating with the Commission in this investigation which is being conducted on a coastwide basis.

The following reports are the results of the coordinated ocean salmon research conducted by the fishery research organizations of the signatory States which are designated by the Compact to act in collaboration as the official research agency of the Pacific Marine Fisheries Commission. In addition, there is included a report of research conducted by the Fisheries Research Board of Canada. This research is being continued in order to observe the effects of the present troll fishery regulations and also to obtain additional data concerning the life history of the king and silver salmon and the factors which affect the survival of these species during their life in the ocean.

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HISTORY AND FISHING METHODS

Ocean trolling for salmon off the California coast started in the early 1880's in Monterey Bay. Commercially, this form of fishing was of little consequence until the late 1890's. About 1898 mild curing of salmon (a light-salting process) was started and acted as a stimulus to the ocean fishery. The early trolling was done from small sailboats rigged with leg-o-mutton sails. About 1908 the Sacramento River gill netters began using power and many of these fishermen took their boats to Monterey Bay to troll for salmon in the summer. These powered gill netters were a big improvement over the boats which had previously been in use, but they would be regarded as somewhat small for trolling as it is done today. By 1914 the troll fishery had spread from Monterey Bay north to Point Reyes. Two years later, some boats had tried the area off Fort Bragg and Shelter Cove, and there was some trolling out of Eureka and Crescent City.

In recent years, the trollers have been gradually tending toward the use of larger boats and the use of ice to preserve the catch. The smaller craft leave the harbor each morning and return the same afternoon or evening. If the salmon are running close to a harbor, even the largest boats will make one-day trips, but if the fish are 30 to 50 miles away, the large boat operator will put on a load of ice and may stay out a week or longer.

In 1937 the most common sizes of ocean trollers were 28 and 30 feet and about 90 percent of the boats were between 24 and 40 feet in length. In 1947 the most common sizes were still 28 and 30 feet, but the boats 32 to 45 feet long were relatively more numerous than in 1937. The number of trollers has been increasing. In 1947 over 1,100 boats landed ocean caught salmon and 876 landed more than 1,000 pounds each. By comparison, Nidever (1937) states that in 1935 there were 570 trollers operating off the coast of California.

Ocean trolling used to be strictly a hand operation, except for the sail or motor which moved the boat. A typical troller of the 1920's and 1930's would use either two or four trolling poles and would fish as many as nine lines. Some of the lines had four or even more hooks, and as much as 30 pounds of lead to keep the hooks at the proper depth. When the fish were biting fast, the one or two men on a troller had a really exhausting job. The modern salmon troller has mechanized equipment and the engine does the back breaking job of lifting fish and lead to the surface, but the fisherman has to have even more dexterity than a hand puller. W. L. Scofield (1921) gives a detailed description of trolling as it was done in 1920.

The typical modern trolling boat has four poles and fishes six lines. The forward or bow poles are usually from 12 to 20 feet long but may be as long as 30 feet. One line is fished from each bow pole. The main poles are longer than the bow poles and usually fish two lines each. One line is fastened to the tip; the other is usually a little outboard from the pole center. Twenty-five to 40 foot main poles are common. Often the main poles will be about as long as the boat and the bow poles about half that length. The diameter of either bow or main poles at the tip is usually from 1¼ to 2 inches. If there is a difference, the bow pole is usually the thicker. The diameter at the base depends on the length of the pole and the shape of the tree from which it was cut. A well-shaped forty-foot pole will measure four inches or a little more at the base.

The lines which are attached near the center of the main poles must have some sort of a shock absorber between the pole and the line. This serves two purposes. One is to keep a very sudden strike from breaking the line or tearing out the hook. The other is to indicate to the fisherman that he has hooked a fish. One type of shock absorber is a pair of coiled springs attached to the pole. Another is a small pole which is spliced to the main pole and which diverges from it at a slight angle. These small poles are sometimes called "sucker" poles because of their resemblance to a sucker at the base of a tree. They are also known among other things as "jigger" or "gaff" poles. The sucker pole will usually be about 1 or 1¼ inches in diameter at the tip. Advocates of this form of gear insist that the wiggling of the pole is a much more delicate indicator of the presence

of small fish than is the spring. Advocates of the spring claim that it is much easier to attach (this is admitted by everyone), that it is just as good an indicator as the pole, and that unlike the pole it is not apt to break when subjected to extra heavy strike by an albacore. (Many fishermen use the same poles for salmon and albacore trolling.)

If a boat fishes six lines, there will usually be four hooks per line. This is fewer lines and hooks than some of the hand pullers used to use but power pulling is so much faster that no more are needed. The fishermen take less time to get the fish on board and the lines fishing again, and spend less time towing recalcitrant salmon through the ocean.

The heart of the typical power pulling mechanism is the set of six small gurdies. These are mounted three on a shaft, one shaft for each side of the boat. Each gurdy is equipped with a clutch and brake. Almost all of the lines are stranded stainless steel one-sixteenth of an inch thick. A single sinker is attached to the end of the line. Fifty pound weights are the heaviest which are commonly used, but a few fishermen have sixty pounders. The heaviest leads are put on the bow lines; thus these lines go more nearly straight down and do not interfere with the others. Lighter sinkers for shallower fishing are used on the lines from the main poles. A fisherman might use 50 pound leads on his bow poles, 30 pounds on the main pole springs (inner lines), and 15 pounds on the main pole tips. A new type of weight is entering the fishery. This device has a flat surface and is so shaped that it has a diving action, thus making it fish deeper than other sinkers of equal weight. The lures used are spoons, wooden plugs, and bait such as sardines or herring. Hooks or lures are attached to stainless steel leaders 4 to 6 feet long. The steel leader in turn is fastened to one of nylon which may be as short as six feet or as long as six fathoms. The nylon leader is attached to a rubber shock absorber which has a metal snap that serves to attach it to the steel line. Small "stoppers" permanently fastened to the metal lines keep the snaps from sliding. Each line passes from its gurdy through a pulley at the side of the boat and through a sliding ring. Each of these six rings is attached to one of the trolling poles by a heavy cotton "pole line." The fisherman reels out the steel line attaching hooks at appropriate intervals. The small stoppers which hold the hooks pass through the sliding ring, but when enough line is out, a larger stopper attached to the steel line engages the sliding ring and the strain of the sinker and hooks is taken by the pole line and trolling pole instead of being directly on the gurdy. Instead of the sliding rings and stoppers, some fishermen use special clamps on the end of the pole lines. These clamps will hold the steel line without kinking it. The clamps take a little more time in that they do not automatically stop the line at a certain point but they make it easier for the fisherman to adjust the depth of his gear.

When a salmon strikes, the fisherman engages the clutch of the appropriate gurdy and winds in the one line. When a hook reaches the surface, he unsnaps it unless the fish is on that hook and lets the gurdy continue winding until the fish is at the surface. If the salmon is obviously over legal size (over 26 inches for kings, 25 inches for silvers), the fisherman usually hits it on top of the head with a combination gaff and club, then he gaffs it in the head and lifts it aboard. Fish of doubtful size are measured and small ones are released. The methods of release are varied and are the subject of controversy. Some methods are easy on the fish; others probably kill more than they save. About the only complete agreement is that the use of a landing net is one of the worst methods. The hook catches in the webbing and unhooking a squirming salmon in the bottom of the net is a time consuming process.

The transition from hand to power pulling was slow. In 1931 a Seattle firm started selling power gurdies not essentially different from those in use today, but more than a decade passed before such equipment reached California in any quantity. During the 1930's some California fishermen used home devised equipment to enable them to apply power to their lines, but by 1941 the great majority of California fishermen were still pulling by hand. About 1943 factory-made gurdies and steel lines began appearing and by 1945, the change to power was almost complete among the large boats and full time trollers. Even today there are handpullers among the small boat operators and men who troll only a small part of the time.

In 1947 nearly 100 percent of the trollers north of San Francisco used power gurdies. At San Francisco, about 80 percent were so equipped and at Monterey only about 20 percent. Probably the chief reason for this difference is that in the more southern waters, salmon are often scarce and

many fishermen fish salmon only a small part of the year. A secondary reason for the higher proportion of hand pullers in the south is that the gurdy is a northern development which has been working its way down the coast.

Another device which has greatly increased the efficiency of the trolling fleet is the radio telephone. About 1944 some trollers started using radio and by 1946 the great majority had sets. Formerly when one fisherman located salmon, there might be a lapse of days before the bulk of the fleet found out about it. Now the interval may be a matter of minutes. Not only has the radio improved communications, it has also improved the spirit of cooperation. Fishermen who used to be very secretive about the location of schools of fish now go to the other extreme.

Another improvement in salmon trollers has been installations of automatic pilots of various types. These devices steer the boat and enable the fisherman to tend his gear, polish spoons, make minor repairs, etc., while underway. Of course they also eliminate the need for steering when the lines are loaded with fish and the fisherman wishes he had four hands just to tend to that one item alone. Some two-man boats have become one-man boats since the installation of an automatic pilot.

Many boats are installing radio direction finders which make the matter of poor visibility much less of a handicap. Boats so equipped can locate each other as well as find their way home in a fog.

Early in 1949 small boat stabilizers made their appearance on a few northern California salmon trollers. They met with wide approval, and by the end of 1949, were being used by the majority of the salmon fleet. These simple devices reduce the rolling of small boats and enable them to fish in rougher weather than would otherwise be possible. The device was described by W. L. Scofield in the January, 1950 issue of "California Fish & Game". To quote part of Scofield's description:

> "The device consists of two horizontal boards, one on each side of the vessel carried six to twenty feet under water with the flat surface of the board parallel to the surface of the water. When the vessel rolls to one side, the flat surface of the opposite board partially checks the roll. This checking action of the boards is exerted even when the vessel is at anchor. The boards usually are hung from the main outrigger troll poles . . . . A few boards are of wood but most are of metal. . . . . Boards vary in size and shape but are roughly 1½ to 2 feet long by 12 to 16 inches wide . . . ."

TROLL SALMON LANDING PORTS OF CALIFORNIA

The salmon landing ports of California extend from Crescent City on the north to Monterey on the south, a lineal distance of 320 nautical miles. Occasionally, salmon are caught south of Monterey but there is no regular fishery for them. California ports which received more than 20,000 pounds of troll caught salmon in 1949 are listed from north to south. These ports are shown on Figure 1.

Crescent City

A breakwater gives protection against blows from any direction. Crabs, troll salmon, albacore and bottom fish are all landed at this port. The silver salmon catch at Crescent City is relatively more important than the take of this species in any other place in the state. During some years, the silver salmon catch will exceed 50 percent of the total salmon landings of this port.

Most of the fish are dressed, head on, before being landed here, and are iced and trucked to Eureka for processing.

In 1949 the total commercial salmon landings were 465,000 pounds and the total commercial landings of all fish and shellfish were 4,336,000 pounds.

Trinidad

This is a beautiful little natural harbor which gives excellent protection from the west and northwest blows that are common throughout the summer. It is not protected against southerly or southwesterly storms. Only small boats land at Trinidad and the landings consist primarily of crabs. At times salmon are abundant in the vicinity of Trinidad and many visiting salmon trollers operate out of the port.

Salmon landed here are trucked to Eureka for processing.

In 1949 the total commercial salmon landings were 37,000 pounds and the total commercial landings of all fish and shellfish were 910,000 pounds.

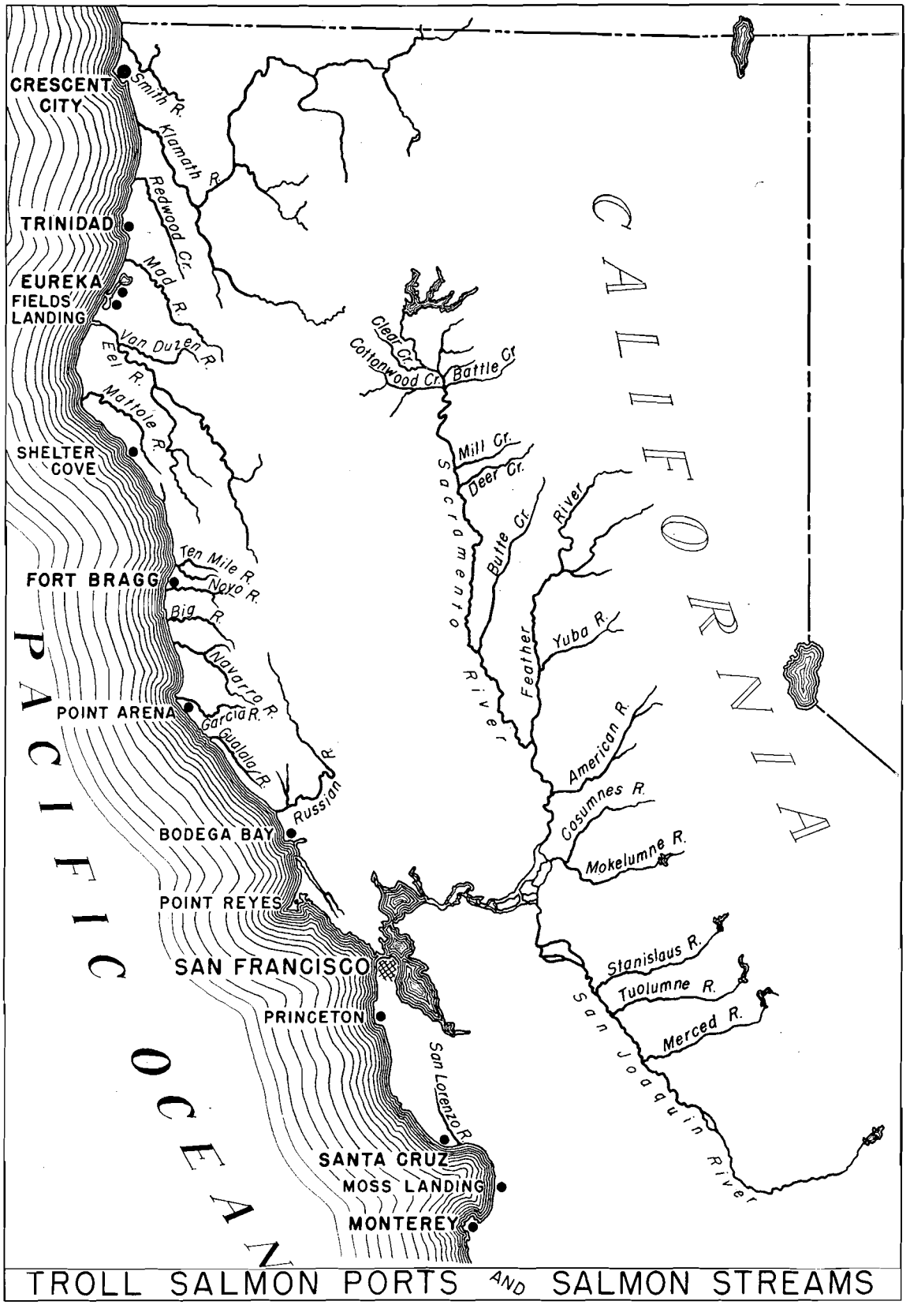

FIGURE 1. Map of Central and Northern California showing important salmon spawning streams and ports where troll-caught salmon are landed.

Eureka

Eureka is on Humboldt Bay — a large, landlocked bay. It is the largest port and the largest fishing port in Northern California, and has a varied fishing industry. To small boat fishermen, its disadvantages are the distance from dock to fishing grounds, and the Humboldt Bar at the entrance of the bay. Frequently, breakers make this bar impassable.

In 1949 the total commercial salmon landings were 902,000 pounds and the total commercial landings of all fish and shellfish were 16,878,000 pounds.

Fields Landing

This port is also on Humboldt Bay and is about six miles south of Eureka. Bottom fish are processed here and salmon are only incidental.

In 1949 the total commercial salmon landings were 46,000 pounds and the total commercial landings of all fish and shellfish were 5,681,000 pounds.

Shelter Cove

This port is well described by its name. It is a small bight protected from west and northwest seas. There is no wharf and anything brought ashore must be landed on the beach. Salmon trollers operate out of Shelter Cove for extended periods and often transfer their catches to pickup boats which deliver them either to Eureka or Fort Bragg. These pickup boat deliveries are listed as Shelter Cove "landings".

In 1949, the total commercial salmon landings were 178,321 pounds and the total commercial landings of all fish and shellfish were 230,319 pounds.

Fort Bragg (Noyo River)

This is a small, fully protected, and highly picturesque harbor situated in the narrow Noyo River at the south edge of Fort Bragg. At times the number of boats operating here is limited by the amount of space in the harbor. Trollers are the biggest part of the fishing fleet but in recent years more and more draggers have been using the port. There are several fish processing plants established here.

In 1949 the total commercial salmon landings were 883,000 pounds and the total commercial landings of all fish and shellfish were 4,985,000 pounds.

Point Arena

This is a point of landing for trollers. It can hardly be called a harbor. Occasionally, the trolling fleet moves into this area and lands large poundages at Point Arena's single pier. Most of the fish are dressed after landing, then iced and trucked out.

In 1949 the total commercial salmon landings were 84,000 pounds and the total commercial landings of all fish and shellfish were 164,000 pounds.

Bodega Bay

This is a landlocked harbor used by all the local types of fishing boats. There are several fish processing plants established here.

In 1949 the total commercial salmon landings were 314,000 pounds and the total commercial landings of all fish and shellfish were 1,503,000 pounds.

Point Reyes

This harbor is good protection from almost all weather except south and southeast blows and is conveniently near to good fishing grounds. Fishing boats of all sizes use the three wharves which are located here. There are three processing plants. More troll salmon are landed at Point Reyes than anywhere else in the San Francisco area.

In 1949 the total commercial salmon landings were 1,278,000 pounds and the total commercial landings of all fish and shellfish were 2,591,000 pounds.

San Francisco

This is the largest port in Central California but as a fishing port it ranks below Monterey. It takes trollers so long to reach the fishing grounds from San Francisco that many of the San Francisco

boats prefer to spend the week operating out of Point Reyes or Princeton and come into San Francisco over the weekends.

In 1949 the total commercial salmon landings were 475,000 pounds and the total commercial landings of all fish and shellfish were 28,517,000 pounds.

Princeton-by-the-Sea

This is a small port which offers fair protection against northwest seas. At times large quantities of troll caught salmon are landed and are dressed and iced ashore. There are two sardine plants here; neither has operated on sardines within the last few years but one has acted as a shipping plant for other species.

In 1949 the total commercial salmon landings were 377,000 pounds and the total commercial landings of all fish and shellfish were 1,171,000 pounds.

Santa Cruz

This is a moderate sized fishing port and a large recreational area. There is ample protection against northwest seas but Santa Cruz is wide open to any blows from the southwest or south. The one long commercial fishing pier is equipped with many pairs of heavy davits which are used to lift small trolling vessels and others of similar size. In this way, part of the fishing fleet can have protection against any kind of weather. Salmon landings at Santa Cruz are erratic as is to be expected in a port so close to the southern limit of the commercial fishery. Salmon are dressed after landing and iced for shipment here.

In 1949 the total commercial salmon landings were 201,000 pounds and the total commercial landings of all fish and shellfish were 5,033,000 pounds.

Moss Landing

This is a landlocked harbor with a large sardine industry. Northern trollers like the harbor and increasing numbers of Oregon and Washington fishermen have been operating out of this port while fishing for albacore or salmon. Salmon buyers have recently started operating. Most salmon are landed dressed, head on, and are used for mild curing.

In 1949 the total commercial salmon landings were 28,000 pounds and the total commercial landings of all fish and shellfish were 25,126,000 pounds.

Monterey

This port is equipped with breakwaters to give protection against all kinds of weather and ranks first as a fish landing port in Central California. The huge sardine canning industry dwarfs all other fishing operations.

Salmon landings at Monterey are erratic. It is the southernmost port at which salmon are taken in any number.

In 1949 the total commercial salmon landings were 239,000 pounds and the total commercial landings of all fish and shellfish were 254,600,000 pounds.

From Crescent City to Eureka, salmon are customarily landed dressed, head on. At Fort Bragg, some are landed dressed, head on, and some are round. South of Fort Bragg, most landings are in the round except at Moss Landing.

OCEAN SPORTFISHING FOR SALMON IN CALIFORNIA

Ocean sportfishing is a major operation in California waters, but only in the vicinity of San Francisco is there a really large ocean sport fishery which depends primarily on salmon. These boats leave from several cities and towns bordering on San Francisco Bay. In four different months of 1950, there were 100 or more sportfishing boats which reported salmon catches. Only in November, December, January, and February was the number below 60. This includes only those boats which are for hire.

The San Francisco sportfishing boats usually operate within ten or fifteen miles of the Golden Gate, and take the fish by trolling with spoons, bait or plugs. Each angler uses a rod and reel.

Commonly the fish are deep enough so that a heavy sinker is necessary. Cast iron balls about two or three pounds in weight are the most common. Most of the anglers also use a sinker release mechanism which will disconnect the sinker if a heavy fish strikes. This results in the loss of large numbers of sinkers but enables an angler to fight a good fish without having a heavy weight hampering its action and putting an unnecessary strain on the rod.

Sportfishing boats operating out of other ports of Central and Northern California depend primarily on rock cod, lingcod, and other bottom fish. They take few salmon.

At times there is an extensive skiff fishery for salmon (primarily silvers) at the mouth of Humboldt Bay, and occasionally in the bay itself. These salmon are feeding on anchovies and are commonly taken by using anchovies for bait. An annual "salmon derby" is an added impetus in this Humboldt Bay fishery.

Skiffs may be rented at Trinidad and at times there is excellent salmon fishing either in the cove or just outside of it.

Skiffs may be rented at the mouth of the Noyo River. Occasionally there is salmon trolling just outside the entrance. For most of the season, these are feeding fish which are not on a spawning migration. (There is sportfishing on the Noyo River's spawning run as well.) Commercial fishermen operating out of the Noyo River will usually take an angler along for a day's fishing, if he looks as though he could stand a long day of bad weather. The understanding is that the length of the trip is strictly up to the desires of the boat owner.

CALIFORNIA SALMON STREAMS

The map, Figure 1, shows the majority of the better salmon streams of California. Silver salmon enter most coastal streams of any consequence as far south as the northern part of Monterey Bay, but there are no runs of silver salmon in any of the streams tributary to the Sacramento or San Joaquin Rivers.

King salmon runs of some importance are found in the following streams: Smith River, Klamath River system, Redwood Creek, Mad River, Eel River system, Mattole River, Garcia River, and the Sacramento-San Joaquin system. At least six small north coast streams not mentioned above have runs of king salmon. Individually, they are not important; collectively, they are.

SALMON LANDINGS[1]

The salmon landings from 1916 through 1949 are shown in Figure 2 and Table 1. During this entire period, the catch has been regulated by the supply. There have been some fishermen's strikes, but in general, both the fishermen and the markets have taken all the salmon they can get. The period of low catches extending from the late 20's to the early 40's was due to a shortage of fish, not to economic conditions. Similarly the rise which started in 1944 and the decline since 1947 have been due to changes in abundance of fish.

Numerous logical reasons have been given for the periods of poor fishing: over-fishing; dams keeping the salmon away from their spawning grounds; diversion of water for irrigation and power; pollution of streams; spearing of salmon on and near the spawning beds; loss of young into irrigation ditches; extreme shortage of water caused by drought, etc., etc. Probably all of the above reasons and many others played a part. Some salmon streams have had their runs exterminated by one or more of the factors mentioned. A constant struggle is necessary to keep the same thing from happening to many more streams.

The improvement in fishing which is shown in the period from 1944 through 1946 is harder to explain. There have been some successes in the numerous battles against the unwanted by-products of civilization, but these victories have not been enough to explain any great increase in the numbers of salmon. The most logical answer would seem to be that there was a period of unusually favorable conditions in the ocean and that these conditions permitted the survival of an unusually high percentage of young fish.

The distribution of troll salmon catches along the three northern statistical areas of California seems to be due primarily to the actual distribution of the fish themselves in the ocean. In the San

[1] Catch statistics are obtained from the Calif. Div. of Fish & Game Fish Bulletins No. 67 and No. 74, and from unpublished records of the Division.

TABLE 1. CALIFORNIA OCEAN CAUGHT SALMON LANDINGS BY REGIONS

Year	Eureka	San Francisco	Monterey	All Other	Total Pounds
1916	98,353	262,889	5,230,839	135	5,592,216
1917	924,192	1,280,312	3,879,487	2,006	6,085,997
1918	1,110,611	1,928,794	2,892,876	1,065	5,933,346
1919	2,949,642	1,442,708	2,816,022	10	7,208,382
1920	3,115,381	1,459,932	1,490,877	.....	6,066,190
1921	2,300,259	938,886	1,243,960	.....	4,483,105
1922	2,496,841	961,317	880,129	30	4,338,317
1923	1,693,711	1,314,877	728,336	.....	3,736,924
1924	1,880,342	3,617,045	877,186	.....	6,374,573
1925	3,111,885	1,270,936	1,098,715	.....	5,481,536
1926	2,849,509	962,413	51,755	.....	3,863,677
1927	2,715,806	1,488,746	717,027	21	4,921,600
1928	2,293,832	815,815	334,654	5	3,444,306
1929	2,320,846	658,718	1,054,096	.....	4,033,660
1930	2,797,993	1,008,242	279,409	6	4,085,650
1931	3,254,846	428,298	91,471	.....	3,774,615
1932	2,656,788	124,010	80,884	16	2,861,698
1933	2,943,962	158,806	569,859	48	3,672,675
1934	2,824,743	818,852	286,230	.....	3,929,825
1935	3,790,733	337,751	219,700	15	4,348,199
1936	3,655,768	266,440	144,924	1,020	4,068,152
1937	3,895,867	1,108,402	891,083	931	5,896,283
1938	1,868,706	94,975	199,474	183	2,163,338
1939	1,821,931	285,194	125,498	.....	2,232,623
1940	3,369,492	1,177,653	613,224	34	5,160,403
1941	2,413,368	375,766	153,662	3,198	2,945,994
1942	2,255,862	1,642,051	164,931	462	4,063,306
1943	2,162,368	2,021,208	1,101,934	17	5,285,527
1944	3,792,103	2,646,714	575,579	7,452	7,021,848
1945	4,627,714	2,431,954	816,303	36,783	7,912,754
1946	4,545,299	2,017,703	569,350	2,120	7,134,472
1947	5,868,577	1,485,657	738,469	.....	8,092,703
1948	4,033,992	1,544,479	250,906	.....	5,829,377
1949	2,601,390	2,455,543	473,741	.....	5,530,674

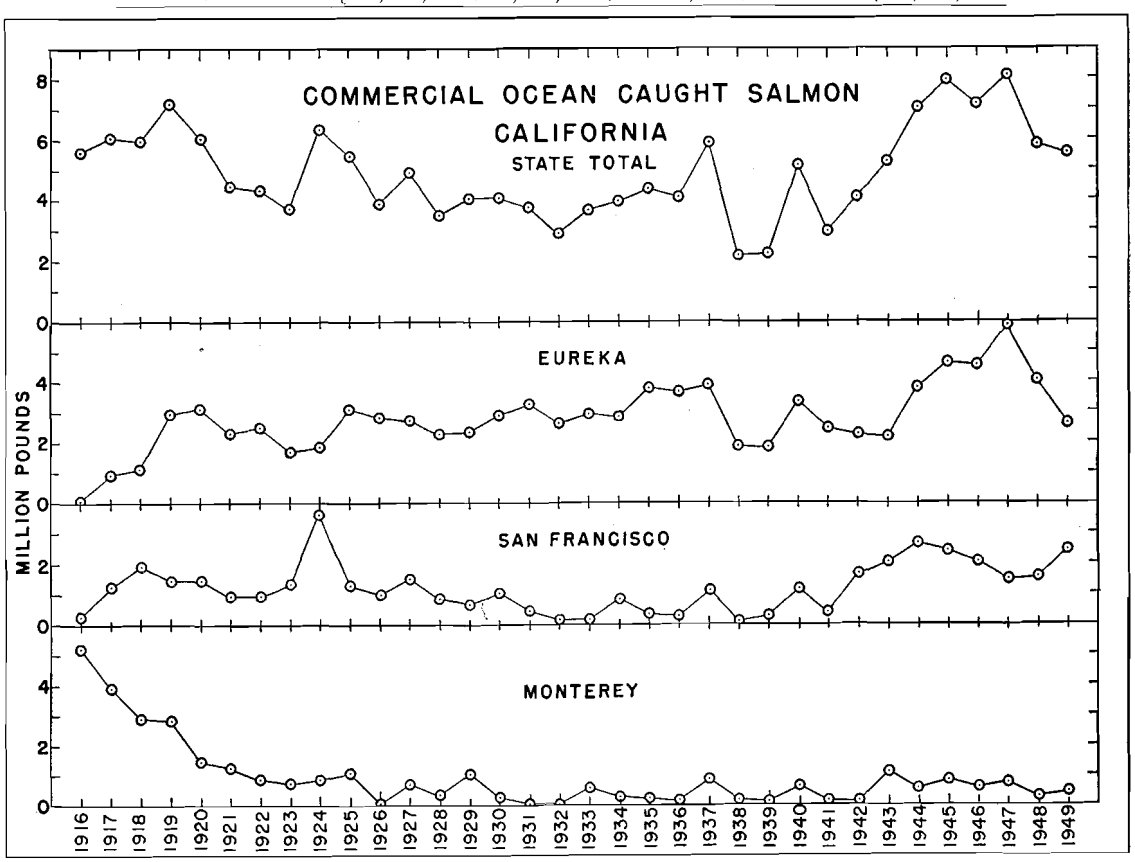

FIGURE 2. California's commercial, ocean-caught salmon catch record for the years 1916 through 1949. The State total and its breakdown by statistical areas is shown in millions of pounds for each year.

Francisco and Monterey districts (the area south of Point Arena), king salmon from the Sacramento-San Joaquin River system so completely dominate the supply that it is only the availability of schools of these particular fish that have any appreciable influence on the supply of salmon as a whole. Even in the Eureka area (the area north of Point Arena), the Sacramento-San Joaquin fish dominate the supply, but there are enough kings from the Eel, Klamath, and other river systems and enough silver salmon so that the domination is not complete. In the area close to Crescent City, silver salmon often make up the larger part of the catch for extended periods.

In summary, it may be said that the California salmon catch consists largely of fish from one river system, and that where these fish choose to feed determines where the fisherman will have to go for his catches. If salmon fishing is poor in the Monterey region and good in the rest of the state, it could mean only that the salmon were staying in the northern areas and not that there was any depletion affecting the Monterey area as such. On the other hand, the indications are that if salmon are scarce along the entire coast of California for a season, it is due to an actual scarcity of fish; i.e., it is not due to the fish being in some other locality.

The high catches of salmon in the Monterey area during the period from 1916 through 1919 cannot be explained with certainty. It could have been due to a much higher general level of abundance of salmon in the ocean at that time with the relative distribution of the fish much as it is now, or it could have been due to oceanographic conditions which attracted a relatively high proportion of the fish to the southern area. The low catches in the other ocean areas during that period mean little or nothing. As previously mentioned, salmon trolling in California started in Monterey Bay, and by 1919 the fishermen were only just learning to look for salmon in other places.

Separation of the Catches of King and Silver Salmon

Almost 90 percent of the California ocean salmon catch is kings, the remainder being silvers. Obtaining an accurate separation has proved very difficult. California customers seem perfectly willing to accept either a king or a silver as a salmon and the California dealers seem only too happy to oblige them by not getting technical about the species. Many dealers make no separation at all, but occasionally the breakdown given by some dealer has seemed good enough so that the California statistical department has had hopes that the landings of that firm might conceivably be used as a sample from which to estimate the relative proportions of silvers in the catch of the entire port. Unfortunately, spot checks have all too frequently revealed that the separation was by no means as good as it seemed. For example, some dealers will make a fairly regular practice of classifying small king salmon as silvers. The only method of separation which has proved continuously dependable is that made from samples and spot checks by employees of the California Division of Fish & Game. Unfortunately, these checks and samples cannot be made frequently enough to give us a really precise breakdown. However, the field men are continuing to work both on the fish and on the dealers, and it is the hope of the Division that eventually some of the dealers may be converted to making a really reliable species separation.

The result of samples taken by staff members in 1948 are shown in Table 2.

TABLE 2. PROPORTION OF KING AND SILVER SALMON IN CALIFORNIA TROLL CATCH, 1948

	Silver	King	Total	% Silver
Eureka Region	644,379	3,389,613	4,033,992	16.0
San Francisco Region	28,260	1,514,927	1,543,187	1.8
Monterey Region	338	229,910	230,248	0.1
Santa Barbara Region	.....	20,542	20,542	0.0
Total Ocean Landings	672,977	5,154,992	5,827,969	11.5

Troll Salmon Seasons in California

Figure 3 shows the monthly troll landings in each of the three northern regions of California during the period from 1945 through 1949. During this period, the legal commercial trolling season for both species was from April 1 to September 15 throughout the entire state except that in 1945 and 1946 the open season in the Eureka area extended until October 15. In 1950 (not shown) the legal trolling season was from May 1 to September 30.

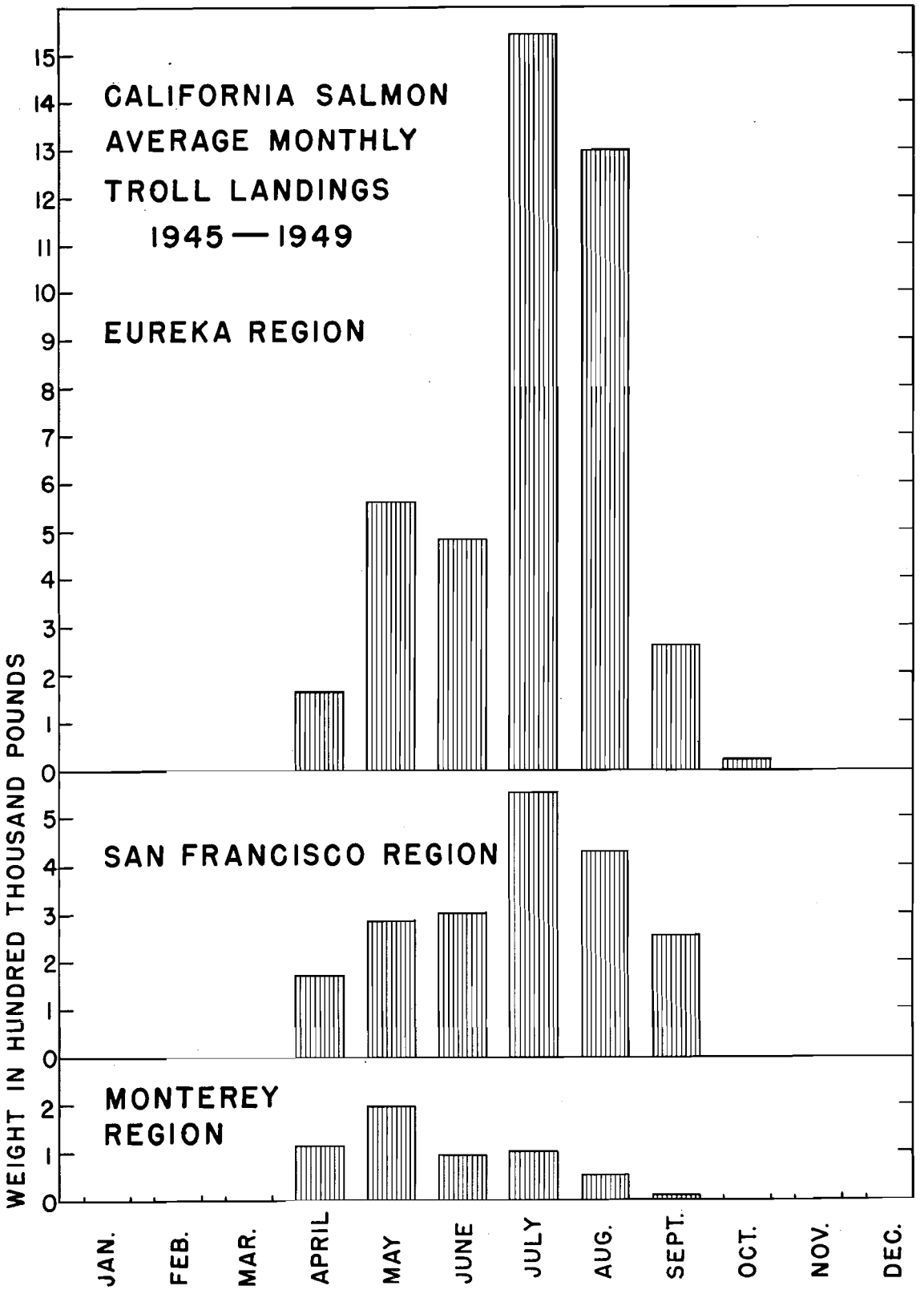

FIGURE 3. California's commercial, ocean-caught salmon catch record by months and areas for the period 1945 through 1949.

In the Eureka region, neither the fishing nor the weather is apt to be very good in April. In May and June, fishing is better, and July and August are the two best months. In September, salmon fishing drops off and if albacore are available, many of the trolling boats are likely to abandon salmon fishing and go after the tuna instead. In the San Francisco region, the catches do not vary as much from month to month as they do farther north. July and August show the heaviest landings in San Francisco but catches in these two months do not stand out above the rest of the season as they do in the Eureka area.

In the Monterey region, the season is much earlier than it is farther north. April and May are the two best months, May being the peak. June and July are still good but August is not, and by September the fish have practically disappeared from Monterey Bay.

SALMON TAGGING

The ocean salmon tagging operations conducted by the California Division of Fish & Game cover the period from 1939 into 1942 and from 1948 until the present.

The operations have covered the area from Crescent City on the north to Monterey on the south. Tagging north of Point Arena has been scattered over 170 miles of coast. South of Point Arena, most of the tagging has been done within 40 miles of San Francisco. More specifically, it has been between the Russian River and Princeton, and offshore to the Farallone Islands. A small amount has been done in the vicinity of Monterey.

All of the salmon tagged in the ocean off California were taken by trolling. The largest part were caught from chartered commercial trollers. In 1949, the Division's research vessel, the "N. B. Scofield," did some tagging in the northern part of the state and at the same time conducted some experiments on the losses due to hook injuries by barbed and barbless hooks. An innovation first tried in 1949 and repeated in February of 1950 is locally referred to as "Tag Day". Skippers of ocean-going sportfishing boats and charter boats agreed to donate the use of their boats for one day and to allow sportfishermen of known ability to fish free of charge with the understanding that all salmon landed would be tagged and released. The Division supplied at least one tagger for each boat. In 1949 the operation was only moderately successful; fifteen boats tagged 69 fish. In 1950, fishing was much better and 20 boats tagged 365 salmon. Since the Tag Day proved so successful, a small amount of tagging has been tried from chartered sportfishing boats, particularly when the lighter sports gear was getting fish and the commercial trolling gear was not. This method was only tried during a period of comparatively poor fishing, and has not yet been given a fair test.

The tags used have all been of the Petersen Disk type. Such tags consist of two plastic disks which are held against the fish by a pin which goes through both disks and some part of the fish's body. The disks ride on the pin like wheels on an axle. When used on salmon, the pin is pushed through the cartilaginous ridge at the base of the dorsal fin.

The tags used in California are ½ inch or 9/16 inch in diameter and 30/1000 inch thick. One of each pair is serially numbered. The other carries a short inscription; a typical one reads: "California Division of Fish & Game, San Francisco, California. Return Both Disks".

Tagging disks used from 1939 through 1948 were all made of celluloid (cellulose nitrate). This material was perfectly satisfactory except that some tags became brittle after being stored for about five years. In 1949 we received some tags made of cellulose acetate. These tags were about 30/1000 inch thick, i.e., about the same thickness as the older celluloid tags. After prolonged soaking, they were not as strong as the celluloid, and salmon which reached the spawning grounds broke a high percentage of the tags while fighting, digging nests, and hiding in brush piles and among roots. Since we were unable to obtain any more cellulose nitrate tags (plastic companies are shying away from this material because of the fire hazard involved), we obtained instead some thicker cellulose acetate tags (45/1000 inch). These proved reasonably satisfactory but they definitely were not as good as the old nitrate disks.

The pins formerly used were of commercially pure nickel, 32/1000 inch in diameter. Nickel was commonly supposed to be quite satisfactory for the purpose. Careful examination of many pins proved that this was not the case; in fact, we were losing an appreciable but undeterminable percentage of the tags because of pin corrosion. We have since changed to 32/1000 inch stainless steel wire (type 302), soft temper, which has given us no trouble because of corrosion, but is harder to

twist into a satisfactory knot. The subject of tagging disks and pins will be discussed at greater length in a forthcoming article in "California Fish & Game."

A tagger's equipment consists of the following: an ample supply of tags and pins, a wooden block drilled to hold 100 tags arranged in consecutive order, a pair of pointed-nosed side cutter pliers, at least one large hypodermic needle from which the base has been removed leaving a sharp-pointed tube of hard metal, record sheets, a sheet holder and supply of pencils, and a tagging cradle to hold the salmon while it is being tagged. The cradle designs have been varied but essentially, each one consists of a V-shaped trough with a flat board across the head end and a ruler along the side.

When a fish is hooked, it is pulled up beside the boat and if it is small and well-hooked, the fisherman simply grabs the leader, lifts it aboard, unhooks it, and places it in the tagging cradle. If the fish is large or lightly hooked, the fisherman uses either a dip net or a gaff. When a gaff is used, it must be very skillfully hooked into the lower jaw. If this is done properly, there is little or no injury to the fish. Once the fish is in the cradle, the tagger takes the assembly of tag, pin, and hypodermic needle and using the disk of the tag as he would the head of a thumtack, pushes the point of the hypodermic needle through the base of the salmon's dorsal fin and out the far side. He then grasps the needle near the point, and pulls it clear through the fish and off the pin. The unnumered tag disk is slipped over this pin and the wire is given a complex knot-like twist which keeps the disk from sliding off. The fisherman then drops the salmon overboard and the tagger records its length opposite the appropriate tag number on his record sheet. He also records the species and whether the fish was in good, fair, or poor condition when tagged.

The above describes the technique as it has been used since 1948. During the period from 1939 to 1942, slightly different techniques were used. In some of the operations, tags and pins were kept in coin envelopes, the outside of each envelope being serially numbered to match the number of the tag contained within. Data was recorded on this envelope after the fish was tagged. Instead of a hypodermic needle, a small awl was used. A hole was made through the base of the fish's fin with this awl and the pin was then pushed through the hole. Instead of the locking knot used to hold the disk in place, the end of the pin was gripped with the pliers and rolled into a small, compact roll. The purpose of this roll was to allow for the growth of the fish after tagging, the theory being that as the growing fish pushed the tags farther and farther apart, the wire roll would automatically uncoil. Unfortunately, the wire unrolled a bit too readily and tags were lost as a result. This was proved in a river tagging experiment in 1943 and the method was changed.

TAG RETURNS

King Salmon Tag Returns

The most important thing accomplished by the two tagging experiments was to demonstrate beyond any possible doubt that the Sacramento-San Joaquin River system is the primary source of salmon to the trolling industry off the California coast. Before 1939, there were many people—fishermen, industry men, and research workers alike—who believed that most of the salmon off the California coast came from the Eel, from the Klamath and even from the Columbia River. The tagging which took place from 1939 through 1942 produced enough evidence to show that actually it was the Sacramento which was the primary source. The later tagging experiment which started in 1948 has confirmed the earlier findings and has added quite a lot of additional information as well.

In the 1939–1942 tagging experiment, 2,639 king salmon were tagged off the California coast south of Point Arena. Seventy-two were recovered in streams and 65 or 90.3 percent of these stream recoveries were from the Sacramento-San Joaquin River system. The Eel, the Mad, and the Klamath rivers (all on the northern coast of California) accounted for all the remainder.

In 1948–1949, a total of 373 kings were tagged in the same area, i.e., south of Point Arena. Of these, 39 were recovered in streams and 35 of them or 89.7 percent were from the Sacramento-San Joaquin. Two were recovered in Northern California coastal streams and only two were recovered north of the California-Oregon line.[1]

[1] Tagging from 1939 through 1941 is reported by G. H. Clark and S. Ross Hatton in "Progress Report on Adult Salmon Tagging in 1939–1941" California Fish and Game, Vol. 28, No. 2, April 1942, pp. 111–115.

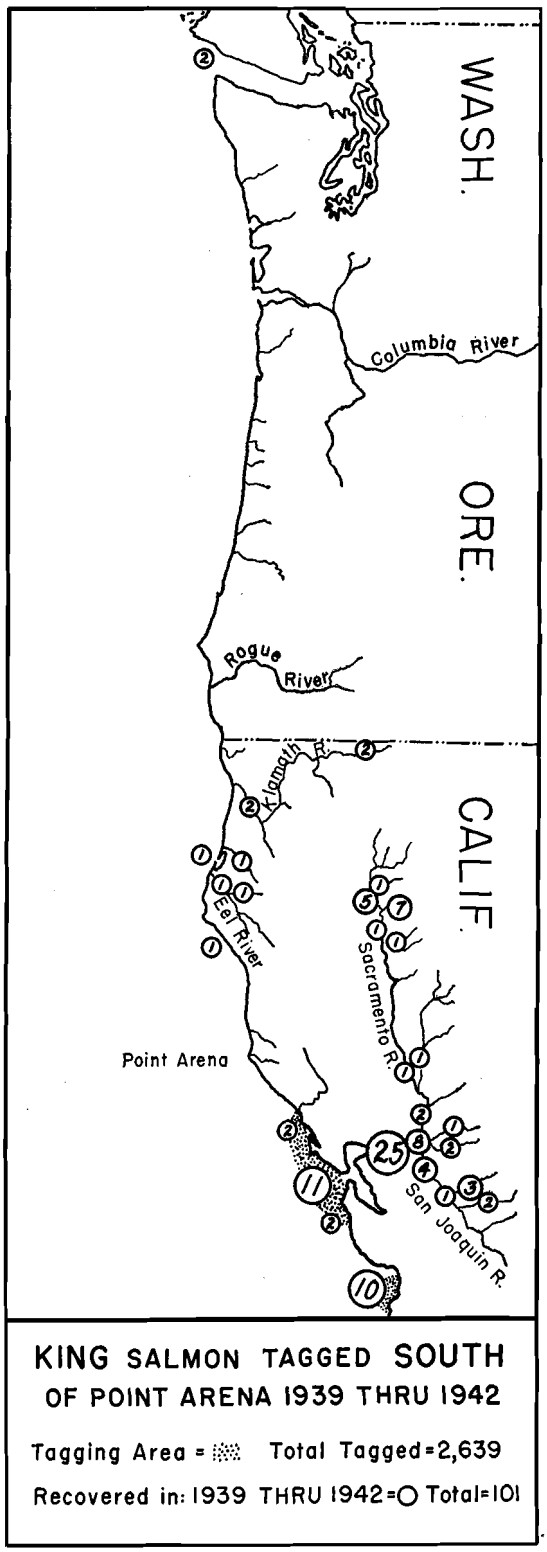

FIGURE 4. Movements of king salmon tagged south of Point Arena in 1939 through 1942. Map shows area of tagging and points of recovery.

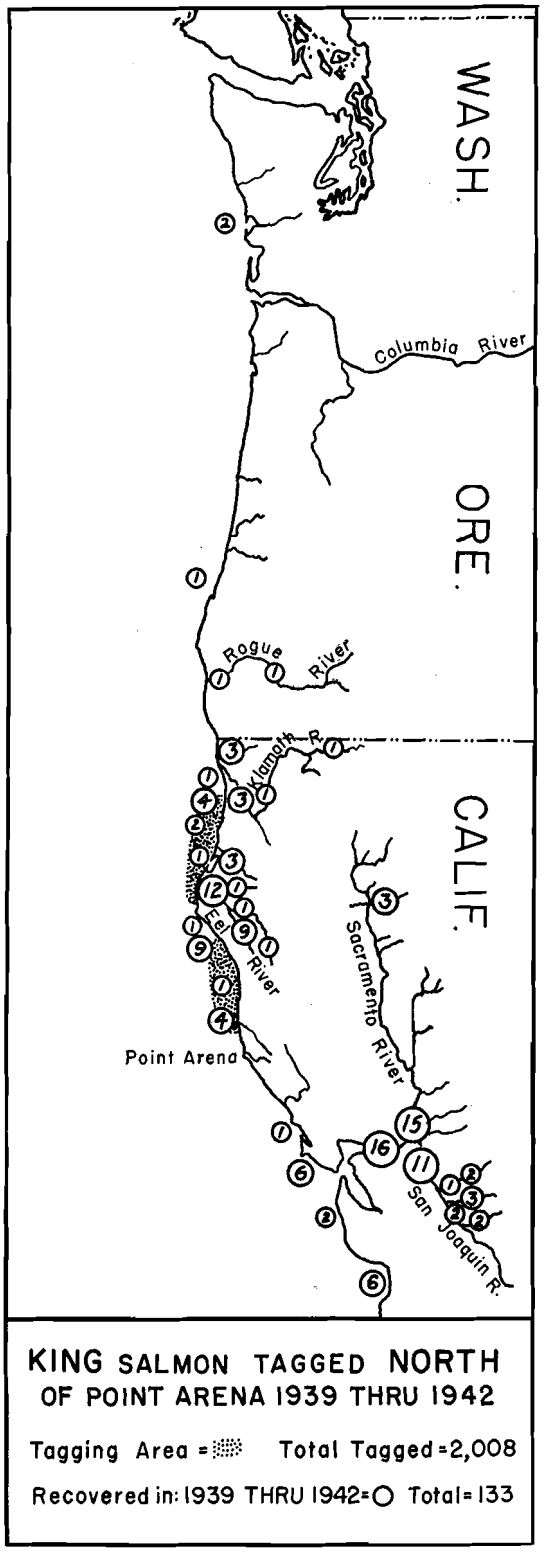

FIGURE 5. Movements of king salmon tagged north of Point Arena in 1939 through 1942. Map shows area of tagging and points of recovery.

The recapture of a tagged salmon at sea does not prove that it was going to spawn either in the area where it was first tagged or where it was finally recaptured. However, the movements do give some indication as to the amount which salmon move around. Apparently, the king salmon tagged south of Point Arena do not migrate to any extent outside of this area. For example, in the older tagging experiment, 25 salmon were recaptured south of Point Arena after being tagged there, and only four were taken north of the area. Two of these were in the northern part of California; the other two were real travelers which were taken off the Strait of Juan de Fuca. In the later experiment, the picture is very much the same. In this instance 38 salmon were retaken south of Point Arena and only six were taken north of there. Of these, one was taken north of the California-Oregon line.[1]

The Sacramento-San Joaquin is the only river system in Central California used by king salmon. Therefore, it is not too surprising that most of the salmon tagged off Central California should turn out to be from this stream system. However, between Point Arena and the California-Oregon line, the fish bound for the Sacramento have quite a way to go while the other California king salmon streams are much closer. In spite of the nearness of the Klamath, Eel, etc., it is still the Sacramento-San Joaquin which dominates the catch in Northern California. In the earlier tagging experiment, 55 out of the 92 recoveries (59.8 percent) of salmon tagged north of Point Arena were recovered in the Sacramento-San Joaquin system. In the later tagging experiment, the proportion was a little higher; 68 out of 87 (78.2 percent) were Sacramento-San Joaquin fish.

The ocean recoveries made of fish tagged north of Point Arena show that the fish retaken in the ocean had a similar tendency to move southward. In the earlier tagging experiment, 41 of the salmon tagged north of Point Arena were recovered in the ocean. Twenty-three of these had not moved out of the area of tagging, 15 had moved south into Central California, and three had moved north. The later experiment again shows somewhat the same tendency. In this instance, 80 of the tagged fish were recovered in the ocean; 28 of them in the area of tagging, 36 had moved, and 16 had gone north. The relatively fewer number of northward movements in the earlier experiment

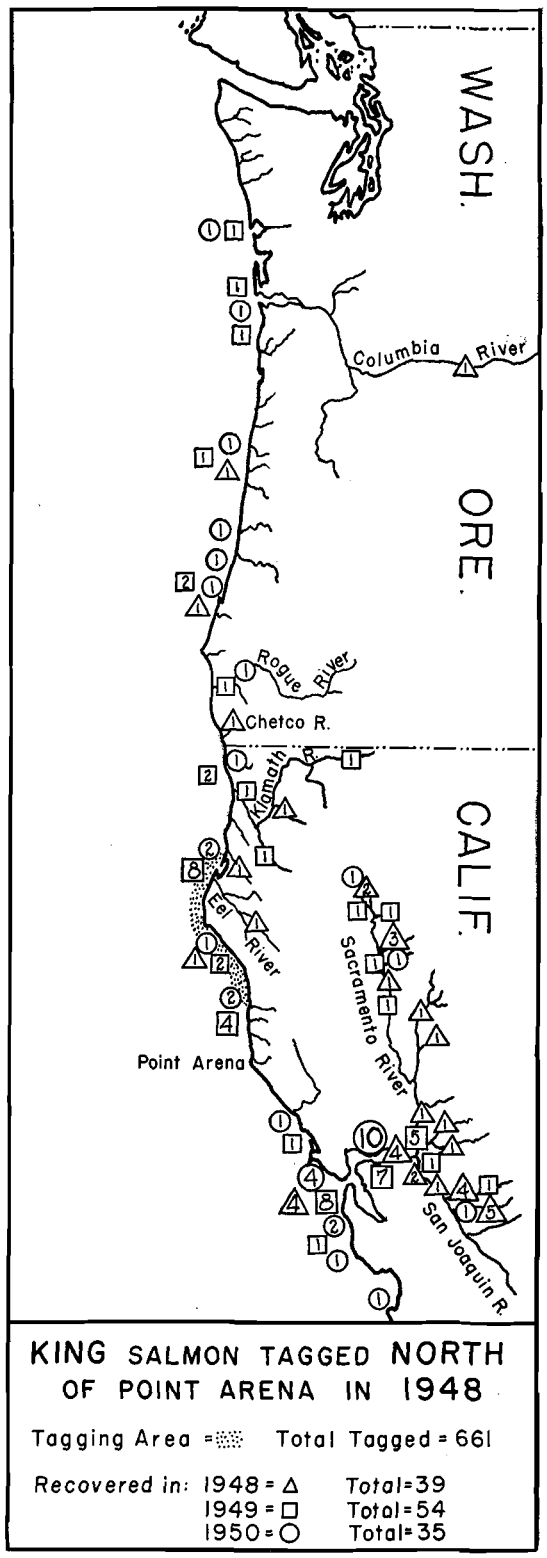

FIGURE 6. Movements of king salmon tagged north of Point Arena in 1948. Map shows area of tagging and points of recovery. Recoveries are classified by year of recovery.

[1] One tag from the 1939–42 experiment was recovered from the Columbia River. The numbered tag of the pair was missing so it was impossible to tell when or where the fish was tagged or if it was a king or silver. The fisherman gave no information on this latter point.

we suspect is probably more apparent than real. During the time of the second tagging experiment, similar tagging was being done all along the coast from California to Alaska and fisheries organizations everywhere were on the lookout for tags so that the chances of return of a California tag from Oregon and Washington waters were very good indeed. This was not the case in the period from 1939 to 1942.

The tagging evidence shows a very little northward movement of king salmon from the Central California area. On the other hand, it does show a great deal of southward movement to that area. This proposes a question: How do fish get into the northern area if such a movement cannot be demonstrated by tag returns? The most logical answer is that the salmon must have made their northward migration at a time they were smaller than taken by our taggers.

In addition to the overwhelming stay-at-home tendencies shown among king salmon off the California coast, we do have records of a few spectacular wanderers. For example, one fish tagged off San Francisco made the trip to Vancouver Island in 31 days. Another, tagged off San Francisco, was recovered in the Columbia River 22 days later. The tagging maps, Figures 4 to 8 (shown on pages 22, 23 and 25), show in some detail the area of tagging and the area of individual returns of king salmon. Tables 3 and 4 (shown on page 26), summarize the same information.

Return of Tags by Commercial and Sportfishermen

When the 1939 to 1942 tagging experiment was conducted, no effort was made to classify the returns as to whether they were taken by a sportfisherman or by a commercial fisherman. When tagging was resumed in 1948, a separation was made. Most of the recoveries were by fishermen who were easy to identify. Sportfishing boat operators were classified as sportsmen because they were a part of the sport fleet. Some men cutomarily operated their boats as sportfishing boats on weekends and holidays and fished commercially in midweek. These were classified as sportsmen if the fish were taken on a holiday or weekend or during the commercial closed season; otherwise they were called commercial. Of the ocean recoveries, 3 out of the 33 taken north of Point Arena were recovered by sportsmen. Two of these fish were taken in the sportfishery at the entrance to Humboldt Bay, and one at Trinidad. South of Point Arena, the percentage of tags taken by sportfishermen is very much higher. Out of 74 tags from the southern area which could be assigned to one fishery or the other, 30 percent of the total (22 fish) were taken by sportsmen. Two other fish were taken; one by a tagging crew, the other by a man who could not be identified. In the Sacramento-San Joaquin delta, the river gill net fishery accounted for the overwhelming majority of the tags taken. Of the 61 tags returned from this area, 51 were taken by gill netters, one by sportsmen, two by taggers working for the Division of Fish and Game, and one could not be classified. In the upper Sacramento and in the tributaries of the Sacramento and the San Joaquin, there is no commercial fishery. Of the 42 tags returned from this area, 21 were recovered by the biological staffs of the Division of Fish and Game and the U. S. Fish and Wildlife Service and by the Coleman Hatchery crew, and 21 were caught by anglers or picked up by passers-by on the spawning areas.

There were 15 tags recovered in other California streams. Twelve of these were taken by sportsmen or passers-by, one by an Indian, and two by Division of Fish and Game employees. There is no commercial river fishing in California except in the Sacramento-San Joaquin delta, but the sportsfishery is very intense in many streams, of which the Klamath, Eel, Smith, and Mad are outstanding examples.

The relative shortage of recoveries taken in 1950 in the tributaries of the Sacramento-San Joaquin system is due primarily to the extreme floods which occurred in this area in November of 1950. For example, in the American River the normal November flow is on the order of one thousand cubic feet per second. During November of 1950, the flow in this stream reached its all-time record of about two hundred thousand cubic feet per second. Obviously it was unlikely that anyone would catch or find fish under such conditions. Floods in the tributary streams north of the Feather River were not particularly severe and tags were recovered in this area. In the main Sacramento, the water was too high for the survey crews to find any spawned out fish, but anglers and the Coleman Hatchery fish trapping crew did recover tags.

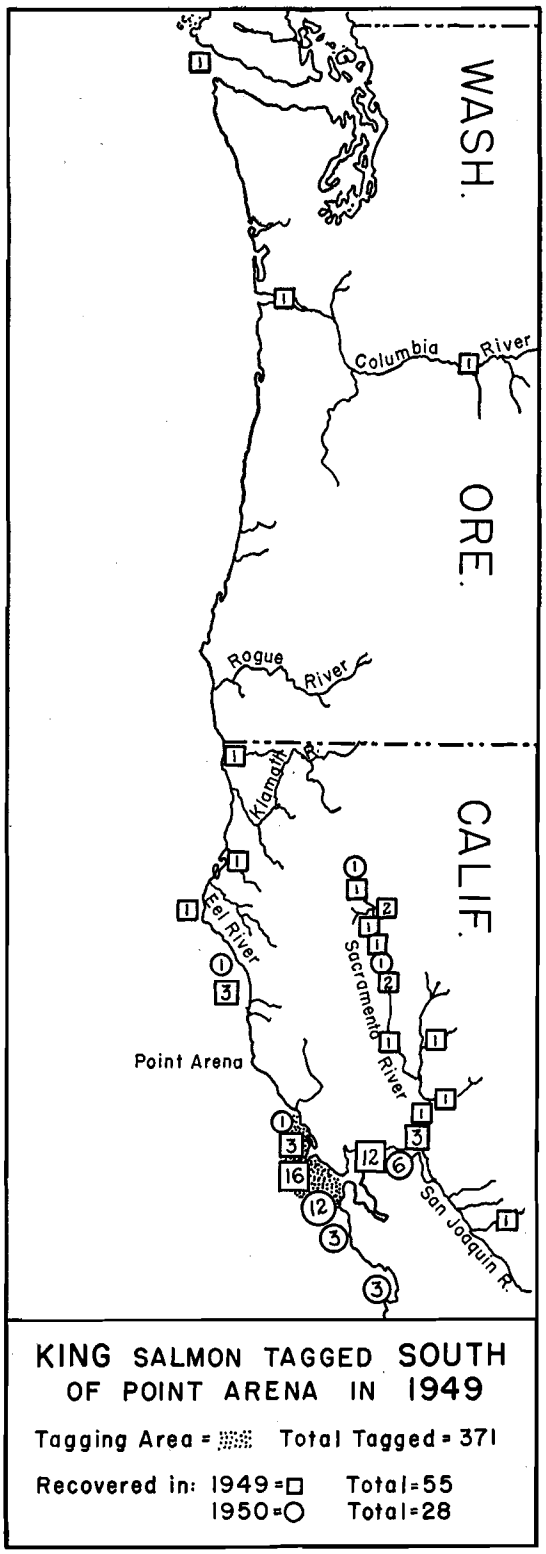

FIGURE 7. Movements of king salmon tagged south of Point Arena in 1949. Map shows area of tagging and points of recovery. Recoveries are classified by year of recovery.

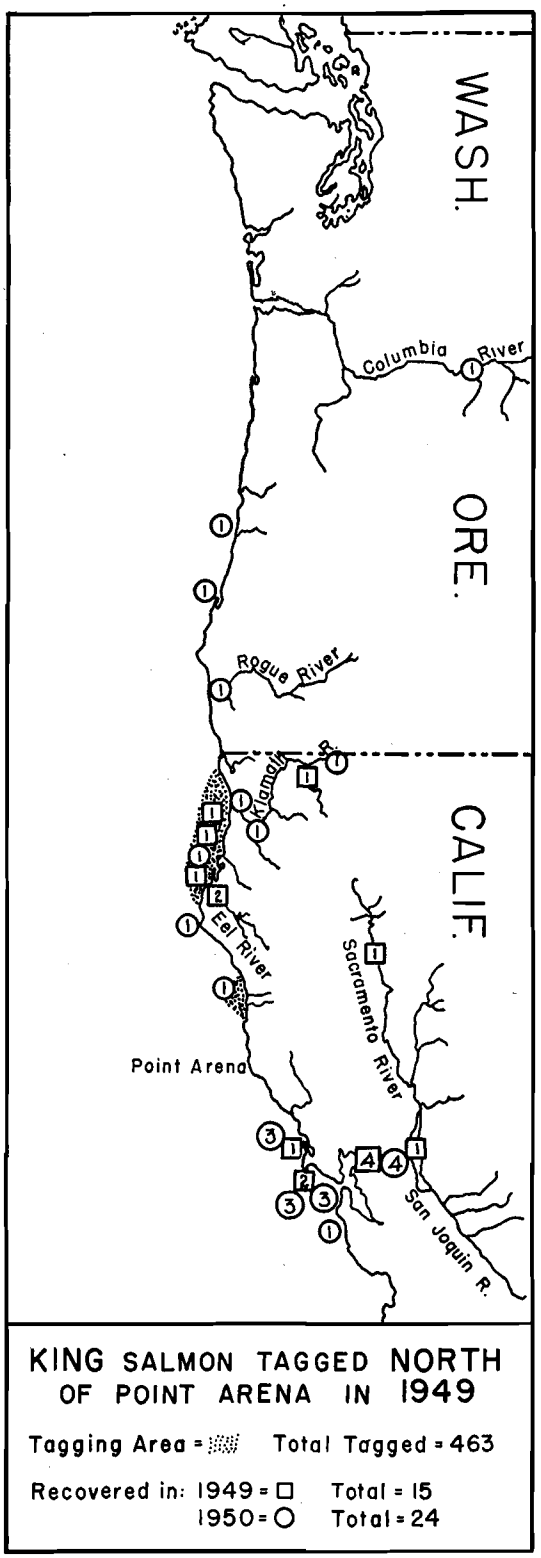

FIGURE 8. Movements of king salmon tagged north of Point Arena in 1949. Map shows area of tagging and points of recovery. Recoveries are classified by year of recovery.

TABLE 3. RECOVERIES OF KING SALMON TAGGED OFF CALIFORNIA COAST SOUTH OF POINT ARENA, 1939–1949

Year of Tagging	1939	1940	1941	1942	Total 1939–42	1948	1949	Total 1948–49
Number Tagged	550	548	1027	514	2639	2	371	373
Number Recoverd in Ocean:								
California south of Point Arena	4	4	5	12	25		38	38
California north of Point Arena		1	1		2		5	5
Oregon					.....			.....
Off mouth of Columbia River					.....			.....
Washington					.....			.....
North of Cape Flattery			2		2		1	1
Total Ocean Recoveries	4	5	8	12	29	.....	44	44
Number Recovered in Rivers:								
Sacramento-San Joaquin system	5	3	25	32	65		35	35
Eel River system				2	2			.....
Mad River				1	1		1	1
Klamath River system				4	4			.....
Smith River					.....		1	1
Other California streams					.....			.....
Rogue River system					.....			.....
Other Oregon coastal streams					.....			.....
Columbia River system					.....		2	2
Washington streams					.....			.....
Total River Recoveries	5	3	25	39	72	.....	39	39
TOTAL NUMBER RECOVERED	9	8	33	51	101	.....	83	83

TABLE 4. RECOVERIES OF KING SALMON TAGGED OFF CALIFORNIA COAST NORTH OF POINT ARENA, 1939–1949

Year of Tagging	1939	1940	1941	1942	Total 1939–42	1948	1949	Total 1948–49
Number Tagged	144	396	321	1147	2008	661	463	1124
Number Recovered in Ocean:								
California south of Point Arena		1	2	12	15	23	13	36
California north of Point Arena	1	3	5	14	23	22	6	28
Oregon		1			1	10	2	12
Off mouth of Columbia River					.....	2		2
Washington				2	2	2		2
North of Cape Flattery					.....	.....		.....
Total Ocean Recoveries	1	5	7	28	41	59	21	80
Number Recovered in Rivers:								
Sacramento-San Joaquin system			4	51	55	58	10	68
Eel River system	2	1	7	14	24	1	2	3
Mad River			3		3	1		1
Klamath River system		1	1	3	5	4	4	8
Smith River			1	2	3	1		1
Other California streams					.....	.....		.....
Rogue River system				2	2	2	1	3
Other Oregon coastal streams					.....	1		1
Columbia River system					.....	1	1	2
Washington streams					.....	.....		.....
Total River Recoveries	2	2	16	72	92	69	18	87
TOTAL NUMBER RECOVERED	3	7	23	100	133	128	39	167

Table 5 shows the numbers and percentages of tagged salmon recovered during the season of tagging, one season after, and two seasons after.

TABLE 5. CALIFORNIA SALMON. SUMMARY OF TAG RECOVERIES BY SEASON OF TAGGING

KING SALMON TAGGED NORTH OF POINT ARENA

Year Tagged	Number Tagged	Recoveries			Total Recovered
		During Season of Tagging	One Season After Tagging	Two Seasons After Tagging	
1939–42*	2,008	108 (5.4%)	24 (1.2%)	0 (0%)	132 (6.6%)
1948	661	39 (5.9%)	54 (8.2%)	35 (5.3%)	128 (19.4%)
1949	463	15 (3.2%)	24 (5.2%)		39 (8.4%)

* One additional tag was reported as recovered during the fourth season after tagging.

KING SALMON TAGGED SOUTH OF POINT ARENA

Year Tagged	Number Tagged	Recoveries			Total Recovered
		During Season of Tagging	One Season After Tagging	Two Seasons After Tagging	
1939–42	2,639	84 (3.2%)	15 (.6%)	2 (.1%)	101 (3.8%)
1948	2	0 (0%)	0 (0%)	0 (0%)	0 (0%)
1949	371	55 (14.8%)	28 (7.6%)		83 (22.4%)

SILVER SALMON

Year Tagged	Number Tagged	Recoveries			Total Recovered
		During Season of Tagging	One Season After Tagging	Two Seasons After Tagging	
1939–42	743*	12 (1.6%)	0 (0%)	0 (0%)	12 (1.6%)
1948	143	14 (9.8%)	0 (0%)	0 (0%)	14 (9.8%)
1949	68†	0 (0%)	0 (0%)		0 (0%)

* Twenty-two of these were tagged south of Point Arena; none of the twenty-two were recovered.

† One of these was tagged south of Point Arena.

Note the returns from the 1939–1942 tagging. North of Point Arena, these drop from 108 to 24 to 0 in the three successive seasons. (One was reported as recovered, the fourth season after tagging.) South of Point Arena, there is an almost equally rapid drop from 84 to 15 to 2. This high rate of decline cannot be satisfactorily explained without assuming a serious loss of tags. Such a loss could have been caused by the tagging pins coming untwisted, or by their failure due to corrosion. As previously mentioned, the twist used on the pins in the 1939–42 tagging was found to be unsatisfactory and was changed. The pins used in the early tagging were essentially the same analysis of commercially pure nickel as was used in 1948 and 1949. We found serious evidence of corrosion in the pins used in 1948 and 1949. It seems probable that the earlier batch of pins was no better or worse than the later ones, but we cannot be certain. Differences that a routine chemical analysis would not detect could possibly make a serious difference in susceptibility to corrosion.

The startling low rate of decline shown by the 1948 and 1949 tags could be explained by an increasing fishing mortality which would take a larger than normal number of the fish of these groups still alive one and two seasons after tagging. The 14.8 percent recovery in the season of tagging in 1949 in the area south of Point Arena was the highest return up to that time.

It does not follow that the increase in fishing mortality is exactly proportional to the increase in tag returns. There are factors unconnected with fishing mortality which would have some effect on the tag returns. These include: (1) Changes in the percent of tags recovered but not sent in by the finder. Every indication is that such losses were low in 1948 but have been getting even lower since then; (2) Loss of tags from the fish; (3) Upper river recoveries of spawned out fish in the Sacramento-San Joaquin were reduced by exceptional floods in the fall of 1950.

Silver Salmon Tag Returns

The numbers of silver salmon tagged have been far fewer than the kings. There were 743 tagged in the 1939–42 experiment. Of these, 721 were tagged north of Point Arena. South of Point Arena, silver salmon are not abundant in the commercial troll catch. In the later tagging experiment, there were 211 silver salmon tagged of which only one was tagged south of Point Arena. The returns from the 1939–42 tagging are shown in Figure 9 and from the 1948 tagging in Figure 10. No maps were made for the 1949 tagging because although 68 silvers were tagged in 1949, there were no recoveries of these fish. Numbers tagged and recovered in each year from 1939 to 1949 are given in Table 6.

The silver salmon tagged in California waters show behavior which is entirely unlike that of the kings. The most conspicuous feature of the silver salmon maps is the number of recoveries off the Oregon coast and in the Oregon streams. These numbers are not large but they are made conspicuous by the great lack of recoveries in either the California ocean or the California streams. This is quite a puzzling phenomenon in view of the fact that there are so many small silver salmon-producing streams in California. Some of these have large numbers of silvers in them and there are times when the sportsmen get good catches of silvers in some streams. However, it can certainly be said that the results of the tagging show that the taggers were catching Oregon silvers to a much larger extent than they were California fish. Just what is happening to the California reared silvers is something that has not yet been answered.

TABLE 6. RECOVERIES OF SILVER SALMON TAGGED OFF CALIFORNIA COAST, 1939–1949

Year of Tagging	1939	1940	1941	1942	Total 1939–42	1948	1949	Total 1948–49
Number Tagged:								
North of Point Arena	211	303	111	96	721	143	67	210
South of Point Arena	.....	7	8	7	22	.....	1	1
TOTAL NUMBER TAGGED	211	310	119	103	743	143	68	211
Number Recovered in Ocean:								
California south of Point Arena					.....			.....
California north of Point Arena		1	2		3			.....
Oregon	1				1	3		3
Off mouth of Columbia River					.....	1		1
Washington					.....			.....
North of Cape Flattery					.....			.....
Total Ocean Recoveries	1	1	2	.....	4	4	.....	4
Number Recovered in Rivers:								
Sacramento-San Joaquin system					.....			.....
Eel River system			1		1			.....
Mad River					.....			.....
Klamath River system					.....			.....
Smith River					.....			.....
Other California streams				2	2	2		2
Rogue River system					.....	1		1
Other Oregon coastal streams			3	2	5	7		7
Columbia River system					.....			.....
Washington streams					.....			.....
Total River Recoveries	.....	.....	4	4	8	10	.....	10
TOTAL NUMBER RECOVERED	1	1	6	4	12	14	.....	14

A summary of the silver salmon returns by seasons is shown in Table 5. Silver salmon are in the fishery only during the last few months of their lives; hence, we would not expect any recoveries after the season of tagging. The low returns in 1949 may be partly explained by the following section.

Mortality of Salmon Due to Holding in a Tank

In 1949 California Fish and Game employees performed experiments on the effects of barbed and barbless hooks on salmon. The results of this work will not be described here except to mention

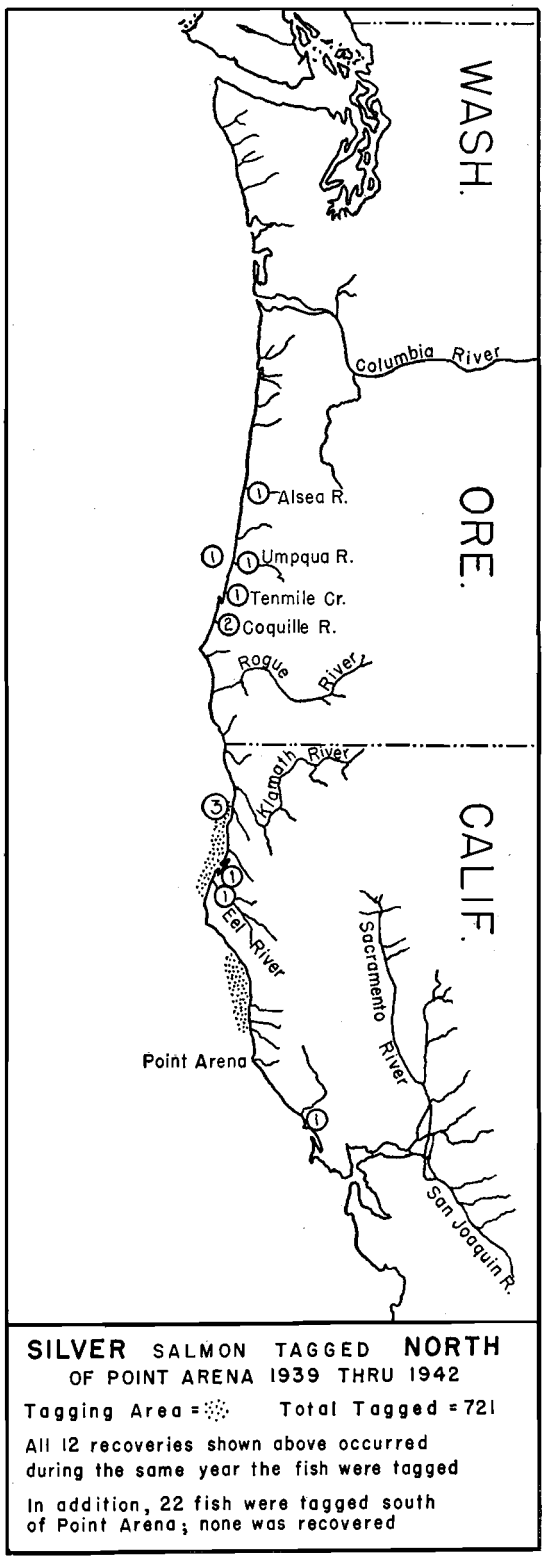

FIGURE 9. Movements of silver salmon tagged off California in 1939 through 1942. Map shows area of tagging and points of recovery.

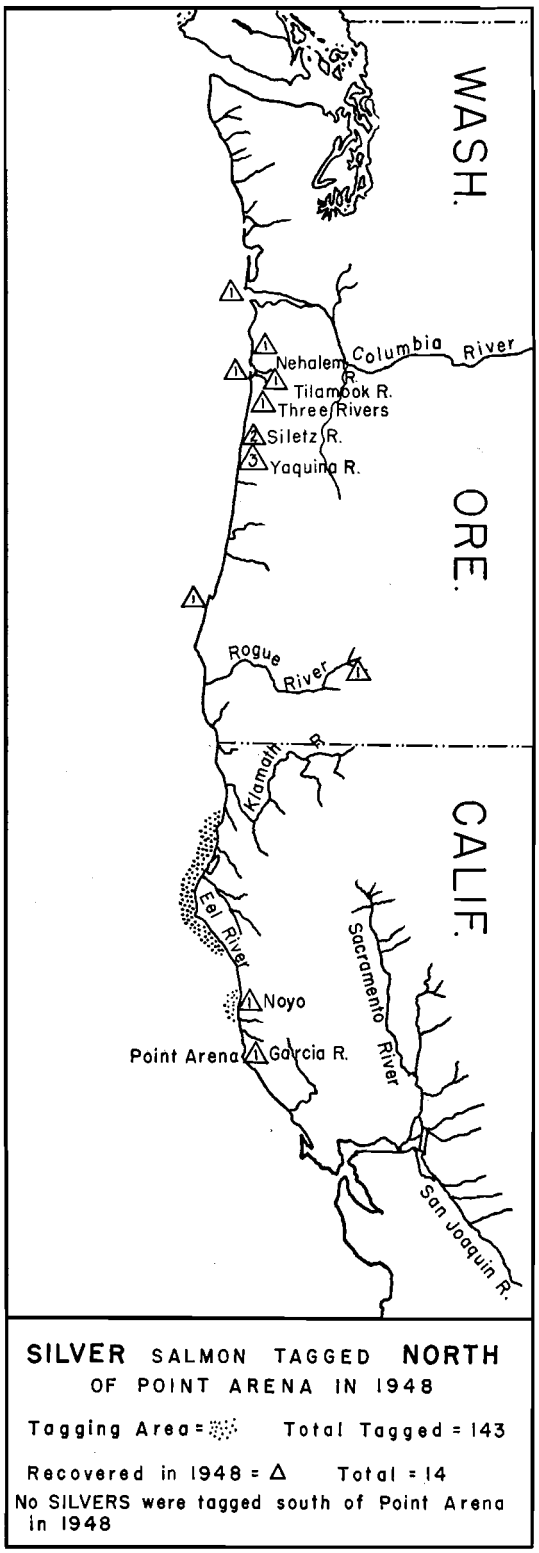

FIGURE 10. Movements of silver salmon tagged off California in 1948. Map shows area of tagging and points of recovery.

an unintended effect on the tag returns. After being unhooked, the salmon were held until the following morning in tanks on board the Division's research boat, "N. B. Scofield". Pumps kept a constant stream of fresh ocean water passing through these tanks. At the end of 24 hours, observations on hook injuries were concluded and the fish that were in good condition were tagged and released. At the time, this period of holding did not appear to have injured the fish in the slightest, but it may have reduced their chance of survival. Unfortunately, a large proportion of the silver salmon tagged in California in 1949 were held in tanks. The entire experiment was conducted north of Point Arena. (See Table 7.) The difference between the rate of returns of the tank held kings and the controls is highly significant statistically. ($P = 0.01$ by the chi-square test.)

TABLE 7. EFFECT OF HOLDING SALMON OVERNIGHT BEFORE TAGGING, 1949

	FISH HELD BEFORE TAGGING			CONTROLS—TAGGED WHEN CAUGHT		
	Number Tagged	Number Recovered	Per Cent Recovered	Number Tagged	Number Recovered	Per Cent Recovered
King Salmon	123	2	1.63	179	18	10.06
Silver Salmon	39	0	.00	19	0	.00

Relationship of Apparent Condition of Fish to Rate of Tag Recovery

As part of the tagging routine, the tagger quickly inspects each fish and if it has no serious injury and seems to have a reasonable chance of survival, it is tagged and its condition is recorded as good, fair, or poor. A comparison has been made of the rate of return of fish in the three categories. Lumping the data of all taggers gave the following results:

King salmon—"Good" condition: 707 tagged—124 recovered—17.5% recovered.
King salmon—"Fair" condition: 102 tagged— 14 recovered—13.7% recovered.
King salmon—"Poor" condition: 22 tagged— 0 recovered— 0% recovered.

The differences between the groups vary markedly with individual taggers. Some show a marked difference in recovery rate between the three classifications listed above; others show no difference. The data include fish tagged in 1948 and 1949. Fish held overnight before tagging are not included.

The data on silver salmon were more limited and show no definite trend in the recoveries from the three groups.

Comparison of Tag Returns from Large and Small Fish

Is a small salmon or a large one more apt to survive the tagging operation? In an attempt to answer this question, a sample of fish which had been tagged for at least three seasons was needed; hence, the returns from our 1948 tagging were used. Figure 11 shows the length frequencies of all fish tagged in our 1948 experiment. These length frequencies are reduced to a percent of the total. Shown on the same graph and also reduced to a percent are the length frequencies (at time of tagging) of the returns from these fish for all three seasons combined. If the returns represented a perfect sample of the fish tagged, the two curves should be identical. However, if by some chance, the small fish were subject to excessive mortality at the time of tagging, the curve of the returns would be noticeably below the curve of the tagged fish in the part representing the smaller individuals. Actually, the two curves are so similar as to show no excessive mortality for either the larger or the smaller fish. Figure 12 shows the curve of the returns broken down into fish recovered the same season they were tagged, those recovered the season following tagging, and fish recovered two seasons after tagging. As would be expected, there were relatively few of the smallest fish recovered in the season of tagging. The size limit in effect on troll caught fish undoubtedly influenced this to a large degree since the trollers definitely try to avoid undersized fish and rapidly unhook those that they do catch. Figure 12 indicates that on the average, it is the largest fish that are recovered during the year of tagging, somewhat smaller ones the next season, and still smaller the following year. When it is considered that the smallest fish were not taken until two years after tagging, it is puzzling that Figures 11 and 12 do not show a shortage of returns of such sizes; instead there would be every reason to suspect that natural mortality would have caused a noticeable decrease

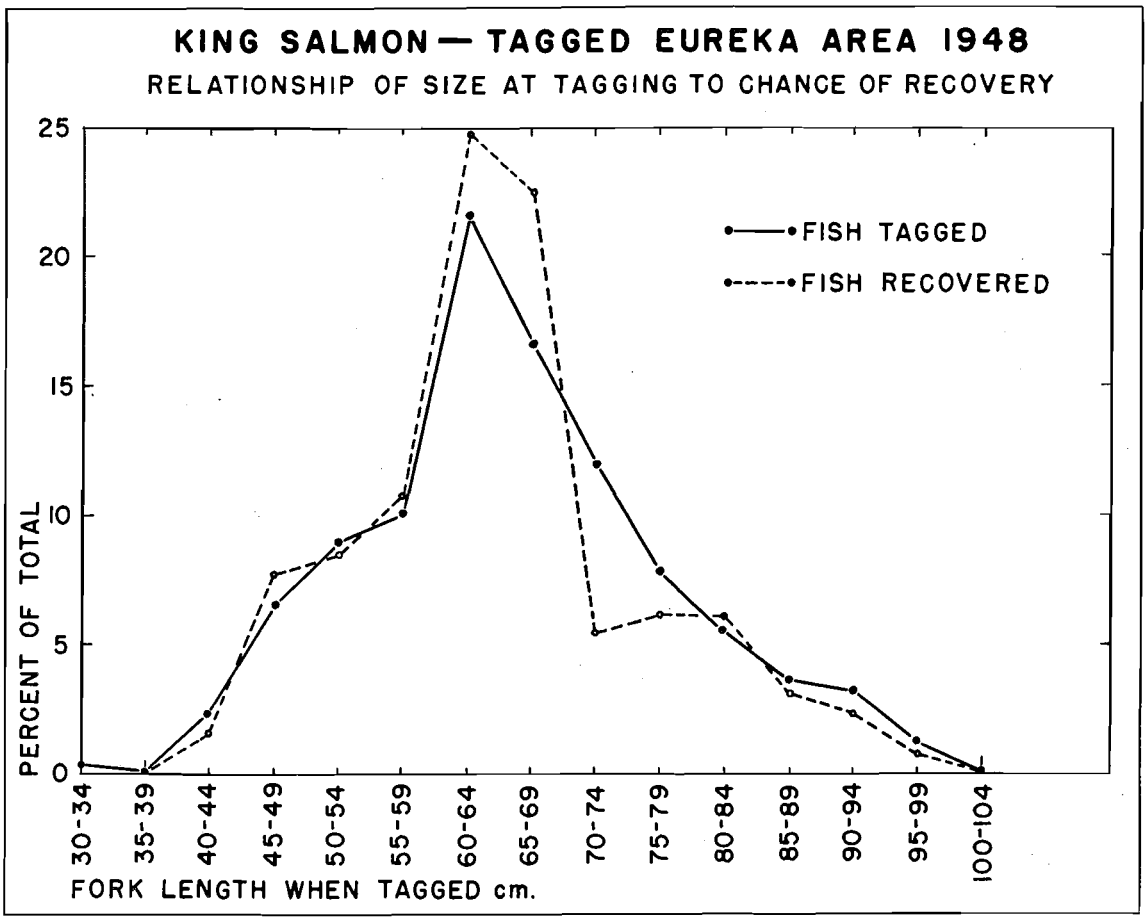

FIGURE 11. Comparing the number of tag returns to size of fish when tagged. These were king salmon tagged off Eureka in 1948. Recoveries during 1948, 1949, and 1950 are included.

in the numbers eventually recovered. Similarly, any continuous, gradual shedding of tags would have had somewhat the same effect on the return. From this, one might wonder if there is a greater mortality among the *larger* fish tagged or if there was an increase in the fishing mortality in 1949 and again in 1950. Such an increase in fishing intensity would result in the capture of a disproportionately large number of the fish remaining in the ocean during those years. Table 5 indicates that there was just such an increase in 1949 in the area south of Point Arena which is where most of these recoveries were taken.

A similar comparison of size of tagged fish with size (at time of tagging) of those recovered was made with the silver salmon records for 1948. Only 14 recoveries were involved. There is no indication that any size class was subject to exceptional mortality, but such a small number of recoveries proves nothing. Since silver salmon are in the fishery only during the last few months of their lives, there is no problem of second and third season recoveries.

SAMPLING OF COMMERCIAL CATCH

The commercial salmon landings were sampled at Eureka during the last part of the 1948 season and through July of 1949. At that time, a change in personnel made it necessary to temporarily abandon the salmon sampling. This was resumed in 1950; and whereas the 1948 and 1949 sampling was confined to the Eureka and Crescent City area, in 1950 samples were taken at various ports from Crescent City to Santa Cruz. It was not possible to obtain a complete series of samples over this entire range. The most complete sampling in 1950 was done in the San Francisco area. The ports actually sampled included Crescent City, Eureka, Fort Bragg, Point Reyes, Princeton and Santa Cruz.

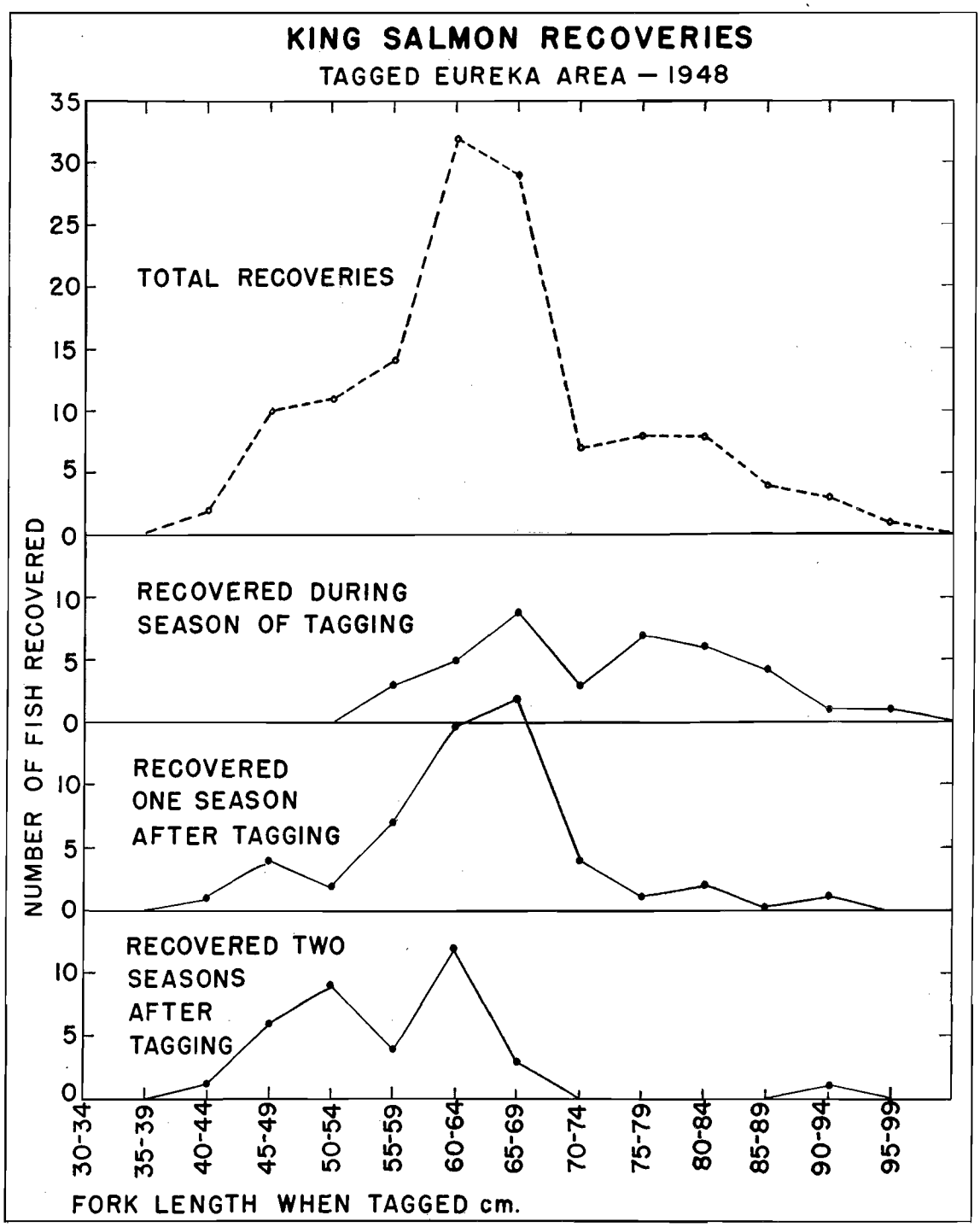

FIGURE 12. Recoveries of king salmon tagged off Eureka in 1948 showing the size of tagged fish and its relation to elapsed time before recovery. Note that large, tagged fish were recovered during the season of tagging (1948) followed by successively smaller fish during the next two seasons.

The primary purpose of the sampling program as it is now being developed is to observe as many salmon as possible for fin marks in connection with the marking program of the Pacific Marine Fisheries Commission. In addition to this part of the work, the samplers get as much data as possible on the average weight of the fish, area of catch, length frequencies, etc.

As a general rule, one man could do all this work at a given fish house unless random lengths or weight-length data were to be taken. In an effort to keep the length frequencies as nearly random

as possible, it was decided to measure every fish received by a given dealer for one day. Obviously this required very rapid measuring of the fish and in most instances, two men were required to do the job. Occasionally a third man would help out by getting information from the fisherman and weighmaster while the other two samplers worked on the catch.

The measuring board developed for this work is capable of very rapid operation. A strip of opaque plastic (cellulose acetate) semi-rough on both sides is fastened to the top of the measuring board. This plastic is four inches wide, 70 centimeters long, and when in position, extends from a line 50 centimeters from the headboard to 120 centimeters. These plastic strips can be quickly replaced in exactly the same spot each time. Each strip is divided by three longitudinal lines into four columns, each one inch by 70 centimeters. The plastic takes a pencil mark regardless of whether it is dry, wet, or covered with fish slime.

The method of operation is as follows: one man picks up a fish and slides it onto the measuring board. The second man places the nose of the fish against the headpiece of the measuring board and the tail over the plastic strip, makes a pencil mark to indicate the position of the fork of the tail, and slides the fish on to the butchers. A different mark is used for silver and king salmon. Usually the entire catch of one boat can be recorded in one column of the plastic strip, thus making it possible to get four boats on one side of the strip. Occasionally a catch is so large or the fish so concentrated around a certain length that it is necessary to use more than one column. Samples are identified by a serial number. Two men working in this manner are able to keep ahead of two or even three fish butchers, and actually reduce the work of these men by sliding the fish to them in a position for cutting. Consequently, the samplers do not hinder operations and they are usually welcome in the fish plants.

Weight-length data was taken by use of this measuring board and a permanently mounted strip of plastic, one inch wide and marked into two centimeters length intervals. After a fish had been placed on the measuring board and its length marked on the wide strip of plastic, its length would then be marked on the narrow strip, and given a serial number. A corresponding serial number on a plastic label would be slipped under the pre-opercle of the fish which would then be set aside. When there was a little slack time, the selected fish were weighed, scale samples taken, and the fish passed on to the butchers table where the sex was determined, after which the fish would be re-weighed to determine cleaning loss. Sometimes when the fish were being landed dressed, it was possible for the samplers to obtain weight-length data without setting the fish aside. Weights were recorded on the scale sample envelope.

The time-consuming process of converting these marks on plastic to recorded measurements is done later with the aid of a transparent plastic template accurately inscribed at half centimeter intervals. This template is placed over the strip of marked plastic and the number of pencil marks between each two lines on the template are tallied off. The template is so placed that the mark for a fish which measured, for example, exactly 70 centimeters would fall at the midpoint of the space similarly labeled on the template.

Reason for Use of Fork Length in These Studies

It would be desirable to use the same method of measurement for the scientific studies and for the legal requirements of the size limit on troll caught fish. However, it does not seem practical to do so. Fork length is the most accurate length that can be readily and rapidly taken by anyone who is measuring a large number of fish for scientific purposes. To determine if a salmon is of legal length, California law specifies total length and does not prohibit bending the tail down to obtain the greatest possible measurement. However, for scientific purposes, this measurement is not desirable because the tip of the tail is often worn or damaged and because it is difficult to always get exactly the same degree of bend on each fish that is being measured. The ratio between caudal fork length and total length with the tail folded down is given below and on the next page.

King Salmon (1,407 measured) Caudal fork length, cm.	61.3	68.3	77.2	87.5	100.2
$\frac{\text{Total length}}{\text{Caudal fork length}}$	1.090	1.089	1.083	1.079	1.075

Silver Salmon (235 measured) Caudal fork length	62.7	68.5
$\frac{\text{Total length}}{\text{Caudal fork length}}$	1.070	1.067

The data were grouped and the mean length of each group is given above with the corresponding total length/caudal fork length ratio.

The above data were collected by one observer. Other observers could get different results by bending the tail differently.

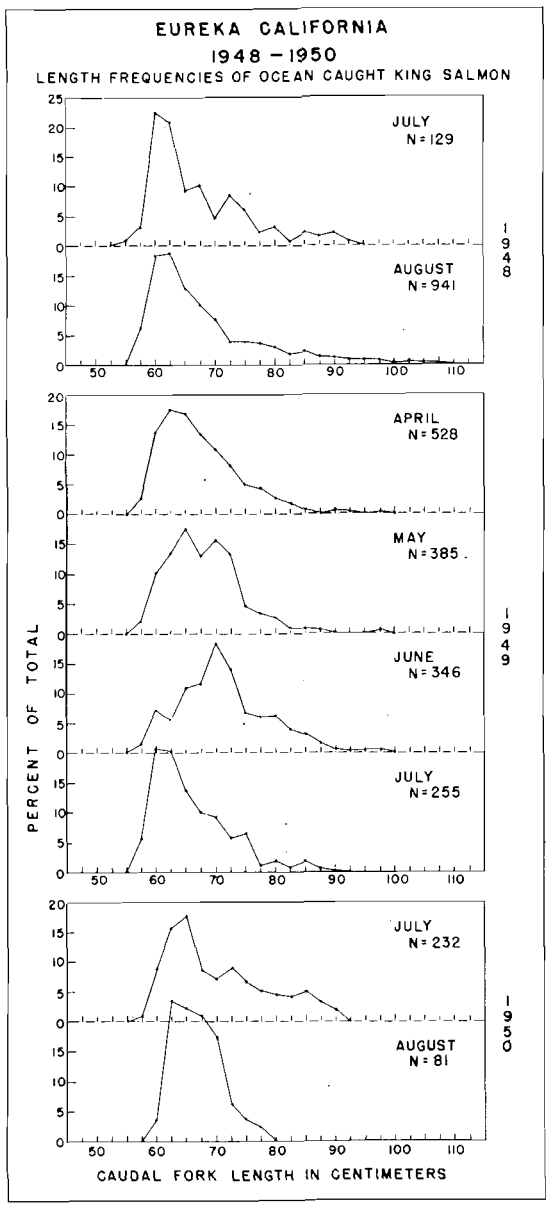

FIGURE 13. Length frequency distributions of ocean-caught king salmon landed and measured at Eureka, California during 1948, 1949, and 1950. Legal size limit in 1948 and 1949 was 25 inches total length (approximately 58.3 cm. caudal fork length). In 1950 it was increased to 26 inches total length (approximately 60.6 cm. fork length). Depth of fork in individual fish varies considerably; hence, an apparently illegal fish based on fork length may be actually legal when measured to total length.

From this data, king salmon of 26 inches total length will have an average caudal fork length of 60.6 cm. or 23.9 inches. Twenty-five inch kings should average 58.3 cm. or 22.9 inches fork length. A sub sample of 127 kings with total lengths between 60.0 and 69.9 cm. showed a mean total length to fork length ratio of 1.090 and a standard deviation of .009. The range was from 1.066 to 1.115. On the basis of this deviation, approximately 95 percent of twenty-six inch (total length) king salmon should have fork lengths between 59.6 and 61.6 cm. (23.5 and 24.3 inches).

The above data on silver salmon indicates that twenty-five inch (total length) silvers will have an average caudal fork length of 59.3 cm. or 23.4 inches.

King Salmon Length Frequencies

Figure 13 gives the length frequency of king salmon measured at Eureka from 1948 through 1950. The most conspicuous thing about these measurements is the large number of small salmon. Note that only in June of 1949 is the principal mode for fish any larger than 65 centimeters. Sixty-five centimeter king salmon will average a little under seven pounds, dressed, head on. Throughout this entire period from July of 1948 through August of 1950, the size of the fish taken was greatly influenced by the legal size limit. During 1948 and 1949, the legal size limit for king salmon in California was 25 inches total length, and during 1950, it was 26 inches total length. These figures correspond roughly to a fork length of 60 centimeters and 61 centimeters, respectively. These do not correspond exactly to any given total length since individual fish vary in the depth of the fork, and some fish with fork lengths slightly less than those given would actually have a legal total length. Figure 14 shows the random lengths of king salmon taken in the San Francisco area from May through September of 1950. Note that these fish are much larger than those taken in the Eureka area. In no instance is the mode below 70 centimeters and in July and August, it is at 75

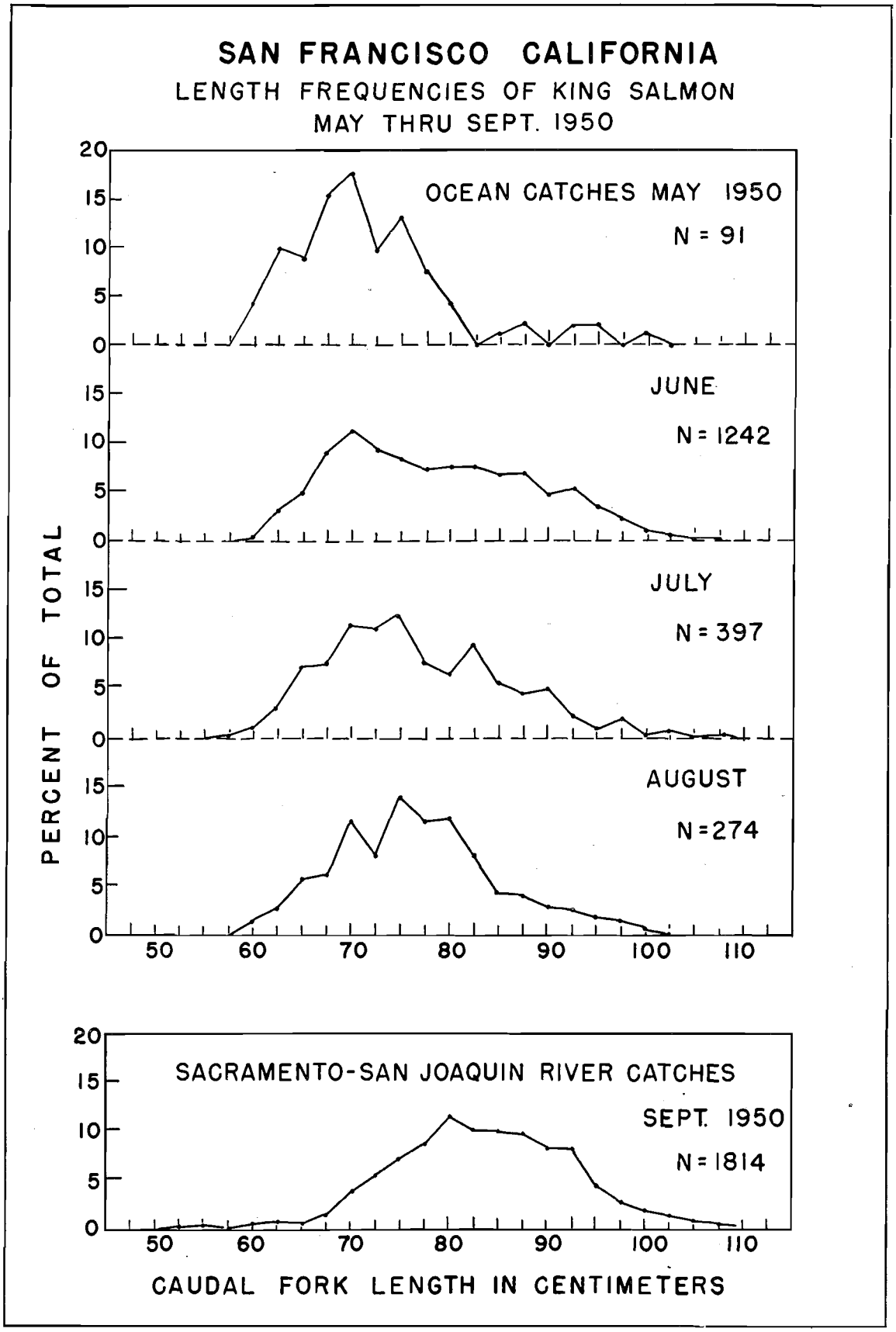

FIGURE 14. Length frequencies of king salmon landed in the San Francisco area, May through September, 1950. The September sample was taken from the Sacramento-San Joaquin River catch to show the size of fully mature fish. Note the increase in sizes from May through September.

centimeters. There are few fish which are just above the legal limit. By way of comparison, the Sacramento River landings for September of 1950 are shown. These gill net fish are all mature and are even larger than the troll salmon of the San Francisco area. However, the nets tend to let the smallest individuals escape and small fish are not quite as scarce in the river as this graph of the catch would indicate. The growth of the fish can be followed from May clear into the September river landings in Figure 14. The following figure shows the landings in July and again in August in Crescent City, Eureka, Fort Bragg, and the San Francisco area. (Figure 15.) Notice that in each of these two months, the fish in Crescent City, Eureka and Fort Bragg show a preponderance of small fish not much over the legal size limit. On the other hand, in the San Francisco area there is no such tendency either month.

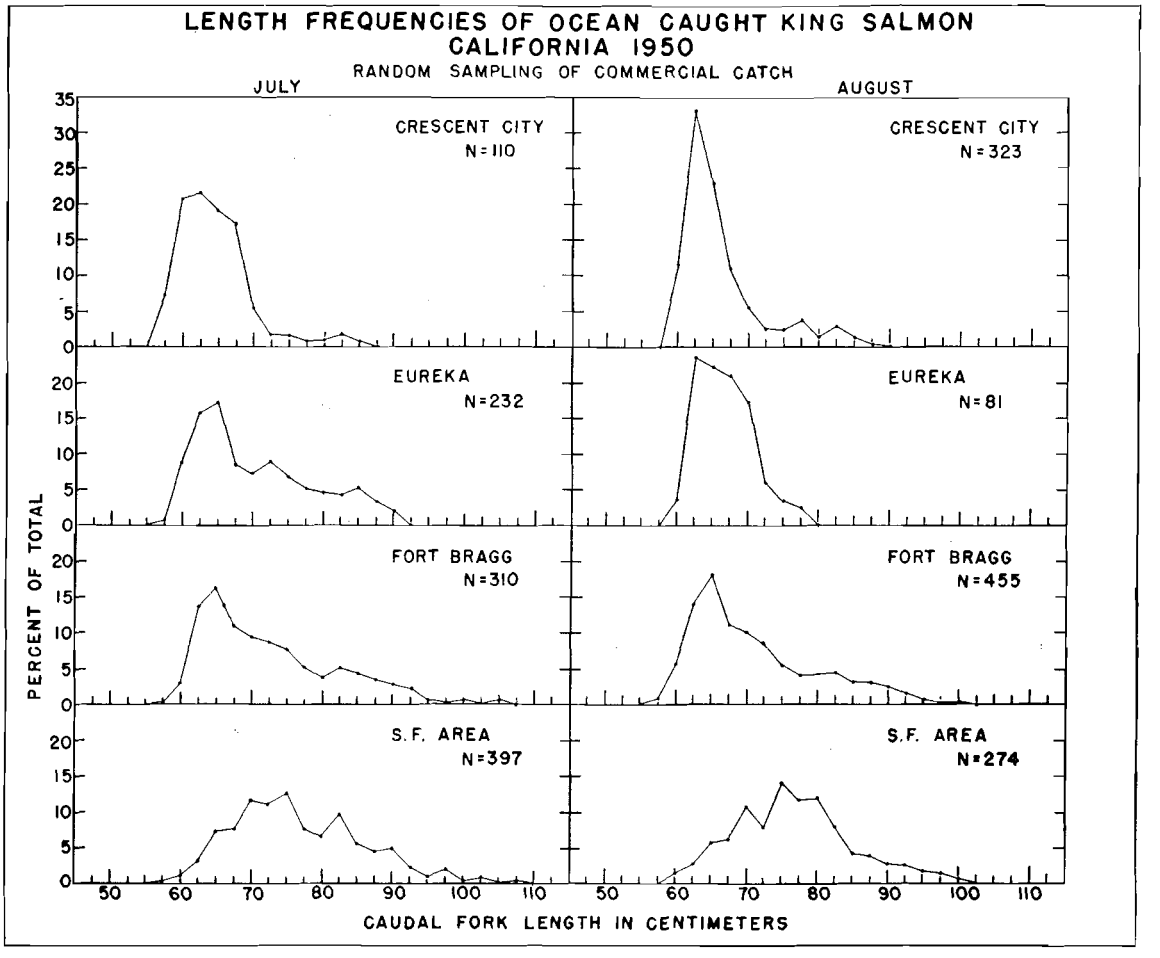

FIGURE 15. Length frequencies of California ocean-caught king salmon during July and August, 1950 shown by ports of general area of landing. Note the consistent increase of sizes from north to south.

It is quite obvious that any change in the size limit of king salmon will have an immediate, marked effect on the numbers of fish that will have to be thrown back by the trollers anywhere from Fort Bragg north, and it is equally obvious that there will be no such effect in the San Francisco area provided the sizes of fish in these two areas remain in the future about as they have been in the recent past.

King Salmon Average Weights

In 1948 and 1949 the average weights of salmon as landed were taken in the Eureka area. These figures are shown in Table 8. In 1950 data was obtained at Crescent City, Eureka, Fort Bragg, Point Reyes, Princeton, and Santa Cruz. This material is shown in Table 9. Because of the tendency

of the San Francisco fleet to shift its base of operations from Point Reyes to Princeton and back again, these two ports were combined. In Eureka and Crescent City, all the weights obtained were of fish which were dressed, head on, but at Fort Bragg, part of the fish were landed round, and at San Francisco only a few were landed dressed. No dressed fish were encountered at Santa Cruz.

TABLE 8. AVERAGE WEIGHTS OF OCEAN-CAUGHT SALMON

EUREKA, CALIFORNIA, 1948 AND 1949
Dressed, Head-on Weights in Pounds

Month	KING SALMON				Month	SILVER SALMON			
	1948		1949			1948		1949	
	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish		Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish
April			7.4	3787	April				
May			7.9	2147	May				
June			11.0	2028	June			6.4	89
July	6.9	495	8.6	2539	July	6.1	75	7.2	311
August	9.4	3939			August	7.4	369		
September	9.3	181			September	7.6	61		

TABLE 9. AVERAGE WEIGHTS OF OCEAN-CAUGHT KING SALMON IN POUNDS

CALIFORNIA, 1950

Month	DRESSED HEAD-ON WEIGHTS									
	Port									
	Crescent City		Eureka		Fort Bragg		San Francisco Area		Santa Cruz	
	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish
May							9.8	75		
June					10.6	37	14.1	46		
July	8.9	681	11.0	135	11.6	208	11.0	25		
August	7.8	919			10.6	99				
September										

Month	ROUND WEIGHTS									
	Port									
	Crescent City		Eureka		Fort Bragg		San Francisco Area		Santa Cruz	
	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish	Average Weight Pounds	Number of Fish
May							10.6	929		
June							15.8	581		
July					11.2	138	14.6	1186		
August					10.5	33	15.3	151	16.6	84
September							10.2	197		

King Salmon Weight-Length Relationship

Weight-length data on king salmon (dressed head on) was collected at Eureka in 1948 and 1949 and in Crescent City, Eureka and Fort Bragg in 1950.

The 1948 weight-length curve is shown in Figure 16. Its formula is Weight (lbs.) $= 41.82 \times$ Length (mm.)$^{3.28} \times 10^{-10}$. The 1949 curve fell below that of 1948. At 60 centimeters the difference was about three-tenths pound and at 95 centimeters the difference had increased to five-tenths pound.

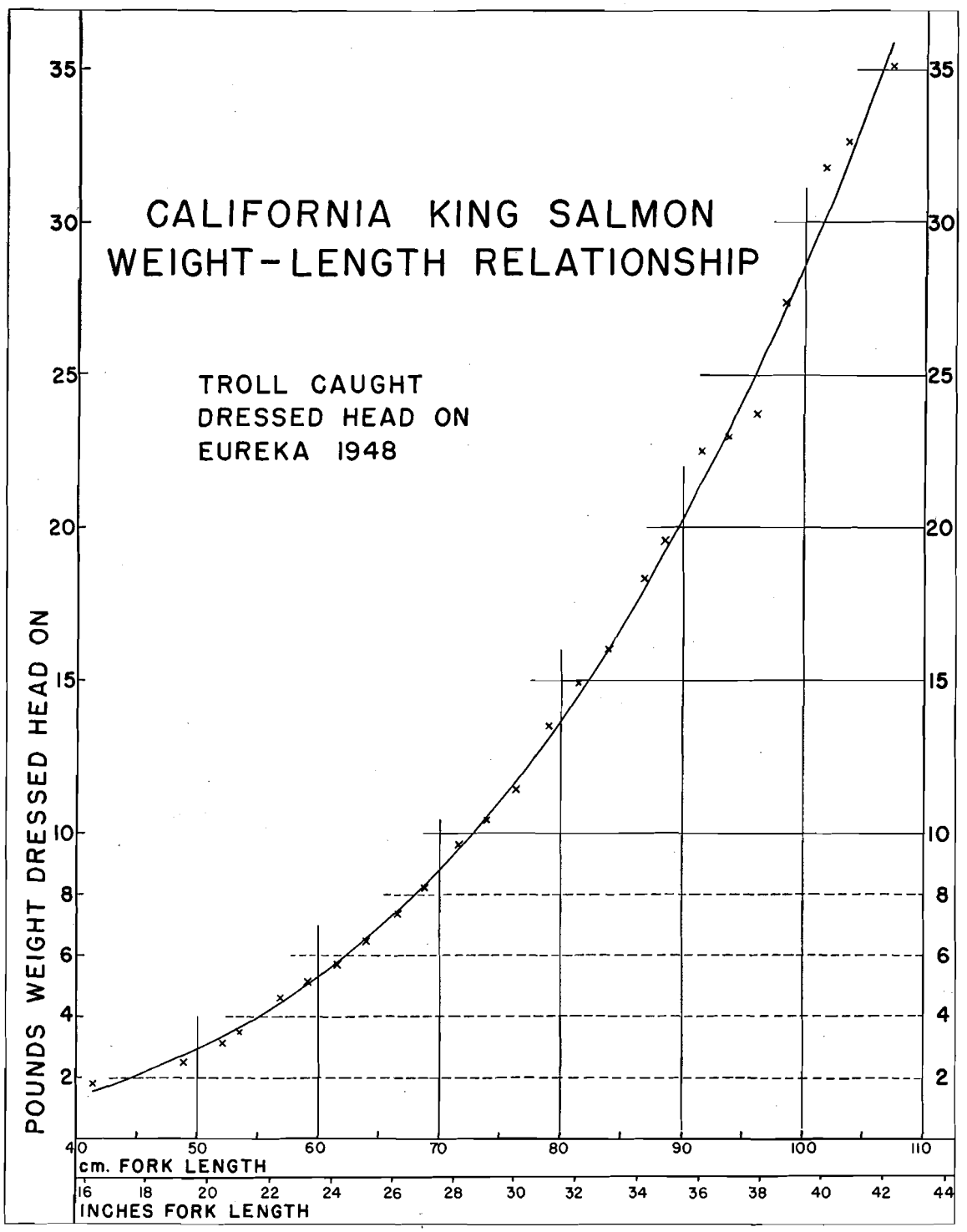

FIGURE 16. California king salmon weight-length relationship. Based on 534 kings weighed and measured at Eureka in 1948. These ocean-caught fish were landed dressed, head on.

In 1950 the data from Crescent City, Eureka and Fort Bragg were compared, and there being no consistent difference, they were combined. The smoothed data for 1950 fell about three-tenths pound above the 1948 curve over the range from 60 centimeters to 95 centimeters.

There were 534 fish used in the compilation of the 1948 curve, 661 for 1949, and 761 for 1950.

Silver Salmon Length Frequencies

Figure 17 shows the length frequencies of silver salmon in July and August in the Crescent City area and in the combined Eureka and Fort Bragg areas. The relatively few silvers examined

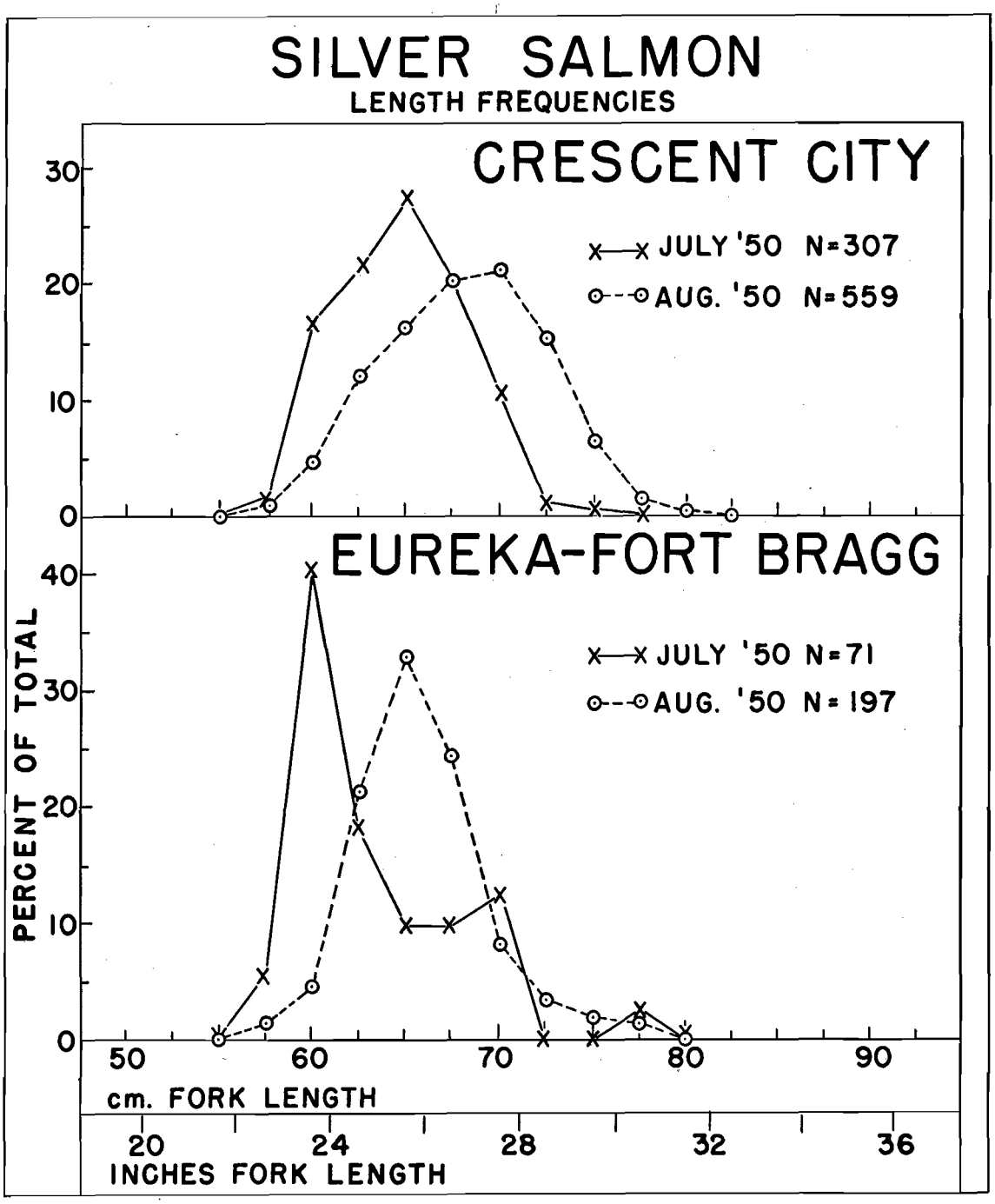

FIGURE 17. California silver salmon length frequency distributions for July and August, 1950. Fort Bragg and Eureka are combined because the data from the two ports were similar and because small numbers were involved. Note that at Crescent City, the fish are larger and in both areas they exhibit a growth of approximately 5 cm. from July to August.

from Fort Bragg and from Eureka made it seem desirable to combine the fish in these two areas, particularly as the sizes of the few fish that we did have from each of these two southern areas were so similar as to show no essential difference. Note that in both July and August, the Eureka and Fort Bragg fish have a mode which is 5 centimeters shorter than is shown by the Crescent City fish for the same month. Each group shows a 5 centimeter growth from July to August. The 25 inch size limit established for silver salmon in California seems to have had some effect on the fish taken in the Eureka-Fort Bragg area during July. The average fork length which most nearly corresponds to 25 inches is 59 centimeters, and the greatest number of silver salmon taken in the Eureka-Fort Bragg area in July measured 60 centimeters. The fish sampled which were shorter than 59 centimeters fork length were not necessarily illegal fish. Differences in the depth of the fork in individual instances could easily account for the fish below 59 centimeters.

The difference in size between the Crescent City fish and the Eureka-Fort Bragg fish is interesting. The possibility that there are two separate populations of silver salmon off the California coast should be examined by future sampling, and if possible, by tagging.

Silver Salmon Average Weights

The average weights of silver salmon at Eureka are shown for 1948 and 1949 in Table 8. The silver salmon season opened on April 1st both of these years. In 1948, we did not start our sampling until July, but in 1949, the sampler started work at the first of the season and examined over 6,000 troll caught salmon before encountering the first silvers on June 21st. It would appear that the 25 inch size limit in California has at least as much effect on protecting small silvers as the Oregon and Washington closed season which extends until June 14th.

In 1950 the samplers were not able to obtain average weights of adequate samples of fish any place except Crescent City. In that port, 961 fish weighed in July averaged 7.8 pounds and 1,286 fish weighed in August averaged 8.4 pounds. These weights are of salmon dressed, head on.

Silver Salmon Weight-Length Relationship

Weights and lengths of 494 silver salmon were obtained at Crescent City in July and August of 1950. The weight-length curve of these fish is shown in Figure 18. These fish were weighed dressed, head on.

SUMMARY

Salmon trolling in California started with sailboats in Monterey Bay in the 1880's. Large scale use of power started about 1908 and by 1916 the fishery had spread to most of the coast of California from Monterey, north.

At present, larger boats are entering the fleet and the use of ice is becoming more common. A typical modern salmon trolling boat uses four poles and six steel lines which are pulled by power gurdies. Sinkers up to 50 pounds in weight are used to keep the lines at the proper depth. Most of the California salmon trollers changed from hand pulling to power pulling between 1943 and 1945. The efficiency of the salmon fleet has been increased by the use of radio telephone, automatic pilots and other devices.

California troll caught salmon are landed at the following ports: Crescent City, Trinidad, Eureka, Fields Landing, Shelter Cove, Fort Bragg, Point Arena, Bodega Bay, Point Reyes, San Francisco, Princeton, Santa Cruz, Moss Landing and Monterey.

Ocean sportfishing for salmon has become a major industry in California, particularly in the vicinity of San Francisco.

Silver salmon enter many coastal streams from Monterey Bay, north. King salmon are found in the Sacramento-San Joaquin system and in some of the larger coastal streams north of San Francisco.

California salmon landings from 1916 through 1949 are shown in figures and tables. King salmon from the Sacramento and San Joaquin River systems dominate the ocean catches of California. Almost 90% of the California ocean caught salmon is kings, the remainder being silvers. Exact separations have not been made, but a large sample shows the proportion of each species in the different regions in the state.

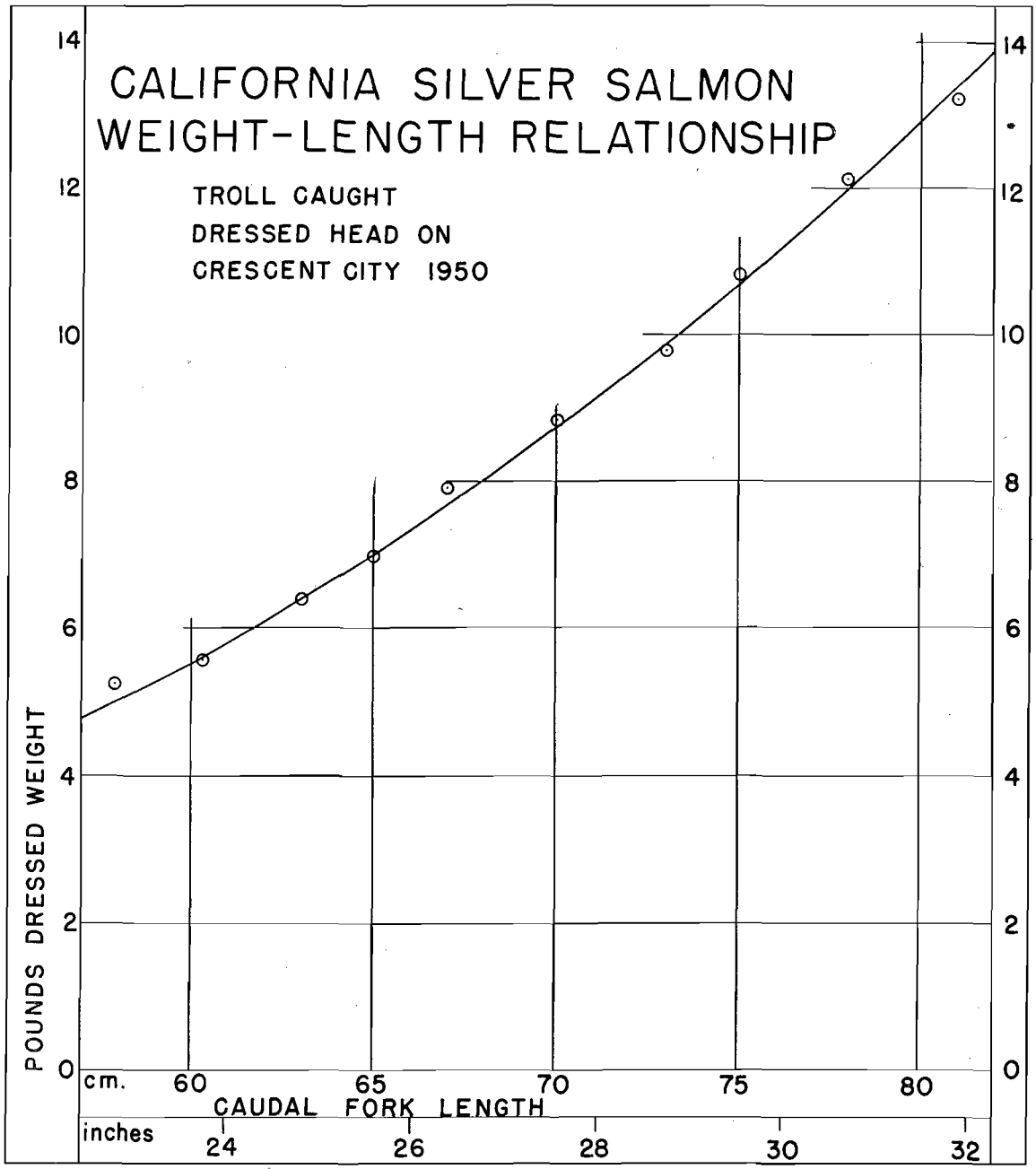

FIGURE 18. California silver salmon weight-length relationship as based on 494 ocean-caught salmon which were dressed, head on. These salmon were landed at Crescent City in 1950.

In recent years, the trolling salmon season in California has been from April 1st to mid-September. There have been minor variations. This period encompasses the period of greatest availability to the fishermen.

Ocean salmon tagging operations by the Division of Fish & Game in California cover the period from 1939 into 1942 and from 1948 until the present. The tags used have all been of the Petersen disk type. Tags made of cellulose nitrate have been satisfactory. Some cellulose acetate tags have been satisfactory; others have given very poor results. Nickel pins have given trouble because of corrosion. Stainless steel wire is now being used. Tags are applied at the base of the salmon's dorsal fin.

Returns of tagged king salmon show that in both central and northern California, Sacramento-San Joaquin fish dominate the catch. In central California, this domination is much more complete.

In central California, sportsmen recovered 30 percent of the salmon tags which were recovered in the ocean. Recoveries in the Sacramento-San Joaquin Delta were primarily by gill netters. Recoveries in the upper regions of the streams were primarily by sportsmen and by employees of the California Division of Fish and Game and the U. S. Fish and Wildlife Service.

There appears to have been a serious loss of tags from the fish in the 1939 to 1942 tagging experiment. Presumably this loss was primarily due to the pin coming untwisted and letting the tags fall off. A different twist is now used.

Relatively few silver salmon have been tagged, most of them off northern California. The largest part of the recoveries were made in Oregon streams.

Holding salmon for 24 hours in a tank prior to tagging appears to have greatly reduced their chances of survival even though the fish seemed in excellent condition when released.

Returns from fish which were of varying sizes when tagged indicate that there is no selective mortality by size of fish when tagged.

Sampling of the troll salmon catch was done in Eureka from the middle of the 1948 season through the middle of the 1949 season. After an interruption sampling was resumed in 1950 and covered the entire coast. Methods of sampling are discussed. Measurements are made from the tip of the snout to the center of the fork of the tail.

Many of the king salmon landed at Eureka are just over the legal size limit. King salmon landed in the San Francisco area are larger. Average length and weight-length data are given.

Silver salmon length frequencies showed fish five centimeters larger were being taken at Crescent City than in the Eureka-Fort Bragg area. Sampling indicates that the 25 inch silver salmon size limit imposed on California fishermen has much the same effect as the June 15th opening of the silver salmon season in Oregon and Washington. Average weight and weight-length relationships of silver salmon taken in California are given.

ACKNOWLEDGMENTS

We have received invaluable help from many fishermen, dealers, conservationists, and fellow research workers, and regret that we can mention only a few.

Mr. Fred B. Hagerman, California Division of Fish and Game, collected all the data at Eureka in 1948 and 1949.

Many Division employees helped in tagging, sampling, marking, and in the recovery of tags.

The U. S. Fish and Wildlife Service provided salmon fingerlings and facilities for the marking experiments, and help in recovering tags.

The Golden Gate Sportfishers provided boats, skippers, and fishermen to help with tagging.

The San Francisco Tyee Club provided special rewards for the return of certain lucky tag numbers, and provided fishermen to help with the tagging.

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THE OCEAN SALMON TROLL FISHERY OF OREGON

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Fish Commission of Oregon

BULLETIN 2
PACIFIC MARINE FISHERIES COMMISSION
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THE OCEAN SALMON TROLL FISHERY OF OREGON

INTRODUCTION

History of the Fishery

After it was found in the early nineteen hundreds that the chinook, king or spring salmon (*Oncorhynchus tschawytscha*) and the silver or coho salmon (*O. kisutch*) could be taken in the ocean by trolling, the fishery spread rapidly along the Pacific Coast.

The first commercial trolling in the Columbia River area was started about 1912 by men who were actively engaged in gill net fishing. They found that at certain times they could catch more salmon by trolling than by netting; thus they would often gill net at night and troll during the day. During the next few years after 1915 there was a rapid development of the fishery due to the influence of World War I, and by 1919 an estimated one to two thousand boats were fishing off the mouth of the Columbia River (Smith, 1920 and Cobb, 1921). These were small boats using comparatively inefficient gear. Since then there has been a decrease in the number of boats fishing but a great increase in their efficiency.

In the early 1920's it was found that the salmon could be caught more easily on the feeding banks than when concentrated off the mouths of the rivers. The fishery then began to change from the small day boat type into its present form, consisting of large ocean-going vessels capable of remaining on the fishing grounds for a week or more. There are still large numbers of small boats, however, which fish around the mouths of the rivers, returning to port each day to sell their catch. These are augmented by many gill net and crab boats which turn to salmon trolling during the height of the troll season. As the fishermen built better boats and gear, more waters were explored, and the Newport and Coos Bay areas became important as troll fishery centers also.

The rapid development of the albacore fishery after 1936 resulted in a significant change in salmon trolling. The large trollers were ideally suited for tuna, and they began to fish for them during July, August and September. These large trollers then did most of their salmon fishing during April, May and June. Thus the height of the fishery has tended to shift from the late summer when the fish are concentrated off the rivers to earlier in the summer when the fish are still on the feeding banks. Many trollers stay with salmon throughout the season, and, especially during a poor tuna year, many fishermen will return to salmon fishing after a few unsuccessful attempts at albacore. The profitable tuna fishery combined with high prices for fish during and after World War II were instrumental in allowing many of the troll fishermen to secure bigger and better boats.

Although it is extremely difficult to obtain a count of boats engaged in the Oregon troll fishery (due to the mobility of the fleet and the fact that trollers which fish beyond the three mile limit are not required to secure troll licenses), there are an estimated 500 boats which make Oregon ports their base of operations. Likewise, it is difficult to make a statement as to how much the fishing intensity has changed. The number of boats has probably decreased from the earlier years, but there has been a great increase in their size and efficiency. The advent of the tuna fishery has also had an important, but unmeasured effect. While these Oregon boats fish mainly off the Oregon coast, they will follow runs of salmon from Eureka, California, to Vancouver Island. Similarly, when salmon are reported off the Oregon coast, trollers from California and various Washington ports, as well as the Oregon trollers, fish in that area.

There have been several excellent descriptions of the gear used for trolling in other areas of the Pacific Coast, and the gear used in Oregon does not differ in any great respect. Smith (1920), Cobb (1921) and Scofield (1921) explain the gear used in the early days of the fishery, while Chapman, Smith and Ellis (1936) describe the recent types of trolling gear and its usage. An excellent description of the trolling gear is also contained in Fish Bulletin 74 of the Bureau of Marine Fisheries, California Division of Fish and Game.

The average Oregon landings from 1940 through 1947 were about 1,500,000 pounds of each species, chinook and silver. The peak of the silver salmon fishery was reached in 1935 when over

6,000,000 pounds were landed; the catch has declined steadily since this date. The chinook landings have shown a slight tendency for an upward trend to a peak in 1947 of about two and one-half million pounds (Fig. 1).

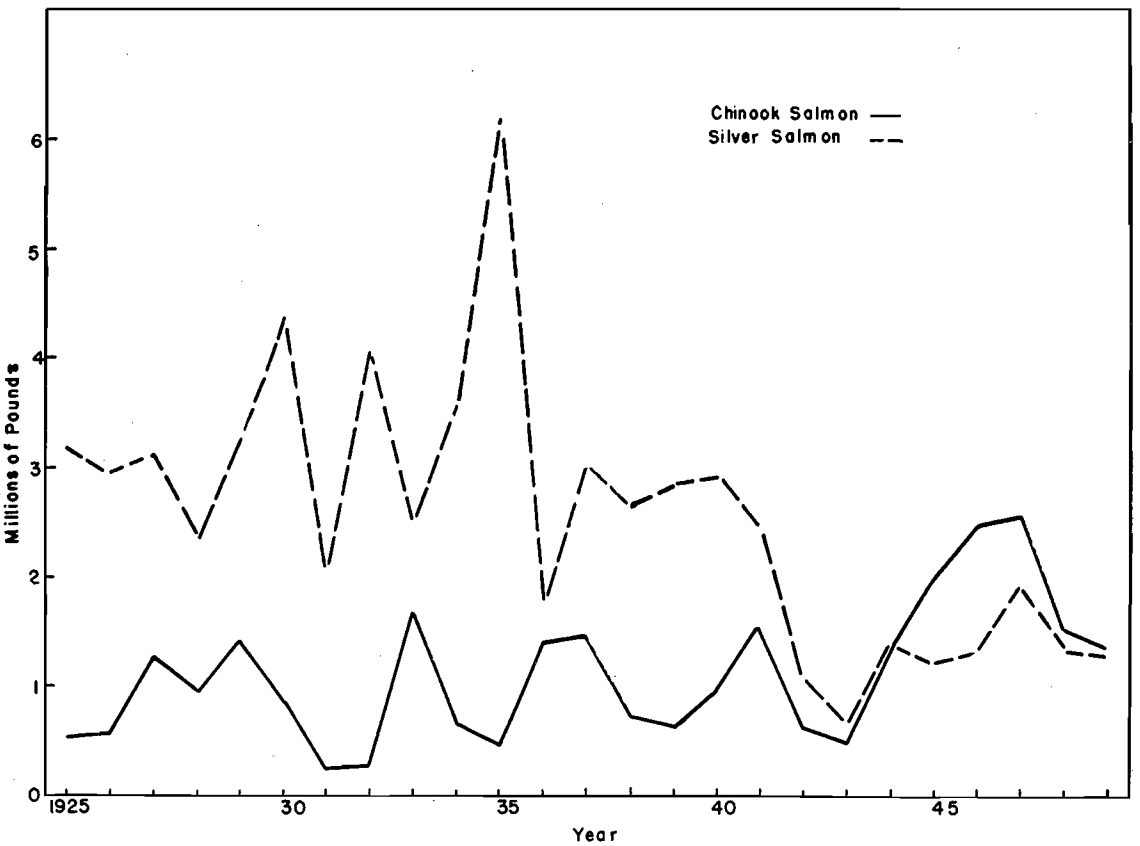

FIGURE 1. Landings of Troll-Caught Chinook and Silver Salmon in Oregon.

Except for occasional size limits this fishery has been practically unregulated since its inception. Beginning in 1948, regulations were imposed based largely on data secured the previous season. The regulations consisted of a 27-inch (total length) size limit on chinooks and an open season from July 1 to November 15 for silvers. To conform with the other Pacific Coast states these regulations were changed in 1949 to include a 26-inch minimum size limit and an open season from March 15 to November 1 on chinooks, and an open season on silvers from June 15 to November 1 with no size limit. These regulations are of a preliminary nature and further research will undoubtedly indicate necessary changes.

History of the Research

Considering the importance of the troll fishery, both in its direct economic value and its possible effect upon the other salmon fisheries, it is surprising what little research has been accomplished.

Smith (1920) discussed the troll fishery of Washington and the Columbia River, with particular respect to the numbers of small immature salmon taken. He compared the average sizes of salmon caught by the troll and purse seine fleets in offshore waters with those taken by gill nets, traps and seines and concluded that the taking of immature salmon was responsible for a great waste of valuable food fish. Not only was the loss great, but much of the ocean-caught salmon was of a poor quality. He also gave some figures on the growth of silver salmon.

Rich (1925) analyzed the growth and degree of maturity of chinook salmon taken off the mouth of the Columbia River and compared the age composition of the ocean catch with that of the river catch. Fish in their fourth and fifth years were found to be most numerous in the river catches,

while in the ocean catches, fish in their third and fourth years were most numerous. The percentage of immature fish in the ocean catch varied during the season from about 80 percent in May to around 10 percent during August. Rich pointed out many of the undesirable features of ocean fishing which he insisted was especially destructive during the spring and early summer.

Spring salmon, i.e. chinooks, were tagged from 1925 to 1930 in Canadian waters, Clemens (1932), Pritchard (1934), Williamson (1927 and 1929), and Williamson and Clemens (1932). These experiments are of great interest to Oregon as they showed for the first time how chinook salmon from the Columbia and other coastal rivers migrated along the coast. A very high percentage of the tag returns from these experiments came from the Columbia River, which indicated that trollers from the Columbia River to northern British Columbia and possibly Alaska, were fishing on stocks of Columbia River salmon.

Chapman, Smith and Ellis (1936) discussed the Washington troll fishery in general, with emphasis on catch statistics, and they also gave some data on growth and food habits.

Preliminary observations on the Oregon troll fishery were made at Reedsport during the summer of 1946 by the staff of the Oregon Fish Commission. These studies led to the instigation of a more intensive research program during 1947 to learn the age composition, growth, migrations, length-weight relationship, and seasonal and area variations in size and abundance of the troll-caught fish. Further impetus to the research program was provided by the formation of the Pacific Marine Fisheries Commission in 1947. Ocean tagging as well as a more intensive sampling program was started in 1948. Observers were stationed at Astoria, Newport, and Coos Bay from June through September. In subsequent years samples have been obtained through the entire trolling season from March to November.

Much of the material presented in this paper is of a preliminary nature, and a large quantity of sampling and biological data awaits more detailed analyses before presentation.

Fishing Areas

The trolling waters of Oregon may be divided into three general areas; Columbia River (Astoria), Newport, and Coos Bay. Various figures show the distinguishing features of the Oregon coast. Refer for example to Figures 4 and 5 (shown on pages 54 and 55).

The Columbia River fishing area extends from Willapa Bay to Cape Lookout. The major ports are Astoria, Oregon and Ilwaco, Washington, with smaller landings being made at Warrenton and Tillamook, Oregon and Chinook, Washington. Astoria was formerly the principal port, but with the improvement of channel and harbor facilities, Ilwaco has become increasingly important. The boats from the two ports fish the same area, and many of the salmon landed at Ilwaco are brought to Astoria for canning and packing.

In this case the port where the fish are landed depends on economic factors, mainly the price, and not biological factors. Therefore, troll landings on the Oregon and Washington side of the Columbia River have been combined in many of the discussions to follow. The Columbia River and Grays Harbor fleets often intermingle on the fishing grounds, but the amount of fish caught off the Columbia River and landed in Grays Harbor is rather inconsequential. Likewise, the amount of fish caught off Grays Harbor and landed in Astoria is of minor importance compared with the landings of fish caught off the mouth of the river. Most of the fishery takes place directly off the mouth of the Columbia River, but many boats also fish north and south of the river and deliver their fish to Columbia River ports.

In March and April the spring chinook run appears off the river, and if the weather is good, large catches are made. During May, June and July small immature salmon are found feeding off the river and most of the larger boats deploy to other areas. Many go to Grays Harbor or farther north and some as far south as California. Many salmon taken off Grays Harbor are landed at Astoria during this time. In July many of the boats turn to tuna fishing, leaving a reduced but still impressive fleet of smaller boats fishing for salmon. During July silvers usually are taken in large numbers, and in August the big fall chinook run appears off the Columbia River. Good catches of both species are made during August, but after the fall run leaves the ocean in early September there

are few chinooks to be found. The fishing after that time is almost exclusively for silvers. Some trolling takes place in the lower part of the Columbia River up as far as Astoria when the chinooks move into the river. Bad weather and lack of fish in October or November usually bring activities to a halt.

The Newport area extends roughly from Cape Lookout on the north to Heceta Head on the south. Most of the fish caught in this area are landed at Newport or Depoe Bay. This area includes the well-known fishing area, Stonewall Bank, commonly called the "Rock Pile." Intensive chinook fisheries take place on this bank, as well as at Heceta Bank and off Heceta Head, Cape Perpetua, and Cascade Head.

Occasional salmon landings are made in the Newport area during the spring months, but for the most part the fishery begins in June with large chinooks appearing on the "Rock Pile." These are later replaced by smaller chinooks and silvers. When the silvers appear they are taken throughout the entire area with concentrations off the mouths of the rivers later in the summer. This area also has a major ocean sport fishery which will be discussed in another section.

The third area is in the vicinity of Coos Bay and extends from Heceta Head to the California border. This includes a large expanse of coastline, but most of the fishery takes place between the Coquille River and Heceta Head. The principal ports are in Coos Bay, but large landings are also made at Winchester Bay and Reedsport on the Umpqua River and smaller landings at Port Orford, Bandon on the Coquille River, and Florence on the Siuslaw River. Port Orford boats and some from Coos Bay fish the area south of Cape Blanco, but much of this area, including the Rogue River, is fished by California boats. (Fig. 2.) The Port Orford troll fleet is an interesting one consisting of about 20 small boats which are kept on a dock extending out into the open ocean. At the beginning of each day's fishing the boats are wheeled on trailers to a crane which lowers them into the water and at the end of the day they are hoisted up again. Very little fishing takes place in the spring in this area due to absence of salmon. The fishery starts in June with the appearance of both chinook and silver salmon scattered throughout the area. The chinooks seem to be mostly immature feeding fish and average somewhat smaller in size than in the other areas.

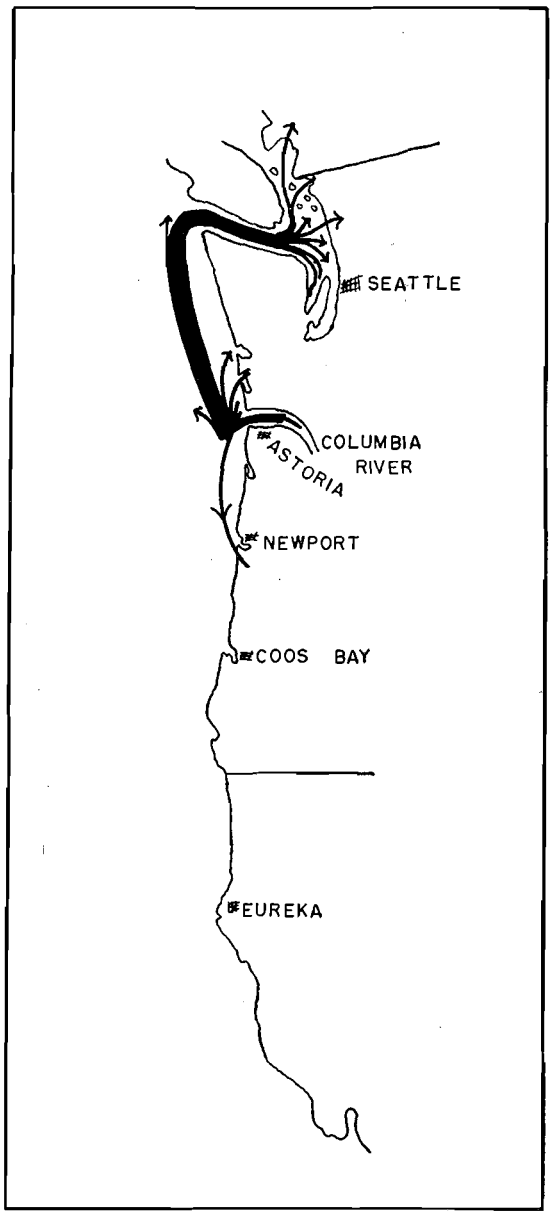

FIGURE 2. Migration of Silver Salmon Tagged between the Columbia River and Cape Lookout, Oregon, in 1948 and 1949.

THE SILVER SALMON FISHERY

Migration

TAGGING EXPERIMENTS

The first attempt to learn the migratory habits of salmon found off the Oregon Coast was in 1926. At the suggestion of the International Pacific Salmon Federation and Dr. Willis H. Rich,

an attempt was made to tag silver and chinook salmon in the ocean. A fisheries patrol boat, equipped with trolling gear and manned by two wardens, was first used. After several days of fishing in early August, this boat was found unsatisfactory for the work. Arrangements were then made to accompany the troller "Mabel" of Hoquiam with Mr. Matt Walteri as captain. A trip was made down the coast from Astoria to Port Orford during August and September. A total of 224 silver salmon and 135 chinook salmon were tagged during the season. Apparently little effort was expended in the recovery of the tags, and the records show only three silvers and two chinook tags recovered.

The silver salmon recoveries were as follows:

1. Tagged August 2, 1926, off Tillamook Head.
   Recovered August 21, 1926, in a trap in the Columbia River.
2. Tagged August 16, 1926, six miles south of the Columbia River.
   Recovered August 23, 1926, in the Columbia River.
3. Tagged September 13, 1926, off Cape Blanco.
   Recovered October 28, 1926, in the Nehalem River.

Additional tagging was attempted during August and September of 1927, during which time 200 silvers and 5 chinooks were tagged. Available records do not state how they were tagged or if any were recovered.

In 1948 and 1949 at the suggestion of the Pacific Marine Fisheries Commission, salmon were, again tagged in the ocean. Tables 1 and 2 summarize the tagging and recoveries. The salmon were caught from commercial trollers and tagged with Peterson-type celluloid disc tags attached below the dorsal fin. The tag number, date, and area of release were noted, and also the condition, where hooked, and fork length were taken at the time of tagging.

TABLE 1.—TROLL SILVER SALMON TAGGING, OREGON*

Area	1948			1949			Total		
	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered
Columbia River	190	16	8.4	32	3	9.4	222	19	8.6
Newport	27	2	7.4	193	7	3.6	220	9	4.1
Coos Bay	32	1	3.1	32	0	0.0	64	1	1.6
Total	249	19	7.6	257	10	3.9	506	29	5.7

* These data do not include fish tagged in 1948 and 1949 that were recovered in 1950 and later.

No reward was paid for the return of the tags, but an intensive campaign to secure cooperation from the fishermen and dealers was instigated in its stead. Also large numbers of both troll and river caught fish were sampled in order to determine the ratio of tagged fish in the catch.

Tagging of Silvers in the Columbia River or Northern Area of Oregon

The troll silver season opened on July 1, in 1948, so it was possible to secure fish at a very reasonable cost before that date. Large numbers of silvers were reported early in the season, and a troller was chartered for eight days during the latter part of June to tag some of these fish. A large school of silvers was encountered in the area between Tillamook Bay and Cape Lookout and 190 of them were tagged. A recovery of 16 or 8.4 percent was obtained from this experiment (Table 1). It is interesting to note how the fish tagged at the same time and apparently from the same school scattered out to their respective recovery areas. Puget Sound contributed the greatest number of returns (seven fish or 43.8 percent) from this particular group of fish, while three (18.8 percent) were found in the Columbia River, three (18.8 percent)were taken by trollers between the mouth of the Columbia River and Grays Harbor, one (6.2 percent) was returned from Willapa Bay, one (6.2 percent) went south to the Alsea River, and for one the recovery area was not known. The results show that this school of fish had individuals bound chiefly for the Puget Sound area, and also contained some bound for the Columbia and coastal rivers as well. The exact contribution made by runs from the areas of recovery will vary with the fishing intensity in the various recovery areas.

In 1949 no silvers were present in the vicinity of the Columbia River early in the season, so the tagging was limited to accompanying the trollers and buying fish from them. Due to an extremely poor silver year, only 32 silvers were tagged in this manner. There were three recoveries, one in the Fraser River, one at Whidby Island (Puget Sound), and one was taken off the Columbia River 50 days later.

In summary, 222 silvers were tagged in the northern Oregon area in 1948 and 1949 and 19 were recovered. Figure 2 shows a map of the migration routes. Of the 19 recoveries, 47.4 percent were recovered in the Puget Sound area, 5.3 percent in the Washington coastal streams, 21.0 percent off the Columbia River and Washington coast, 15.8 percent in the Columbia River, 5.3 percent in the Oregon coastal streams, and as previously mentioned, one fish was returned with no information as to locality of recovery. It must be remembered that nearly all of this tagging was done during June and July; if more had been tagged later in the season, there undoubtedly would have been more recoveries from the Columbia River and southern areas. It is interesting to note that two silvers tagged in 1948 were recovered in 1949 (Table 2). Recoveries in 1950 are not included.

TABLE 2. TROLL SILVER SALMON TAG RECOVERIES, OREGON TAGGING
(Tagged in 1948–49, Recovered in 1948–49)

TAGGED			RECOVERED				
Tag No.	Date	Location	Date	Location	Days Out	Migration	Gear
A-423	19 June 1948	Cape Lookout	2 Oct. 1948	Hoods Canal	105	300 N.	Sport
429	do.	do.	13 Sept. 1948	Whidby Island	86	310 N.	Sport
444	do.	do.	28 Oct. 1948	Willapa Bay-Nemah R.	131	100 N.	?
468	do.	do.	1 Oct. 1948	Hoods Canal	104	300 N.	Sport
426	do.	do.	Aug.-Sept. 1949	Cape Flattery to Swiftsure	450 ±	200 N. ±	Purse seine
432	do.	do.	8 Dec. 1948	Col. R. at Cathlamet	172	95 N.	Gill net
447	do.	do.	15–21 Aug. 1948	Off North Head	60 ±	65 N.	Troll
443	do.	do.	24 Aug. 1948	Skagit R.	66	285 N.	Gill net
493	do.	do.	16 Sept. 1948	Nooksac R.	89	320 N.	?
474	do.	do.	7 Oct. 1948	Alsea R.	110	55 S.	Gill net
484	do.	do.	15–21 Aug. 1948	?	60 ±	?	?
525	22 June 1948	do.	19 Sept. 1948	Off Grays Harbor	89	85 N.	Troll
502	do.	do.	10 Sept. 1948	Off Columbia R.	80	45 N.	Troll
564	do.	do.	29 Sept. 1948	Lopez Island	99	270 N.	Purse seine
540	do.	do.	28 Nov. 1948	Lower Columbia R.	160	85 N.	?
513	do.	do.	Oct. 1949	Columbia R.	500 ±	100 N. ±	?
C-703	24 June 1949	Off Col. R.	6 Sept. 1949	Fraser R.	74	280 N.	Gill net
738	13 July 1949	Off Col. R.	1 Sept. 1949	Off Columbia R.	50	0	Troll
762	22 July 1949	Off Col. R.	17 Aug. 1949	Whidby Island	26	240 N.	Purse seine
24	22 June 1948	Off Newport	10 Sept. 1948	Off Columbia R.	80	85 N.	Troll
34	do.	do.	25 Aug. 1948	Off Willapa Bay	64	120 N.	Troll
98	4 Aug. 1949	Off Depoe Bay	22 Sept. 1949	Sooke, B. C.	49	270 N.	Trap
106	4 Aug. 1949	do.	1 Oct. 1949	Kalama R., Wash.	57	160 N.	Hatchery
124	5 Aug. 1949	do.	28 Aug. 1949	Off Umpqua R.	23	70 S.	Sport
136	6 Aug. 1949	do.	19 Aug. 1949	Off Newport	13	20 S.	Troll
199	19 Aug. 1949	do.	10 Sept. 1949	Lower Columbia R.	22	90 N.	?
250	27 Aug. 1949	do.	18 Oct. 1949	Naselle R., Wash.	52	130 N.	?
246	28 Aug. 1949	do.	22 Sept. 1949	Tillamook R.	26	55 N.	Gill net
R-100	17 June 1948	Off Coos Bay	28 Oct. 1948	Lower Columbia R.	133	195 N.	?

Tagging of Silvers in the Coastal Area South of the Columbia River

In 1948 tagging along the coast was confined to silvers obtained from the trollers before the season opened. Twenty-seven were tagged off Newport and 32 off Coos Bay. Two tagged off Newport were caught by trollers between Willapa Bay and the Columbia River, and one from the Coos Bay tagging was recovered in the Columbia River.

In 1949 a small boat was chartered during June, July and August to tag salmon out of Depoe Bay and Newport. Due to an extreme lack of fish and poorer than usual weather, only 193 silvers were tagged. Recoveries from this experiment were very few, only seven being recovered. One was taken in a trap at Sooke, Vancouver Island, one in a Washington stream, two in the Columbia

River, one in an Oregon coastal stream (Tillamook River), and two by trollers off the Oregon coast (Table 2). Thirty-two silvers were tagged off Coos Bay in 1949, but there were no recoveries.

Figure 3 shows the migration routes of silvers released in the coastal area. A summary of the ten returns from the coastal tagging shows a ten percent recovery from Puget Sound, ten percent from Washington coastal streams, 40 percent by trollers off the Washington and Oregon coasts, 30 percent from the Columbia River and ten percent from the Oregon coastal streams. It appears that the Puget Sound's influence becomes less as one proceeds southward, while the Columbia River's influence becomes more dominant along the Oregon coast. However, as mentioned before, the tagging did not all take place at the same time which could change the conclusion somewhat.

The predominant northward movement of silvers from the point of tagging is obvious. This is the reversal of what Mottley (1929) and Pritchard (1934) found for silver and spring salmon tagged off British Columbia, but the results can perhaps be interpreted in much the same manner, only with a northward instead of a southward migration back to their home streams.

The young silvers enter the ocean during the spring of their second year and apparently turn south on a "feeding" or "dispersal" migration. They feed and move south during that summer and the following winter. The spring of their third year finds them a considerable distance south of their point of origin. Perhaps their approaching maturity is the factor which stops them in their southward migration and turns them north to make a rapid migration back to their parent streams. The young silvers which leave the northern streams will probably not travel as far south on their "feeding" migration as those from the more southern streams before they turn back to their spawning areas. Pritchard (1934 and 1940) found that the chinooks from the larger rivers dominate the catch in certain areas, and he suggested that each large chinook river has a "sphere of influence." For example the Columbia River fish dominate the catch as far north as the west coast of the Queen Charlotte Islands. This cannot be shown as clearly for silvers since they spawn in nearly every stream along the coast, but if they are grouped into larger areas, a similar situation is suggested, in that silvers originating from a certain area dominate the catch at certain times. That some silvers make a northward feeding migration and a southward spawning migration is demonstrated by one silver tagged at Sooke, B. C., and recovered in the Columbia River.

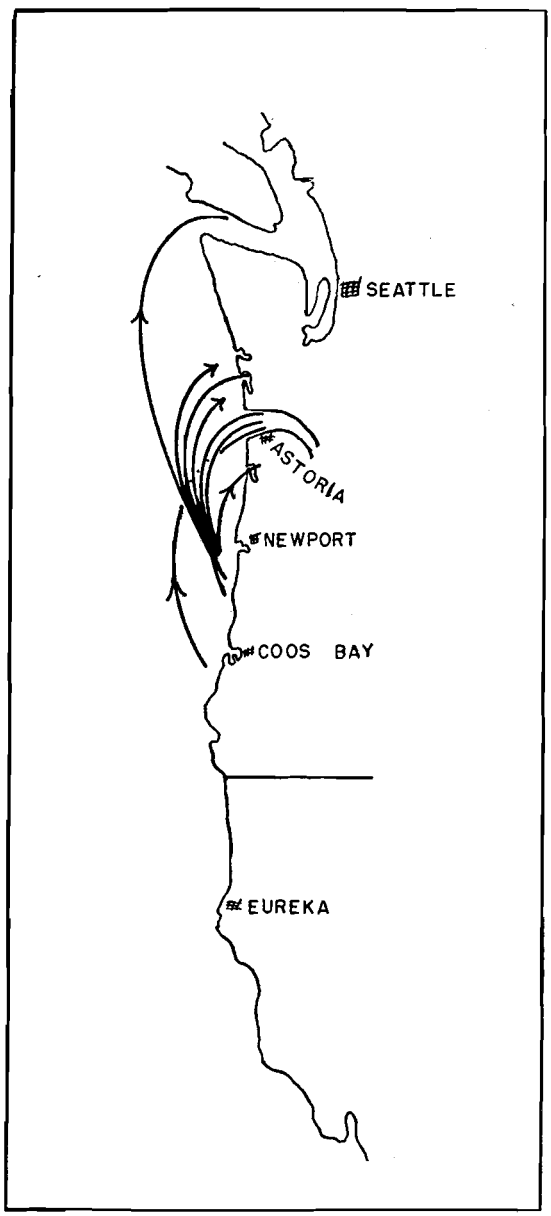

FIGURE 3. Migration of Silver Salmon Tagged Off the Coastal Areas of Oregon in 1948 and 1949.

The rate of ocean migration for those silvers tagged and recaptured is calculated to be 1.6 miles a day, with a range of from 0 to 9.2 miles a day. Only the recoveries which were made in salt water were used in calculating this rate, since in the case of most river recoveries, the distance up the river was not given, and in no cases would it be possible to tell how long the fish had been in the stream. It is interesting to note the decrease in percent recovered from north to south (Table 1), possibly indicating a decrease in fishing intensity from the northern areas to the southern areas.

This preliminary tagging does not show the exact contribution of the various rivers to the troll catch, but it does give a general picture of silver salmon migration along the coast. More tagging, especially during the height of the troll season, will give a better understanding of the migration patterns and the contributions of the various areas to the troll catch.

Marking Experiments

In view of the proposed program to mark (fin clip) large numbers of small salmon at the hatcheries and study their subsequent recovery in the ocean, it would be of value to point out what has been learned of ocean migrations from previous marking experiments. These experiments were designed to investigate various phases of the salmon's fresh water life, but something of their ocean life may also be determined. The numbers of ocean returns will of course be subject to the various types of treatment the fish received during their early life history, plus varying intensities of fishing and recovering the marked fish.

Two extensive experiments were undertaken by the Oregon Fish Commission with silvers of the 1944 brood year to determine the best time to release hatchery-reared silver salmon. There were 100,061 silvers released at the Bonneville Hatchery on the Columbia River and 99,436 were released in the Alsea River, a central Oregon coastal stream. The recoveries were made in 1947, by offering a $0.50 reward for the mark and also by sampling the catch. Most of the returns were obtained through the reward system by the cannery workers, and in those cases the exact locality of the catch cannot be determined, but they have been grouped by the ports at which they were landed. This gives a rough approximation of their distribution along the coast. Unfortunately no record was kept of the locality of capture of the marked fish which were recovered in the sampling.

The ocean recoveries of the Alsea River marked silver salmon are shown in Figure 4. In general they confirm the tagging, in that early in the season most of the silvers were found south of their home streams, with a scattering to the north. Large numbers of them were recovered off Coos Bay in June and July. During August they left the southern coastal areas and began to gather around the Alsea River, and during September and October, as one would expect, they were mostly gathered off the mouth of the Alsea with some possibly still left to the north. The apparent presence of numbers of them off the Columbia River might be explained by the fact that, although they were landed at Astoria, they could have come from boats that had been fishing off Newport and the Alsea River. Although no effort was made to recover these marks in other states, at least two were found off Eureka and Crescent City in June and one was reported off the northern tip of Vancouver Island.

Figure 5 shows the ocean recoveries of the Bonneville Hatchery marking of 1944 brood year silver salmon fingerling. Again is noted the southerly distribution early in the season, becoming more northerly as the season advanced. Relatively few of these fish were taken off Coos Bay, compared with large numbers of the Alsea River fish. It is not known if there were any of these fish taken off the Washington or California coast.

As mentioned before, this gives a very general idea of the migration pattern and is in no sense as precise as tagging, but coupled with a tagging program, the marked fish returns give a clearer picture of the ocean habits of silver salmon. The numbers of marks returned from the various areas depend upon the intensity of the fishery as well as upon the intensity of effort in recovering the marks. This can be overcome by sampling a portion of the catch in the different areas on a coastwise basis and correcting the recoveries by the catch by areas.

This seems to be the only marking experiment where an intensive campaign to secure marks from the ocean fishery has been carried out. These fish apparently had a very high survival rate, as fewer marked fish have been found in succeeding experiments.

Of the 382,300 troll-caught silvers landed in Oregon and the Washington side of the Columbia River in 1947, 35,000 were examined or 9.2 percent of the catch. In this sample there were found 260 marks of the 1944 brood year marking of 199,497 fish. Calculating the number of marked fish in the catch from these data gives 2,843, with a marked to unmarked ratio of 1 : 135. This indicates a recovery by the Oregon and Columbia River troll fishery in 1947 of 1.4 percent of the total number of marked fish. Some marked fish from these experiments were also recovered in 1948, which would raise the percentage recovered even higher.

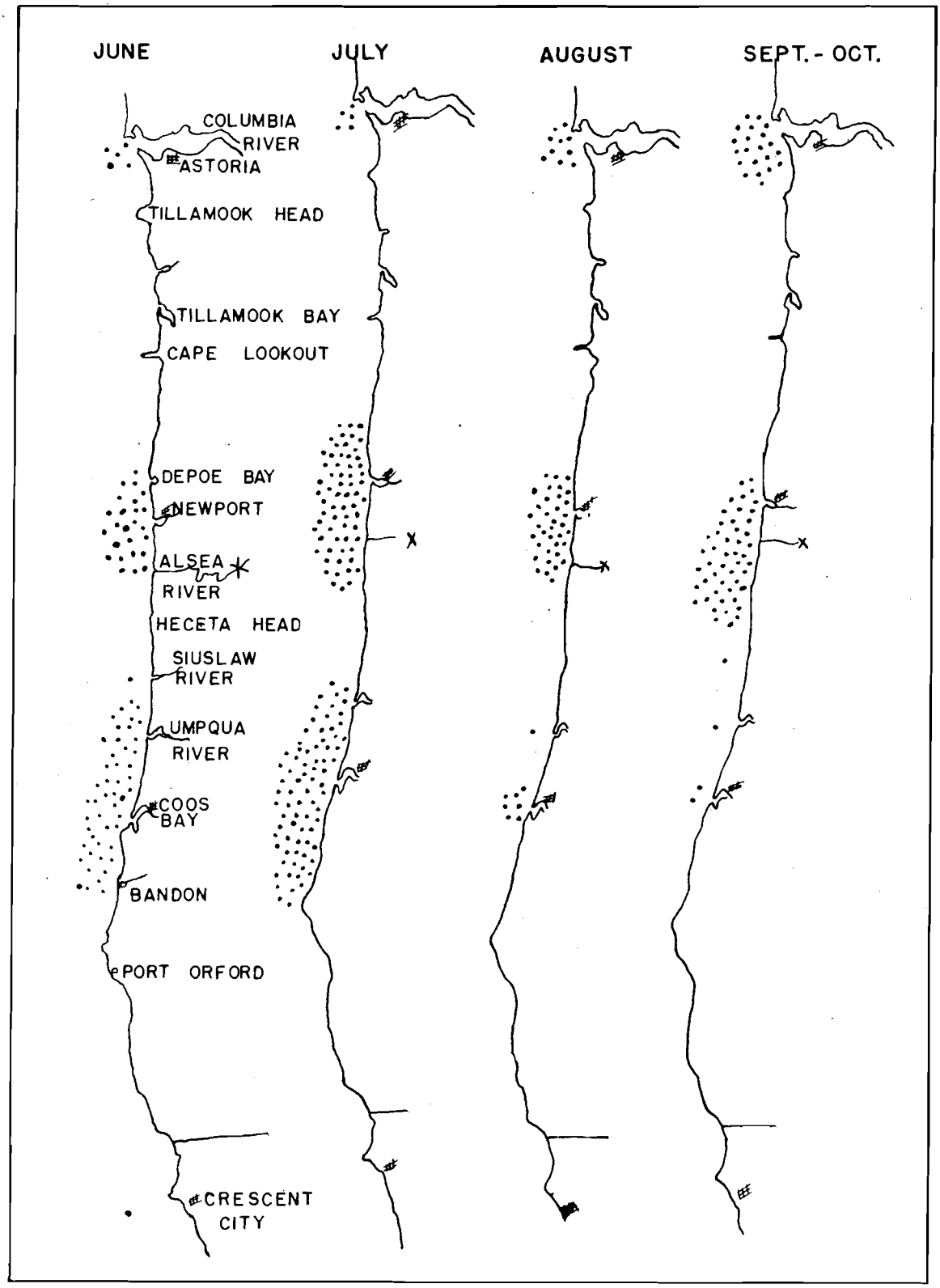

FIGURE 4. Ocean recoveries of Alsea River Silver Salmon marks of the 1944 brood year (Also showing distinguishing features of the Oregon Coastline).

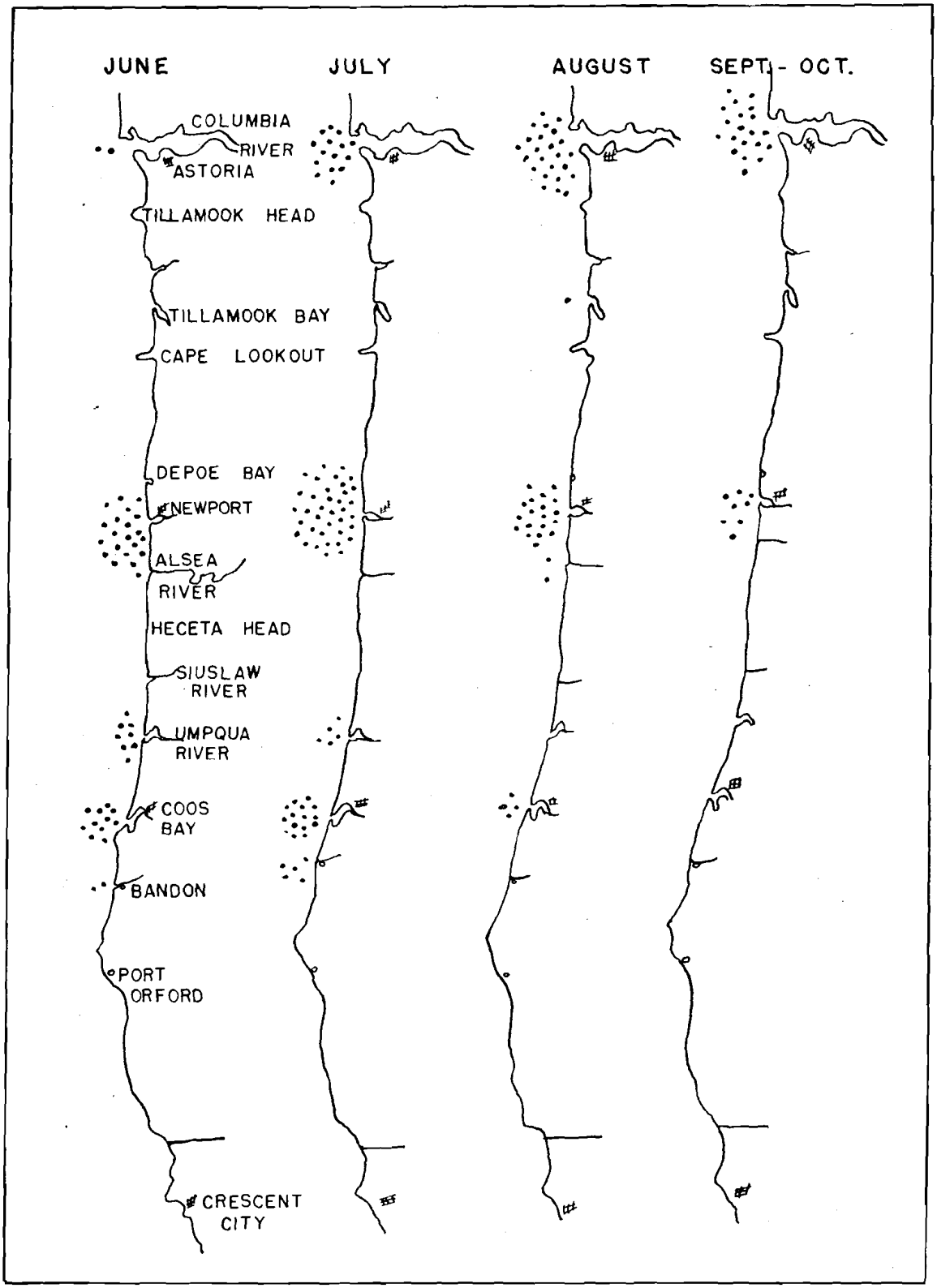

FIGURE 5. Ocean recoveries of Bonneville silver salmon marks of the 1944 brood year.

The returns from similar markings in 1948 are not as high. The catch in 1948 was 320,695 fish of which 30,183 (9.4 percent) were examined for marks. There were 110,308 fish marked that year (1945 brood year), but only five of them were recovered. In addition seven other marks of uncertain origin were found which have been tentatively assigned to the 1944 brood year.

These marks were obtained by sampling the catch; no reward was offered and no effort was made to collect marks other than by sampling. The marked to unmarked ratio was 1 : 6,037, with the calculated number of marked fish in the catch being 54. Only 0.05 percent of the marked fish of the 1945 brood year were recovered by the troll fishery. In 1949, 11,385 silvers were examined and one mark was found, a ratio of 1 : 11,385. Only 14,609 were marked of the 1946 brood year which of course accounts for the paucity of marks.

In 1948 and 1949 a record was kept of the single fin clips observed in the sampling. From the sample of 30,183 in 1948 the following single marks were noted:

Adipose—11	A ratio of	1 : 2,744
Left Ventral—8	A ratio of	1 : 3,773
Both Ventrals—7	A ratio of	1 : 4,312
Right Pectoral—7	A ratio of	1 : 4,312
Right Ventral—6	A ratio of	1 : 5,030
Left Pectoral—2	A ratio of	1 : 15,091
Both Pectorals—1	A ratio of	1 : 30,183
Dorsal—1	A ratio of	1 : 30,183

In 1949 the following were noted:

Adipose—10	A ratio of	1 : 1,138
Right Ventral—6	A ratio of	1 : 1,898
Both Ventrals—4	A ratio of	1 : 2,846
Left Ventral—2	A ratio of	1 : 5,692
Right Pectoral—2	A ratio of	1 : 5,692
Left Pectoral—1	A ratio of	1 : 11,385

Due to the small number of returns, very little can be said about migration from the 1948 or 1949 data. In 1948, fish from Bonneville were reported off Astoria, Newport, and Coos Bay, and one mark from Minter Creek in Puget Sound was found off Newport. In 1949 a silver from Sand Creek on Tillamook Bay was landed at Astoria.

If the conditions which promoted such an excellent recovery of the 1944 brood year can be repeated with the 1949 brood year a great deal of data concerning the movements of these marked fish can be anticipated from marking experiments. If, however, conditions for survival are poor, as they apparently were for the 1945 brood year, the results may not be up to expectations.

Condition and Mortality of Hooked Fish

Whenever time permitted on board the salmon trollers during 1948 and 1949, observations were made as to the condition of the fish tagged and where they were hooked. In 72 days spent tagging, there were 794 silvers caught. Of these, 506 were tagged and 288 were kept by the fishermen, and of the 794 caught, only 15 or 1.9 percent were dead when landed. There were 569 (71.7 percent) hooked in upper or lower jaw, corner of mouth, or cheek; 64 (8.1 percent) were hooked in the gills, eye, or throat; 3 (0.3 percent) were foul-hooked in the back or operculum, and observations were not made on 143 (18.0 percent).

Condition of the tagged fish was judged as good if it swam away rapidly; fair—swam away slowly at surface and appeared stunned; poor—floated away. Table 3 summarizes the data on the condition and place of hooking of the tagged silvers and the numbers of each category which were returned. The number of returns is not sufficient to warrant a statistical analysis; however, the fact remains, and, contrary to popular opinion, that fish which are hooked in the gills or eye or which float away will often live. From Table 3 it can be seen that the percentage of recoveries from fish which were released in poor condition (5.9 percent) is similar to that of fish released in good condition (6.8 percent). Likewise the recoveries from fish which were hooked in the gills or eye (5.0 percent)

compares favorably with the percentage recovery of those which were lightly hooked. From these rather scanty data it would appear that there is very little difference in survival of tagged silver salmon which were lightly hooked and those severely hooked in the eye or gills.

TABLE 3. CONDITION OF TAGGED SILVER SALMON AT TIME OF RELEASE, OREGON

	Tagged		Recovered		Percent of Number Recovered from Each Tagging Category
	Number	Percent	Number	Percent of Total Number Recovered	
Good (1)	311	61.5	21	72.4	6.8
Fair (2)	109	21.5	3	10.3	2.8
Poor (3)	85	16.8	5	17.2	5.9
Unknown	1	0.2	0	0.0	0.0
	506		29		
Hooked in:					
Jaws, cheek, etc.	394	77.9	24	82.8	6.1
Gills, eye, etc.	40	7.9	2	6.9	5.0
Miscellaneous	3	0.6	0	0.0	0.0
Unknown	69	13.6	3	10.3	4.4
	506		29		

The Length-Weight Relationship of Troll-Caught Silver Salmon

Numerous observations have been made to obtain the length and weight of troll silver salmon in an effort to obtain an accurate length-weight curve. Information on the length-weight relationship is needed in growth and age studies to convert average lengths to average weights and vice versa, to convert pounds of fish into numbers of fish, to evaluate size limits, and to learn something of the condition of the fish.

The weights given are all dressed weights (heads on), taken with a spring scale, accurate to one-tenth of a pound. The lengths are fork lengths, measured from the tip of the snout to the fork of the tail. In 1947 total lengths to the nearest inch were taken, and were then converted to fork lengths in centimeters. In 1948 fork lengths were taken to the nearest centimeter.

The weights taken for each centimeter of length were averaged and the weighted mean was used in the calculations. Only the data between 50 and 80 centimeters, inclusive, were used in calculating the curve (Table 4).

It is customary in curve fitting to plot the points to be fitted on various scales to determine the best type of curve to fit the data. If the points form a straight line on standard coordinate paper a linear relationship is indicated. If they form a straight line when a regular scale is used on one axis and a logarithmic scale on the other axis (semi-log) an exponential type of curve, of the type $W = AB^L$ (Snedecor, p. 374) is indicated. If the points form a straight line when both the horizontal and vertical axis are a logarithmic scale (log-log), a parabolic curve of the type $W = AL^b$ is indicated. The latter equation is the usual form of the length-weight relationship as given by Keys (1928), Clark (1928), and others. In these equations W = weight, L = length, and A and B are empirically determined constants.

This procedure was followed for the 1947 and 1948 data, and it was found that the points fell in a reasonably straight line on both the semi-log and the log-log scale. However, a close examination showed that the points plotted on a log-log scale formed a definite curve and did not fit the straight line as well as when they are plotted on a semi-log scale. The relative deviations of the points from the straight line on the two types of scales are especially striking in 1948 when large samples were obtained.

Figure 6 shows the calculated exponential curve for the two years. The curve below 50 centimeters and above 80 centimeters is extrapolated. These curves fit the empirical data very closely although they do not originate at zero. The parabolic curves plainly did not fit the points as well as the exponential curves, so it was concluded that the exponential equation best expresses the

TABLE 4. THE LENGTH-WEIGHT RELATIONSHIP OF TROLL-CAUGHT SILVER SALMON, OREGON

1947

Total Length In Inches	Fork Length In Centimeters	Number of Weights	Average Weight
21	49.93	43	3.3
22	52.38	110	3.5
23	54.84	180	4.0
24	57.29	281	4.6
25	59.75	307	5.2
26	62.20	277	6.0
27	64.66	243	6.7
28	67.11	151	7.8
29	69.57	114	8.8
30	72.02	84	10.0
31	74.48	69	11.1
32	76.93	43	12.4
		Total 1,902	

1948

Fork Length In Centimeters	Number of Weights	Average Weight	Fork Length In Centimeters	Number of Weights	Average Weight
40	3	1.8	63	187	5.8
41	1	1.8	64	217	5.9
42	3	2.1	65	227	6.2
43	2	2.0	66	232	6.6
44	1	2.6	67	229	6.8
45	4	2.3	68	251	7.2
46	3	2.5	69	236	7.6
47	5	2.5	70	204	8.0
48	17	2.6	71	143	8.5
49	9	2.9	72	130	8.8
50	30	3.0	73	98	9.2
51	27	3.2	74	90	9.8
52	45	3.4	75	65	10.3
53	75	3.6	76	44	10.8
54	84	3.7	77	31	11.3
55	83	3.9	78	18	12.0
56	90	4.2	79	14	12.5
57	126	4.3	80	12	12.8
58	118	4.5	81	3	13.1
59	148	4.7	82	3	14.9
60	181	5.0	83	5	14.2
61	160	5.1	84	2	13.6
62	165	5.5	85	0	
			86	1	16.6
				Total 3,822	

length-weight relationship of dressed troll-caught silver salmon in the given size ranges. The equation for 1947 is $W = 0.23215 \times 1.0535^{L}$ and for 1948, $W = 0.27952 \times 1.04949^{L}$. This is the first published case that has come to the writer's attention where the length-weight relationship does not conform to the usual parabolic length-weight equation but instead fits the exponential type of curve.

There is a considerable difference in the length-weight relationship between the two years. The fish in 1947 were heavier for the same length than in 1948. Between 60 and 70 centimeters, which includes most of the catch, there is a difference of about half a pound.

Relationship Between Fork and Total Lengths

The biological measurements are measured to the fork of the tail for reasons of uniformity, while the fishermen measure to the tip of the tail in observing the size limits. It is, therefore, essential to be able to convert one measurement to the other. Total length measurements were taken from the tip of the snout to the end of the caudal rays in the normal position and also with the rays extended to their maximum limit. The total length measurement with the tail extended was considered to be superior to the measurement taken with the tail in the normal position. Regression

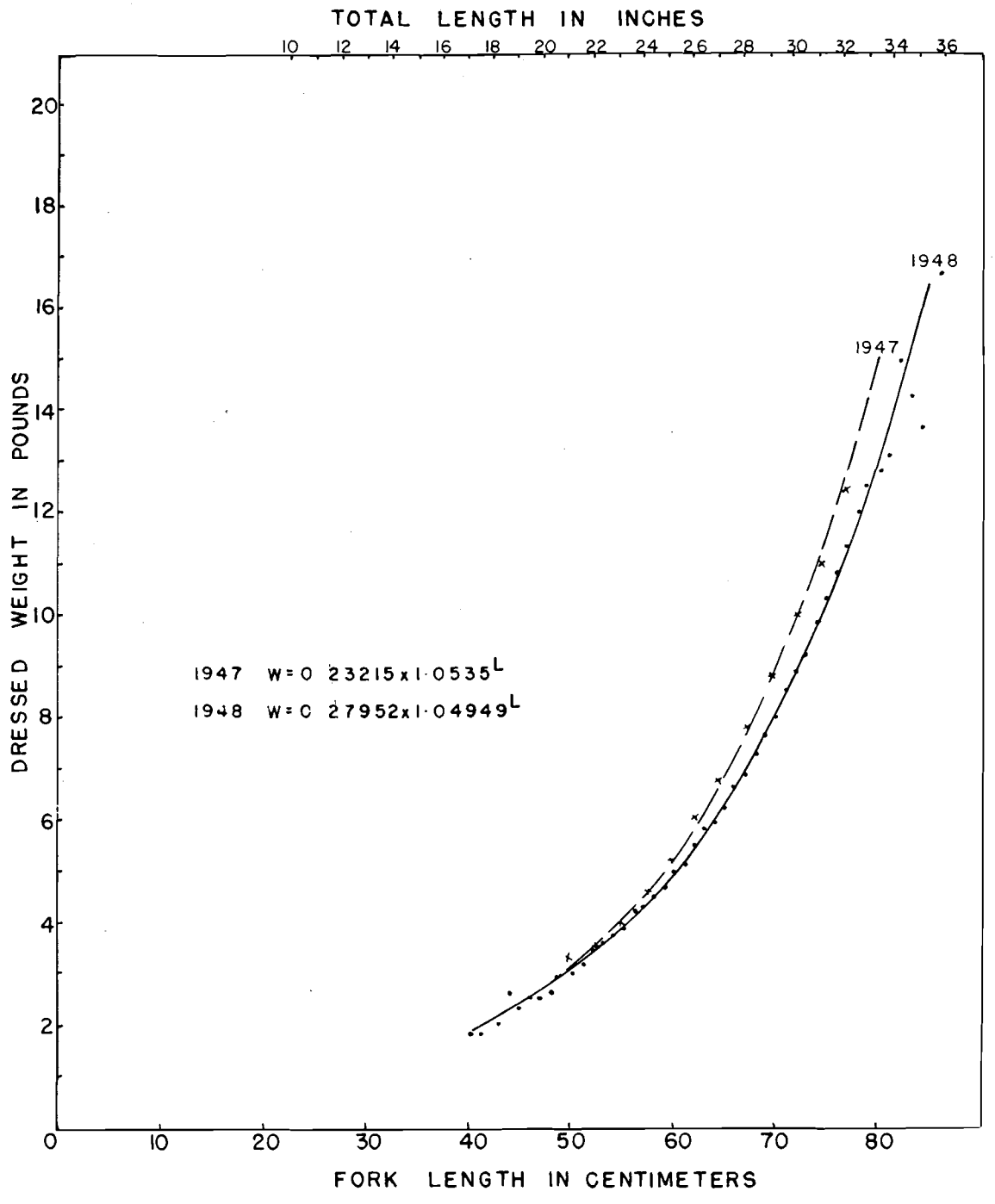

FIGURE 6. The length-weight relationship of troll-caught silver salmon, exponential curves.

lines were calculated for 218 measurements with the tail in normal position and for 330 measurements with the tail extended. The formulae for the lines are given in Table 5 and they can be used to convert from one measurement to the other.

TABLE 5. FORMULAE FOR CONVERTING FORK AND TOTAL LENGTHS OF SILVER SALMON

Tail in Normal Position:	TL (cm.) = 1.67995 + 1.03467 FL (cm.)
Tail Extended:	TL (cm.) = 1.78433 + 1.03706 FL (cm.)

Growth of Silver Salmon

Silver salmon are extremely fast growing animals, and it has long been known that they double their weight during their third and last summer (Smith, 1920). Previous work has shown that the commercial catch of silver salmon is largely of one year class, i.e., fish in their third year (Gilbert, 1913), (Pritchard, 1940). The average weights of the silvers through the season show an increase which has been attributed to the growth of this dominant year class.

Average weights have been obtained for the past three years at ports along the Oregon Coast and are shown on a weekly basis in Figure 7.

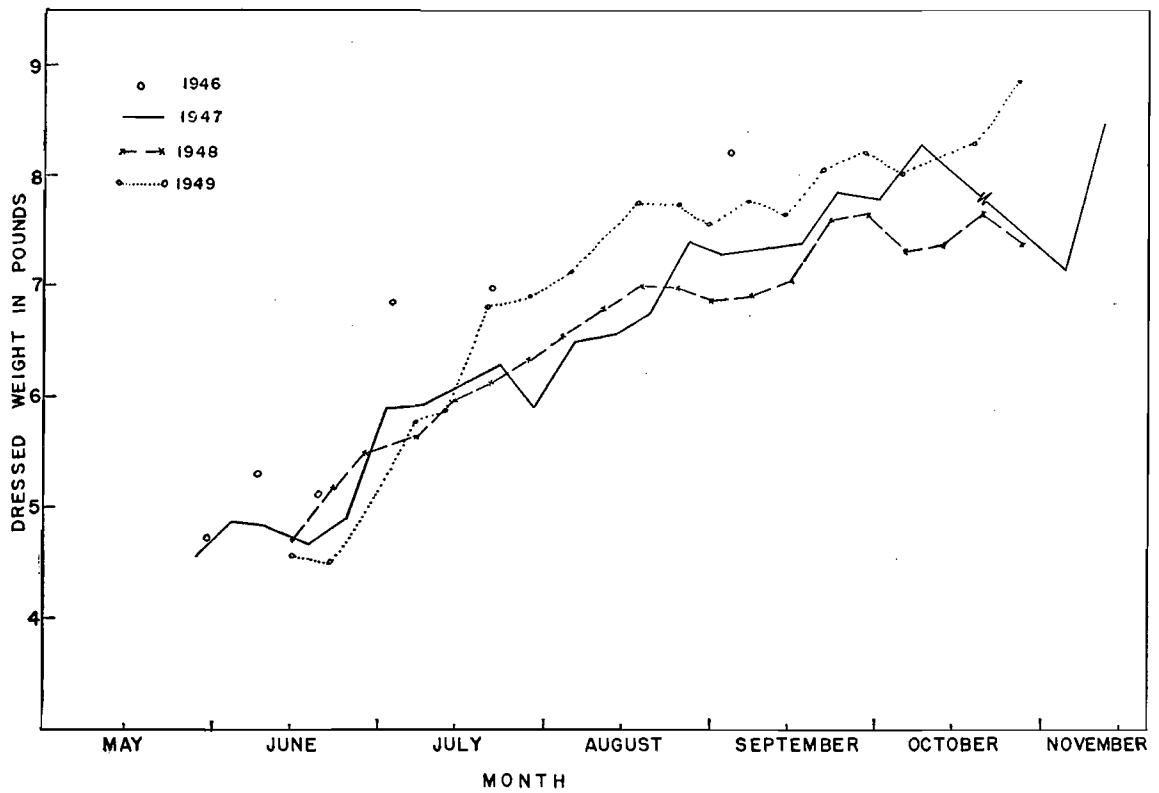

FIGURE 7. The weekly average weights of troll-caught silver salmon, Oregon.

Scattered observations at Reedsport in 1946 are shown by the circles. There seems to be quite a difference in the growth rate of the different years, but a line fitted by inspection to the three year's data shows an increase in mean weight from about four and a half pounds on June first to eight pounds on November first. The 1949 data indicate that the silvers had a faster growth rate and a much higher average weight in 1949 than the previous two years, and it may have been even higher in 1946.

The growth can perhaps better be shown by an analysis of the length-frequency curves. The mode of the length-frequency should be the mode of the third year class, and not include the possible influence of other minor year classes. The length-frequency curves are shown on a monthly basis in Figure 8 for 1948.

The movement of the mode to the right as the season progresses is plainly evident and may be interpreted as growth, although the migration of larger races into the area could also cause a similar phenomenon.

The length-frequency data were weighted by the number of fish landed; thus, the curves actually show the number and size of the fish landed, not just the size of the sample during the period. The season was closed during most of June which accounts for the small landings during that period; this would also cause the average weight and length-frequency data to be higher than actually is the case, since the fish were landed in the last two weeks of the month. The mode for the different

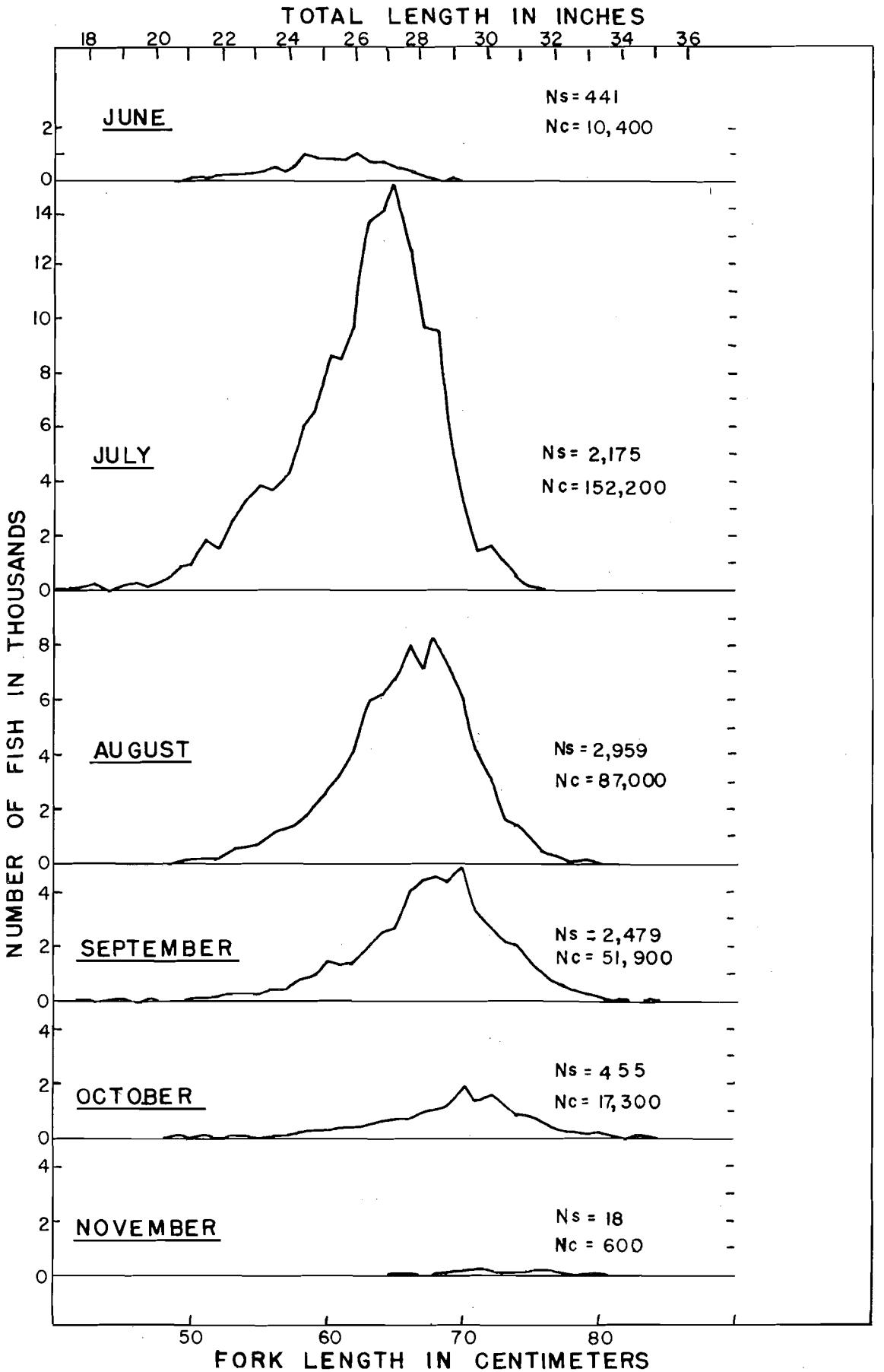

FIGURE 8. Monthly length-frequency of the Oregon and Columbia River troll silver salmon catch in 1948. Weighted by the numbers of fish landed.

months has been calculated by the method used by Brock (1943); i.e., the mean of the five adjacent classes that contained the greatest numbers of individuals was taken as the mode. Figure 9 shows that the modal lengths form a very uniform growth rate, with an increase from 60 centimeters (25.2 inches total length) during June to 72.7 centimeters (30.4 inches total length) during November.

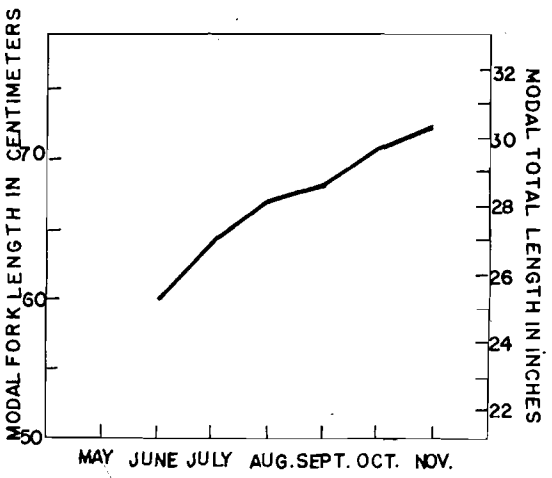

FIGURE 9. The monthly increase in modal length of troll-caught silver salmon in 1948.

THE CHINOOK SALMON FISHERY

Migration

TAGGING EXPERIMENTS

The early attempts at tagging salmon at sea were discussed in the section on silver salmon; there were two chinook recoveries from the 1926 and 1927 tagging of 140 chinook salmon. One tagged off the Nehalem River on August 4, 1926 was recovered at the Big White Salmon River Hatchery, Columbia River, and another tagged off Coos Bay in early September, 1926 was recovered ten days later in the Coos River.

The work done by the Canadians off Vancouver Island and the Queen Charlotte Islands from 1925 to 1930 is summarized by Pritchard (1934) and has been previously mentioned in connection with the silver salmon migration. The Canadian work implies that the young chinook salmon leave their natal streams and make what Mottley (1929) has termed a northwesterly "feeding" or "dispersal" movement. The young fish from the coastal waters of Washington, Oregon, and California, but particularly the Columbia River, disperse north along the American and British Columbian coasts. Undoubtedly some of them also turn southward but the extent of this is not known. At some time in their life history the salmon turn from their slow feeding migration in the ocean and make a rapid southward journey to their natal streams. It was found that as the tagging moved northward the recoveries in United States waters became fewer. The Columbia River contributed by far the greatest percentage of the returns, but nearly every Oregon coastal stream was represented to some extent.

Tagging chinook salmon off the west coast of Baranof Island in 1926 and 1927 by the United States Bureau of Fisheries (1928) resulted in a 60 percent recovery from the Columbia River.

A start has been made in determining the migrations of chinook salmon off the Oregon coast, but with the present data, one can do little more than speculate at the origin of the stocks. In 1948 arrangements were made to accompany the trollers and tag undersize chinooks, those less than the legal length of 27 inches, and in 1949 undersized fish were again tagged in addition to some larger fish which were purchased for tagging. The recoveries were relatively few, probably due largely to the fact that most of the fish were small and had several years of ocean life before maturity. It is possible that more will be recovered in future years. Tables 6 and 7 summarize the tagging and recoveries and Figure 10 shows the migration routes of the recovered fish.

TABLE 6. TROLL CHINOOK SALMON TAGGING, OREGON

Area	1948			1949			Total		
	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered	Number Tagged	Number Recovered	Percent Recovered
Columbia River.	6	1	16.7	54	4	7.4	60	5	8.3
Newport.....	15	0	0.0	8	0	0.0	23	0	0.0
Coos Bay.....	88	5	5.7	50	1	2.0	138	6	4.4
Total.....	109	6	5.5	112	5	4.5	221	11	5.0

TABLE 7. TROLL CHINOOK SALMON TAG RECOVERIES, OREGON TAGGING
(Tagged in 1948-49, Recovered in 1948-49)

TAGGED			RECOVERED				
Tag No.	Date	Location	Date	Location	Days Out	Migration	Gear
D-222	29 April 1948	Off mouth Col. R.	9 Sept. 1948	Celilo Falls	153	170 E.	Col. R. seine
C-769	22 July 1949	do.	7 Sept. 1949	Lewis River, Wash.	57	80 E.	Sport
C-742	13 July 1949	Off Tillamook Head	1 Dec. 1949	Tuolumne R., Cal.	141	650 S.	?
R-100	17 June 1948	Off Coos Bay	19 Sept. 1948	Off Nehalem R., Ore.	94	135 N.	Troll
B-627	4 July 1948	do.	21 Aug. 1949	Off Sea Lion Caves	413	50 N.	Troll
B-626	4 July 1948	do.	7 Aug. 1949	Off Newport, Ore.	399	70 N.	Troll
B-658	27 July 1948	Off Port Orford	24 Oct. 1948	Sixes River, Ore.	89	10 N.	Sport
C-792	20 Sept. 1949	Off Nehalem R.	2 May 1950	Ucluelet, B. C.	224	200 N.	Troll
C-728	7 July 1949	Off Columbia R.	25 June 1950	Umatilla	353	135 N.	Troll
B-641	27 July 1948	Off Port Orford	21 June 1950	Farallone Islands, Cal.	694	290 S.	Troll
F-545	16 Aug. 1949	Off Coos Bay	1 Aug. 1950	Trinidad Head, Cal.	350	105 S.	Troll

The northerly migration of the three fish from Coos Bay and the two from off the Columbia River strongly suggests a northerly feeding migration from some southern stream, while the recovery in the Tuolumne River, California of a fish tagged off the Columbia River indicates a rapid southward journey to its home stream. The two which were tagged in the Coos Bay area and recovered one and two years later off California may have made a more extensive northward migration before returning south. These two fish may have been on a southward feeding migration from the Columbia or other northern rivers. The two which were tagged off the Columbia River and later recovered in the Columbia River were "jacks," precociously mature males, as was also the one recovered in the Sixes River in southern Oregon.

Tagging efforts are now being concentrated on the chinooks, and a great deal of work remains to be accomplished before the complex migration pattern of the chinook salmon is comprehended.

To date most of the recoveries have been made in the ocean, and it is impossible in this case to assign the fish to their proper stream system. Until more chinooks have been recovered in the rivers it will not be possible to determine the composition of the stocks along the Oregon Coast. In an effort to obtain more river recoveries, many large chinooks are now being tagged, and since it is also important to know the origin of the small fish, an improved type of strap tag is on experimental trial. It is hoped that this tag will allow the fish to grow normally to adult size without losing the tag or covering it over with flesh, and it also appears to cause less resistance to the passage of water and should lessen the chances of irritation and infection.

MARKING EXPERIMENTS

There has been no really systematic recovery of marked chinook salmon in the ocean. Rich and Holmes (1928) reported one of their Columbia River marks from Dixon Entrance in S. E. Alaska and two off Vancouver Island from various marking experiments. Their most successful experiment was in the spring of 1923, when 100,000 fall chinook were released at the Big White Salmon River Hatchery on the Columbia River. Eighteen of these were recovered in the troll fishery and 435 in the river fishery and at the hatchery. Ten of the 18 troll recoveries were made

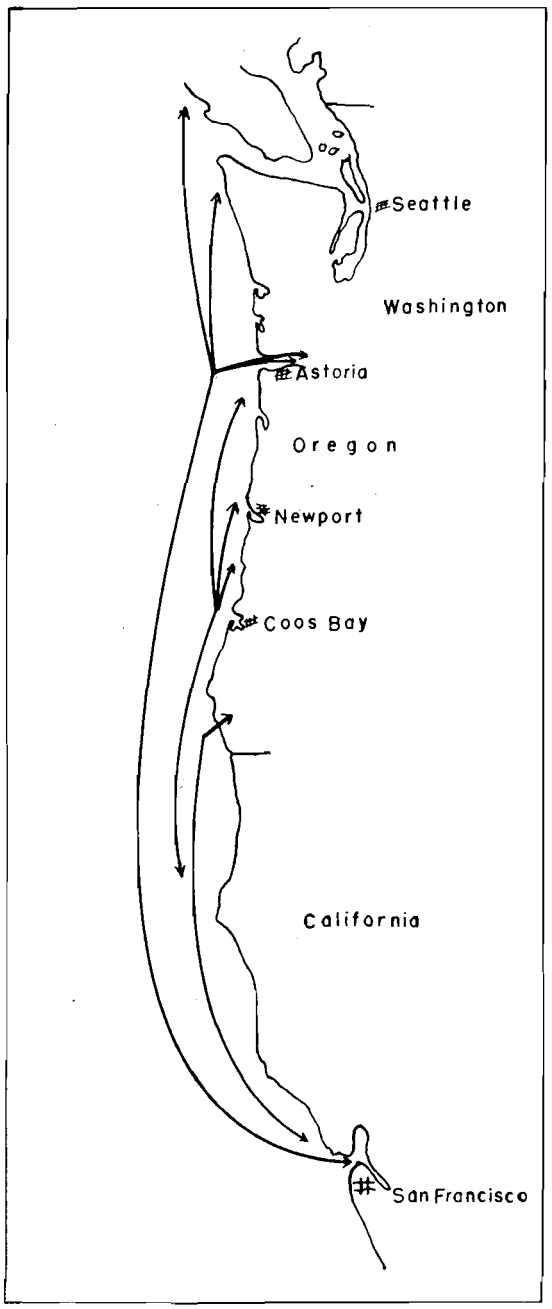

FIGURE 10. Migration of Chinook Salmon tagged off the Columbia River and coastal areas of Oregon in 1948 and 1949.

off the mouth of the Columbia River in 1925 (fish in their third year, 2+), three off the Columbia River and two off Vancouver Island in 1926 (3+), and three off the Columbia River in 1927 (4+). Since most of the recovery effort was directed at the Columbia River, it is to be expected that most of the recoveries should be from that area. Undoubtedly many of these fish were taken along the coast, and the marks not recovered. The records indicate that some of these marked fish were to be found within a short distance of the mouth of the Columbia River during the entire fishing season from May to September.

In 1947 emphasis was placed by the Fish Commission on the recovery of silver salmon marks and little was done with chinook marks. A few chinook salmon marks were found incidental to other activities, but the ratio of marked to unmarked is not known. The marks were turned over to the U. S. Fish and Wildlife Service. These were Columbia River marks and were recovered off Newport and Coos Bay, indicating that Columbia River chinooks do migrate to the south to some extent.

In 1948, 14,213 fish were examined out of a catch of 146,327 fish, and 13 marks were found. Again marks were duplicated on the Sacramento and Columbia Rivers, and it is impossible to assign them to their respective home streams. Five of the fish were recovered in their third year, seven in their fourth year, and one in its fifth year. The Fish and Wildlife Service paid a reward for the recovery of their marks in 1947 and 1948 and they recovered many additional marks from the troll fishery. In 1949, 7,173 chinooks were examined and three marks were found. These were Columbia River fish taken off the mouth of the Columbia River in their third year (2+).

Condition and Mortality of Hooked Fish

In the 72 days spent tagging there were 393 chinook salmon caught. Of these, 10 (2.5 percent) were dead when landed; 243 (61.8 percent) were hooked in the jaw or cheek; 41 (10.4 percent) were hooked in the eye, gills, or throat; and on 99 (25.2 percent) the place of hooking was not noted. Table 8 gives the condition and the place of hooking of the tagged fish. These data do not warrant any conclusions about the relative survival of the different condition categories; however, it may be noted that about the same proportion of fish in category 3 (poor when released) were recovered as those fish in category 1 (good condition when released). There seems to be a tendency for chinooks to be hooked in the gills or eye slightly more often than silvers, and a higher percentage are dead when landed. This is possibly due to the greater depth at which they are usually taken. However, the condition of the fish when released is better, since the chinooks do not fight as strenuously as silvers and are easier to unhook without injury.

TABLE 8. CONDITION OF TAGGED CHINOOK SALMON AT TIME OF RELEASE, OREGON

	Tagged		Recovered		Percent of Number Recovered From Each Tagging Category
	Number	Percent	Number	Percent	
Good (1)	174	78.7	10	90.9	5.8
Fair (2)	29	13.1	0	0.0	0.0
Poor (3)	18	8.1	1	9.1	5.6
	221		11		
Hooked in:					
Jaw, cheek	135	61.1	7	63.6	5.2
Gills, eye	26	11.8	0	0.0	0.0
Unknown	60	27.1	4	36.4	6.7
	221		11		

Relationship Between Fork and Total Lengths

Again measurements were taken with the tail in its normal position and with the rays extended to determine the difference in measurements of length taken by these two methods. Two hundred and twelve measurements with the tail in normal position and 462 measurements with the tail extended were used in calculating the formulae for converting one measurement to the other; the formulae are given in Table 9.

TABLE 9. FORMULAE FOR CONVERTING FORK AND TOTAL LENGTHS OF CHINOOK SALMON

Tail in Normal Position:	TL (cm.) = 1.41281 + 1.04389 FL (cm.)
Tail Extended:	TL (cm.) = 1.71728 + 1.05625 FL (cm.)

The Length-Weight Relationship of Troll-Caught Chinook Salmon

These data were treated in the same manner as for silver salmon. Table 10 gives the empirical data; the points plotted on a semi-log scale showed a definite curve to the line, indicating that the exponential curve would not fit the data; plotting the data on a log-log scale straightened the curve almost to a straight line. The parabolic relationship ($W = AL^b$) was accordingly considered to more accurately depict the length-weight relationship for chinook salmon. It is strange that such closely related fish as the chinook and silver salmon should have different length-weight relationships. These unusal relationships may be related to the fact that the fish were dressed with the heads on when the lengths and weights were taken. Figure 11 (page 67) shows the calculated curves for the two years with the empirical data. The equation for 1947 is $W = .000013126\ L^{3.17008}$, and for 1948 $W = .000009256\ L^{3.24142}$. The chinook, like the silver salmon, were heavier in 1947 for any corresponding length than during the 1948 season.

Size and Age Composition of the Troll Chinook Salmon Catch Off Oregon

Unlike the silver salmon, the catch of which consists largely of one year class with a fairly constant life history, the chinook salmon catch consists of several year classes. It is further complicated by the varying lengths of time the fingerlings stay in fresh water, by the different ages at which they mature and leave the ocean, and by the different growth rates and sizes of the many races.

The technique of stratified sub-sampling was used in determining the age composition of the catch; this method has been used by the International Fisheries Commission in their study of the Pacific halibut and by Fridriksson (1934) studying the cod of the North Atlantic. Many random length-frequency measurements were taken, and scale samples were selected to cover the entire range of sizes. The percentage age composition of each length was determined, and from the random length-frequency distribution the age composition was computed.

The works of Gilbert (1913), Rich (1925), and Mattson (unpublished ms., 1949) were used as criteria in interpreting the scales. They recognized two principal types of early scale growth. Scales

TABLE 10. THE LENGTH-WEIGHT RELATIONSHIP OF TROLL-CAUGHT CHINOOK SALMON, OREGON

1947

Total Length in Inches	Fork Length in Centimeters	Number of Weights	Average Weight	Total Length in Inches	Fork Length in Centimeters	Number of Weights	Average Weight
20	47.31	12	2.9	32	76.51	60	12.6
21	49.74	10	3.5	33	78.94	42	13.0
22	52.18	6	3.3	34	81.39	37	15.1
23	54.61	5	4.5	35	83.81	32	16.3
24	57.04	3	5.0	36	86.24	46	17.8
25	59.48	5	5.7	37	88.68	24	20.2
26	61.91	13	6.2	38	91.11	19	22.3
27	64.34	16	6.6	39	93.54	18	25.4
28	66.78	18	8.1	40	95.98	14	24.8
29	69.21	62	8.7	41	98.41	3	26.2
30	71.64	51	9.7	42	100.84	2	31.0
31	74.08	56	11.1	43	103.28	3	32.3

1948

Fork Length in Centimeters	Number of Weights	Average Weight	Fork Length in Centimeters	Number of Weights	Average Weight	Fork Length in Centimeters	Number of Weights	Average Weight
40	1	1.6	63	192	6.3	86	65	17.4
41	1	2.1	64	233	6.6	87	52	18.3
42	0		65	203	6.9	88	43	18.3
43	0		66	183	7.2	89	55	19.2
44	3	2.3	67	156	7.6	90	52	20.0
45	0		68	135	7.8	91	33	20.4
46	1	2.6	69	121	8.4	92	34	21.4
47	0		70	140	8.9	93	30	22.4
48	6	2.6	71	105	9.2	94	21	22.7
49	2	2.7	72	108	9.8	95	22	24.1
50	6	3.0	73	77	10.0	96	17	25.1
51	2	3.2	74	90	10.7	97	15	26.0
52	9	3.5	75	92	11.0	98	11	26.7
53	9	3.9	76	79	11.5	99	6	26.6
54	5	4.6	77	92	11.8	100	11	28.6
55	10	4.5	78	85	12.6	101	4	28.7
56	17	4.5	79	85	13.0	102	7	30.5
57	18	4.7	80	100	13.7	103	1	29.0
58	33	5.0	81	77	14.2	104	3	28.8
59	57	5.4	82	72	14.7	105	2	34.0
60	93	5.5	83	61	15.4	106	1	32.0
61	151	5.8	84	71	15.8	107	4	33.2
62	220	6.0	85	64	16.4	108	2	43.0

from salmon which went down to the sea during their first year were regarded as having "ocean" nuclei, and those from salmon which stayed in the stream a full year were regarded as having "stream" nuclei. There are, of course, many combinations of these two principal types, including those which apparently spent some time in the estuary or brackish water. In this paper the age is given by the number of annuli counted, i.e., a fish with the age of 3+ would have three annuli and would be in its fourth year.

Three scales from every fish were mounted by the celluloid impression method. They were first studied with the high power of a binocular dissecting microscope, and the three age readings were recorded. They were later examined with a projector, and those three readings were also recorded without reference to the previous readings or the length of the fish. If the six readings agreed as to type of nucleus and age, that was considered to be the age; if they did not agree, the scale was again examined under the microscope and the most logical interpretation accepted. A few were discarded as being too doubtful. Of the 374 scales examined for the years 1946 and 1947, 267 agreed on all six readings, 97 did not agree on all six readings, but the age was determined with no great doubt as to its accuracy; ten were discarded.

The first observations on the age of chinook salmon in the troll catch of Oregon were made in 1919 by Dr. Rich. He compared the ages of chinook salmon found in the ocean off the Columbia

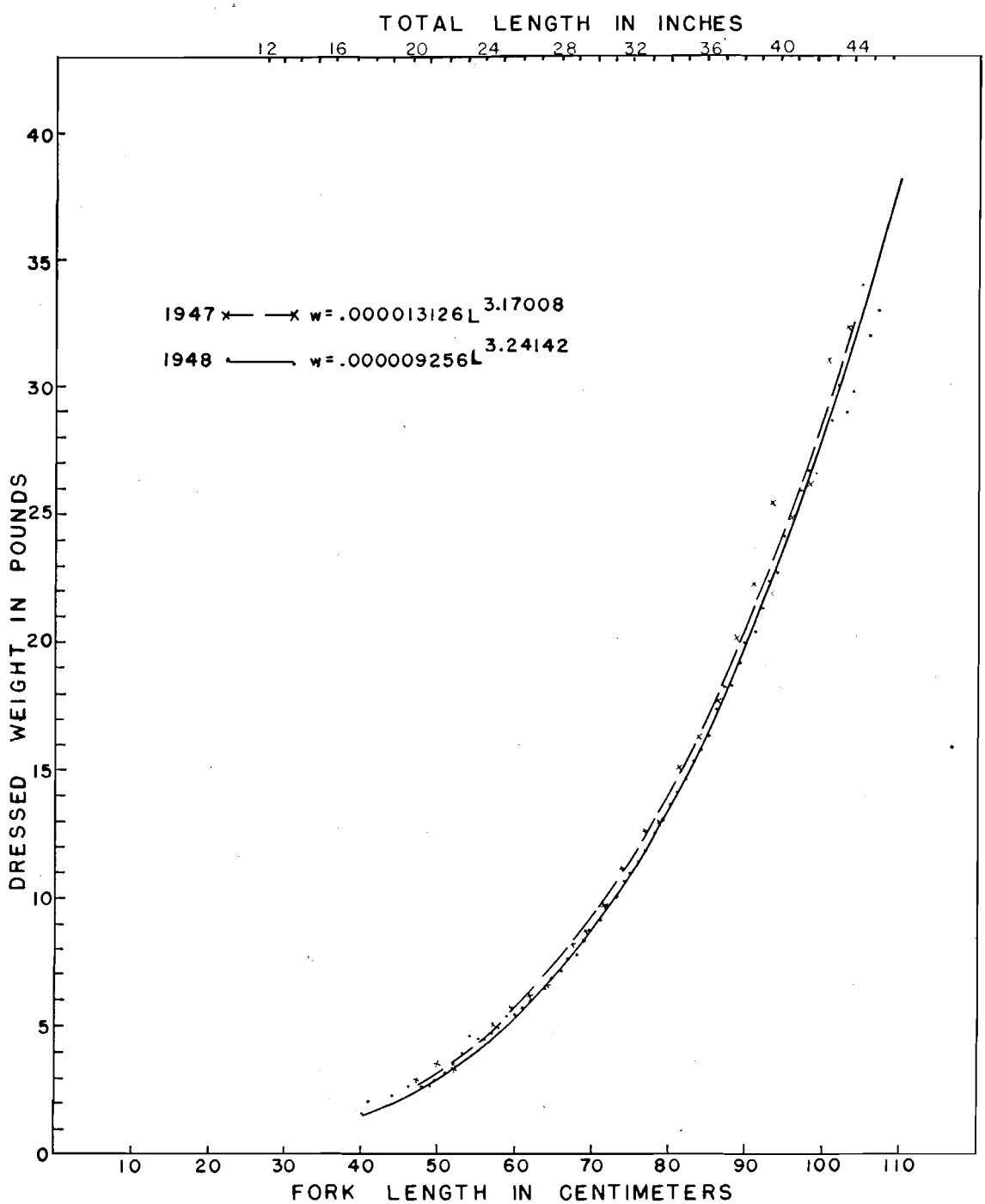

FIGURE 11. The length-weight relationship of troll-caught Chinook Salmon, Oregon.

River with those found inside the river. More recent observations were begun by the Oregon Fish Commission in 1946 at Reedsport. During May, June, July, and September, 362 length-frequency measurements were taken, and 73 scale samples were taken between May 20 and June 11. Figures 12 and 13 show the length-frequency and the percentage age composition of each inch of length for 1946.

As can be seen, the 2+ group is the dominant year class in this sample. The computed percentages of the various year classes in the sample are as follows: 8.51 percent were 1+; 67.13 percent were 2+; 23.65 percent were 3+; and 0.07 percent were 4+. This probably does not represent the true age composition of the catch inasmuch as no samples were taken during August, the

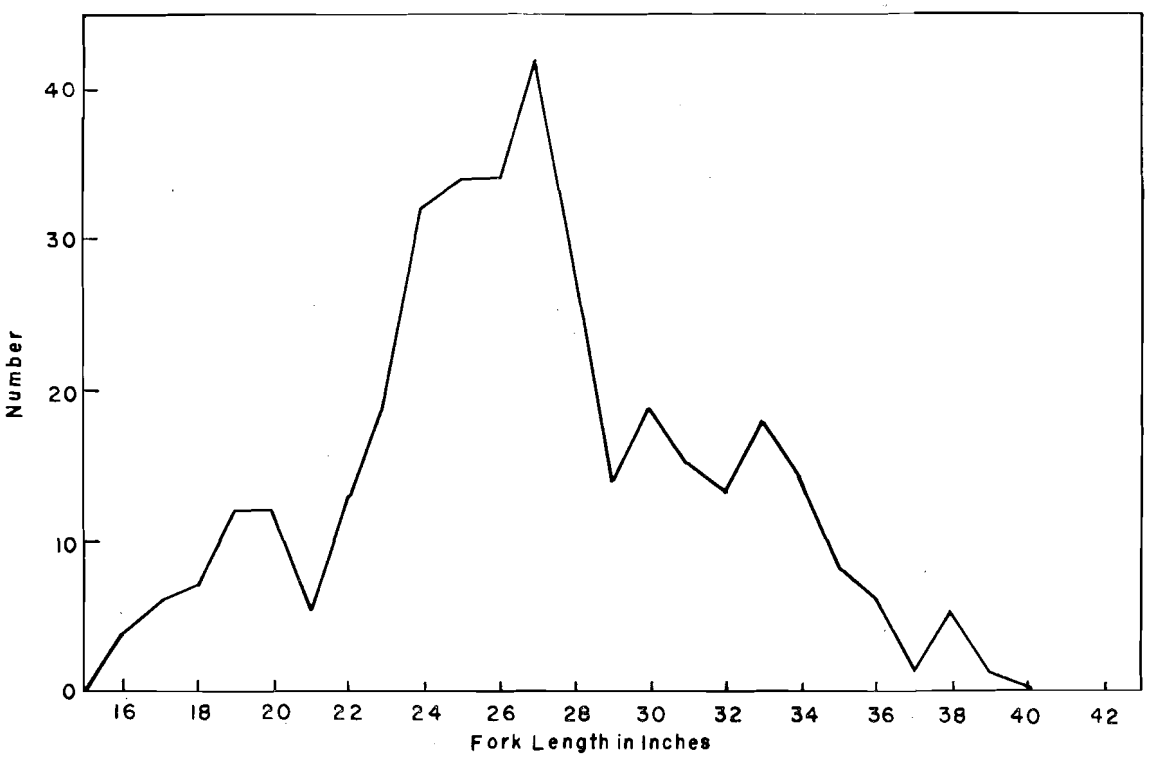

FIGURE 12. Length-frequency of troll-caught Chinook Salmon, sampled at Reedsport, Oregon, in 1946.

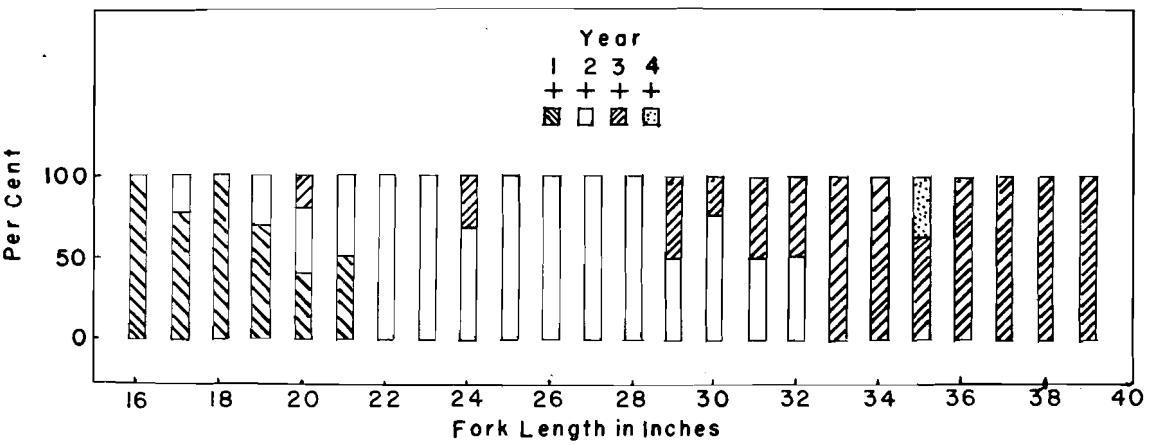

FIGURE 13. The percentage age composition for each inch of length of troll-caught Chinook Salmon in 1946.

sampling may not have been in direct proportion to the catch, and it was confined to one port; but it does indicate the preponderance of small immature 2+ fish found during May, June, July, and September, 1946, off the Umpqua River. Although a size limit of only 20 inches (total length) was enforced, the number of 1+ fish was still relatively small. Due to the small sample, the final analysis is not separated into type of nucleus, but there were 64 (87.7 percent) of the scales which had the ocean type and nine (12.3 percent) which had the stream type of early growth.

In the summer of 1947 and 1948 more observations were made. Samples were taken at Astoria and Newport in 1947 and at Astoria, Newport, and Coos Bay during 1948. There were 534 length-frequency measurements and 301 scale samples taken during July, August, and September of 1947, and 8,008 length-frequencies taken during 1948. The scale samples for 1948 have only been partially analyzed.

Due to the great difference in sizes of chinooks in the different areas and seasons, and the fact that sampling is not proportional to the catch, it is necessary to weigh the sampling by the number

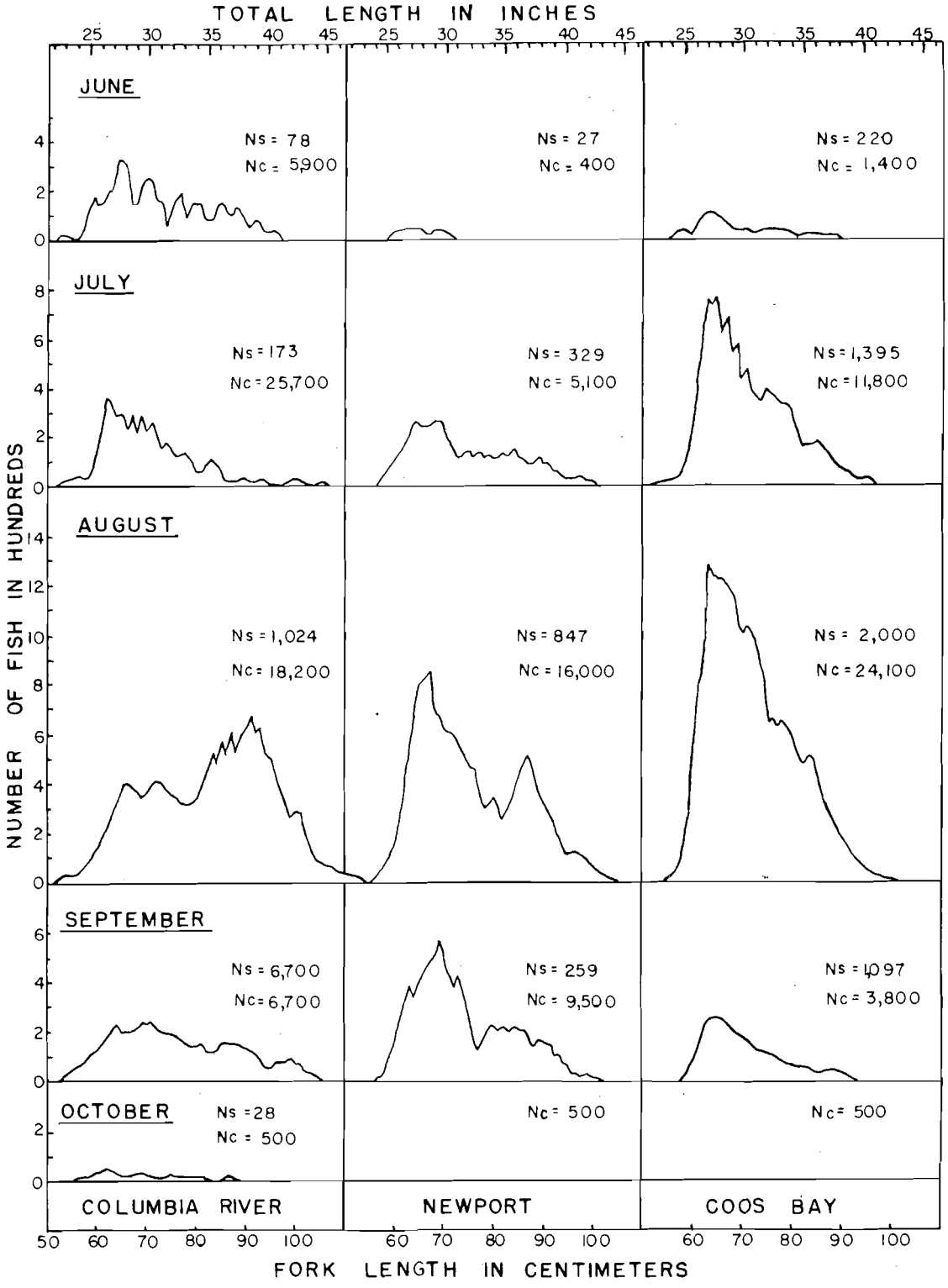

FIGURE 14. Length-frequency of the Oregon and Columbia River troll Chinook Salmon catch in 1948, by area and month.

of fish landed at each port each month in order to get a true picture of the length composition. This has been done for the 1947 and 1948 data. The small sample for 1947 did not warrant breaking down into area or month, but this was done for 1948. Figure 14 shows the variations in the size of the fish and their abundance in the different areas through the 1947 and 1948 season. There seems

to be two dominant size groups present. The Columbia River fishery was characterized by mostly small fish until August when a larger group appeared. Off Newport were found both small and large fish all season with the small fish having a slight majority, while the Coos Bay catch contained a very large number of small fish, and relatively few large ones.

In Figure 15 is shown a comparison of the length-frequencies for 1947 and 1948. Despite the small sample in 1947, it is obvious that there is a considerable difference in the length-composition (and therefore age composition) of the catch between the two years. In 1947 the large mode of fish was at about 74 centimeters, while in 1948 it was at 65 centimeters or just over the legal size limit of 27 inches total length (63.5 centimeters fork length).

The analysis of the scale samples for 1947 has been completed; it appears upon examination of the length-frequency graphs (Figures 12 and 15) and the bar graph showing the proportion of ages at each length for 1947 (Figure 16) that there would be more fish of the 3+ age group present in 1947 than in 1946. Upon calculating the age composition this proved to be the case. The scales were separated as to nucleus, and the percentage age composition of each group is as follows:

Ocean nucleus:	1+— 1.8 percent	Stream nucleus:	2+— 7.4 percent
	2+—33.7 percent		3+—12.2 percent
	3+—32.5 percent		4+— 8.3 percent
	4+— 3.6 percent		5+— 0.5 percent
	71.6 percent		28.4 percent

The percentage with stream nuclei (28.4 percent) was slightly higher than the 22 percent found by Rich (1925).

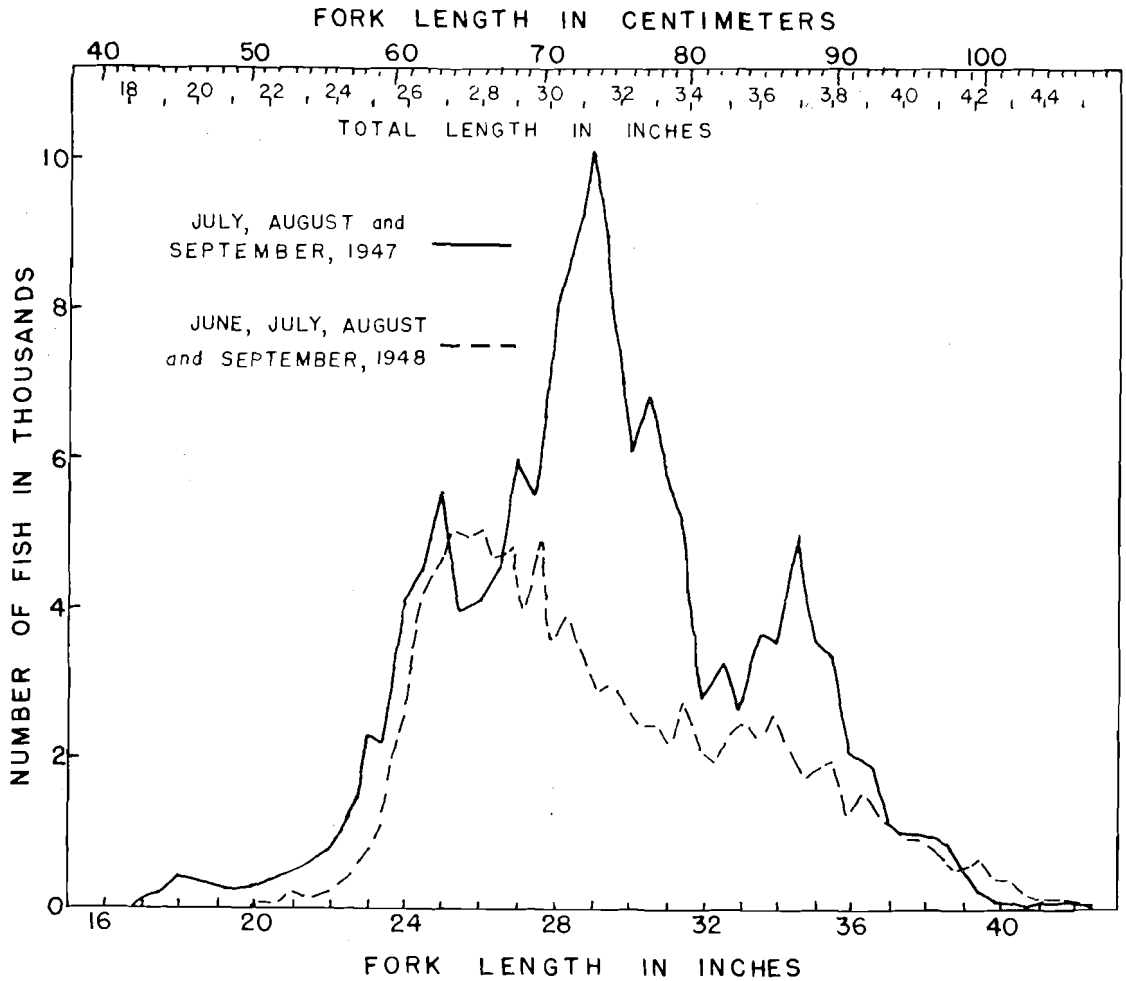

FIGURE 15. Length-frequency of the Oregon and Columbia River troll Chinook Salmon catch for 1947 and 1948.

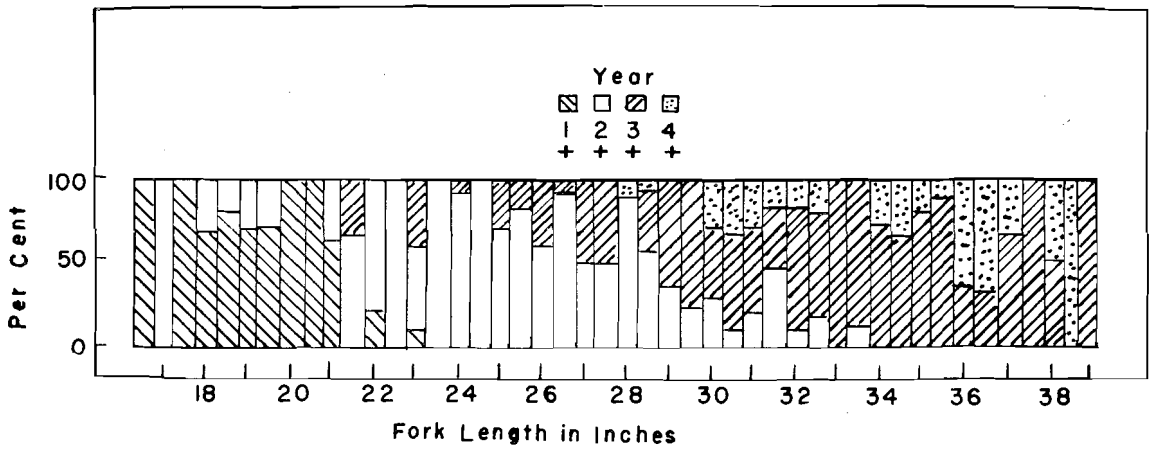

FIGURE 16. The percentage age composition for each half-inch of length for troll-caught Chinook Salmon in 1947.

Although the age analysis of the 1948 catch has not been completed, a comparison of the 1948 length-frequency graph (Figure 15) with the bar graphs of the age composition for each length of the previous two years (Figures 13 and 16) indicates that in 1948 the 2+ class again becomes dominant.

Figure 17 is a series of bar graphs showing the age composition from Rich's (1925) data of 1919 and the 1946 and 1947 Oregon experiments. In 1919, only fish caught off the Columbia River were analyzed, while the 1946 data consisted of a small sample from off the Umpqua River. In 1947 observations were made at Astoria and Newport, but very few Coos Bay fish were included, which have been found to average smaller than in the other areas. For these reasons the graphs are not strictly comparable, but it is believed that they show the general trends of age composition of chinook salmon off the Oregon coast. The preponderance of 2+ fish in 1919 and 1946 is obvious, while in 1947 there was more of the 3+ group present. A situation similar to 1919 and 1946 is expected for 1948, although with fewer of the 1+ group available to the fishery due to the 27 inch size limit. Even with a size limit of only 20 inches, the number of 1+ fish entering the catch during 1946 and 1947 was relatively small.

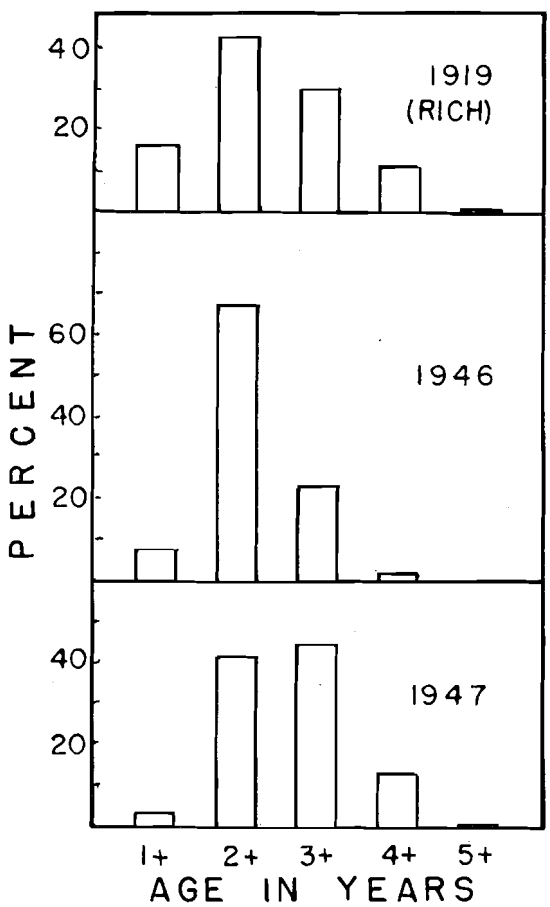

FIGURE 17. Age composition of troll-caught Chinook Salmon sampled in 1919, 1946 and 1947.

These observations on the age composition of the chinook catch are of a preliminary nature. Much more complete observations were made during the summer of 1948, which are now being analyzed, and during 1949 and 1950, scale samples and length-frequencies were taken through the entire troll season from March to November.

The troll chinook catch probably contains fish from every major stream on the Pacific Coast as well as hatchery-reared fish, and one can hardly imagine the variation that occurs in the early life history and growth patterns of their scales. The age and growth of troll caught chinook salmon

is a very complicated problem and will require a great deal more study before the results may be accepted without considerable qualification.

Growth of Chinook Salmon in the Sea

The growth rate is being determined from the analyses of the scales. As would be expected from their complicated life history, there is a great overlap of the year classes, and for that reason they are separated as to the type of first year growth. Figure 18 shows the growth curves for the fish remaining only a short time in fresh water and also for those that remained in fresh water for an entire year. As would be expected, the fish which went down to the sea during their first year average a larger size for the same age than those which stayed in the stream a year. Due to the apparent differences in the growth rate between the years, several more years of data are required before an average growth curve can be determined.

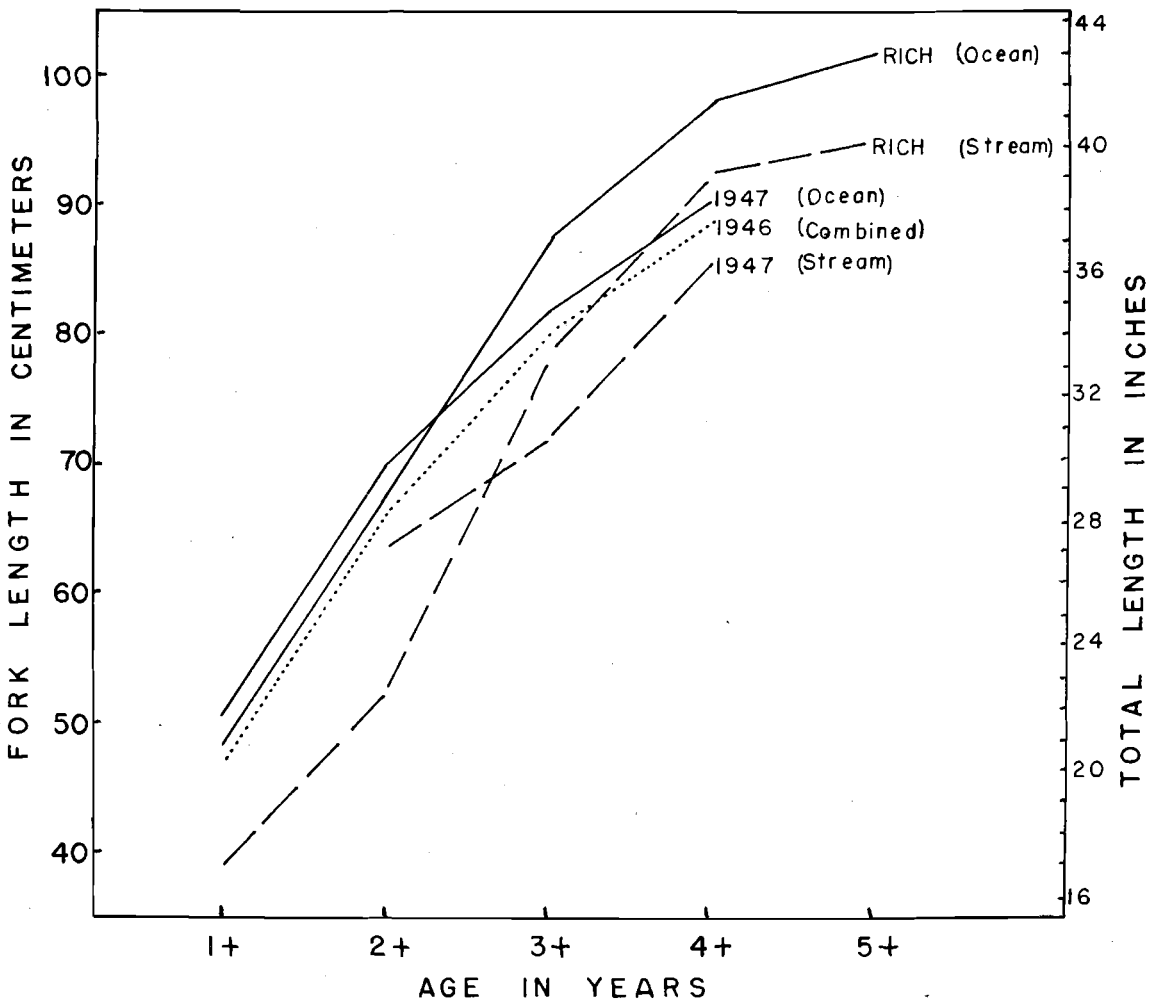

FIGURE 18. Average length at each age of troll-caught Chinook Salmon for 1919, 1946, and 1947.

Average Weight of Troll Caught Chinook Salmon

The average weight of the salmon is easily secured by counting the fish as they are unloaded from the boats and then securing the weight of the load. These data are primarily used for converting the catch statistics, which are in pounds, into numbers of fish, but they also show some of the variations in size of the chinooks during the season and in the different areas.

In 1947 samples were taken at Astoria and Newport, Astoria representing fish taken off the Columbia River and Newport representing the fish taken in the coastal areas. The average weights of all fish checked have been combined by month and are shown in Figure 19. Since the graph does not indicate the number of fish sampled, attention is drawn to the fact that only one day samples

were taken in April and May. June samples were small. In 1948 sampling began in June and continued through October (Fig. 19). In 1949 (Fig. 19) sampling was begun in April and continued through October.

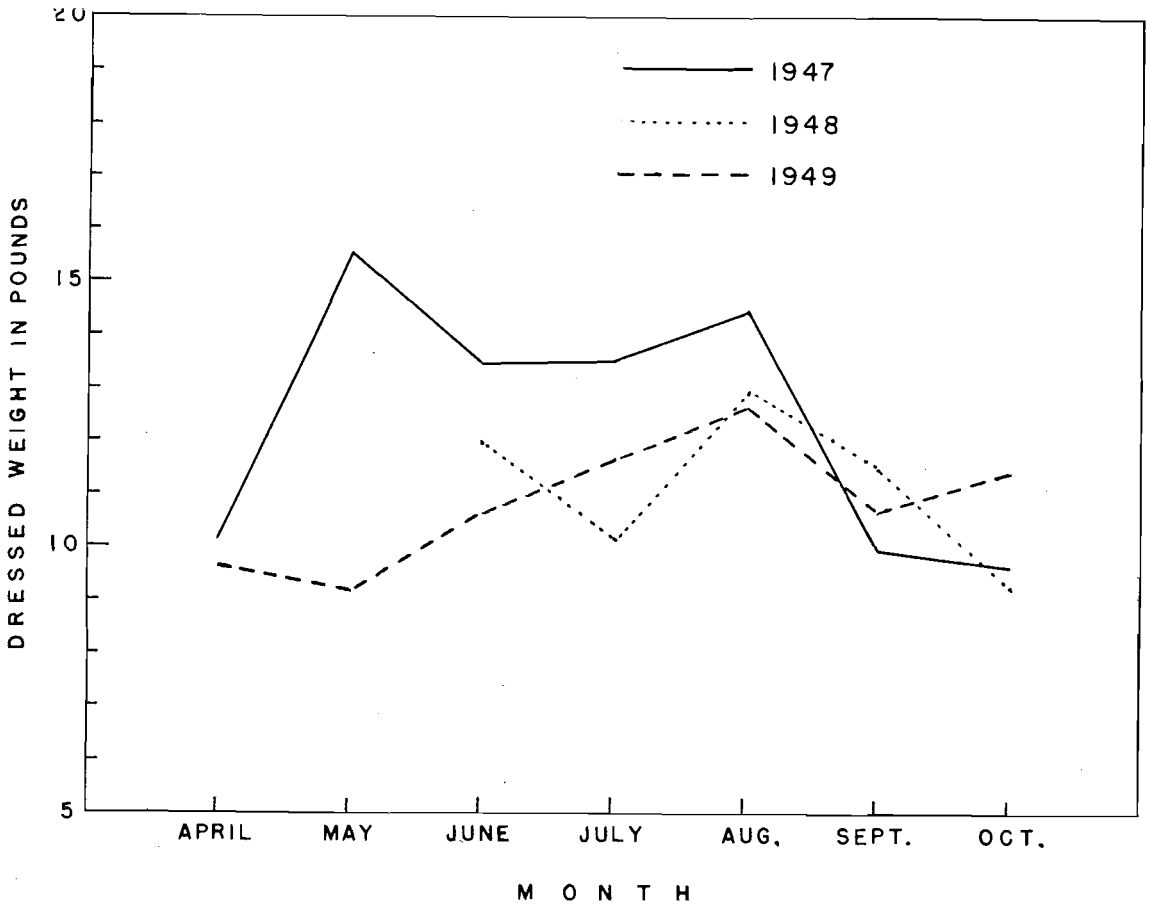

FIGURE 19. The average weight of troll-caught Chinook Salmon in 1947, 1948, and 1949, by month, Oregon.

The data show in general that there is usually a peak in average weight early in the season, but varying considerably as to month of occurrence and ranging from 10 to 15 pounds. Following this early and rather inconsistent peak in average weights, there follows, apparently, a drop followed in every case by a definite and consistent rise in August. After August when the big fall chinook run enters the Columbia River the average weight drops with the departure of the mature fish.

THE OCEAN SPORT FISHERY OF OREGON

Another factor in the ocean catch of salmon is the ocean sport fishery. A few sportsmen have fished for salmon in the ocean for many years, but since World War II the sport has expanded and become highly commercialized. The fishery is prosecuted mainly from the port of Depoe Bay, Oregon. This small picturesque bay on the central Oregon coast harbors a large fleet of sport and commercial trollers. The fishery has branched out in recent years until nearly every port on the Oregon coast now has a few boats which take parties sport fishing on the ocean. The Depoe Bay and Newport fleet consists of large luxurious yachts, but in the other places smaller cruisers are used.

The mainstay of this fishery is the silver salmon, but in the absence of salmon, the boats seek ling cod, rock fish, and halibut. Occasional trips are made for albacore when they approach the shore. Chinook salmon usually swim too deep to be taken in any numbers by the sport gear. In 1949 most of the salmon were caught during August with July and September furnishing some fish.

A preliminary survey of this fishery was made in 1949 to determine the number of fish caught. Log sheets were supplied the skippers of the party boats, in which they recorded the number of fish caught each day.

There were 14 boats engaged in this fishery out of Depoe Bay and Newport. Good records were obtained from 11 of them. These 11 boats caught 363 chinooks and 4,423 silvers during the season, for an average of 33 chinooks and 402 silvers per boat. The three boats without records were presumed to have caught this average number also. The total ocean sport catch in the Depoe Bay-Newport area was calculated to be about 500 chinooks and 6,000 silvers.

Seven small boats operated out of Coos Bay on a part-time charter basis, and they caught 36 chinooks and 517 silvers. Four boats fished out of Winchester Bay, three out of Tillamook Bay, one out of the Siuslaw River and there were possibly several more unnoticed. No data were obtained on their catch, but it was estimated that they landed about the same number of salmon as the Coos Bay fleets or around 50 chinooks and 600 silvers.

Five or six surplus navy DUKW operated through the surf at Pacific City, Rockaway, and Seaside. While these were used primarily as excursion boats, they also took out fishing parties, and at times these vessels caught considerable numbers of salmon. Although their exact catch is not known, it was comparable with or slightly greater than the seven boats at Coos Bay, and it may be roughly estimated in the magnitude of 100 chinooks and 1,000 silvers.

On exceptionally calm days it was possible to take small outboard motor boats out of almost any of the bays along the coast. The catch of these small boats was believed to be of minor importance, compared with the other fisheries.

Frequently immature salmon enter the various bays on feeding migrations, and are subject to a skiff fishery. These migrations seem to be rather sporadic and entirely absent in some years. Large numbers of feeding fish were found in Coos Bay, Winchester Bay, and possibly others in 1949. Mathisen (1950) gives the 1949 summer sport catch at Winchester Bay as 1,200 chinook and 3,800 silver salmon. He was of the opinion that the bulk of the salmon entering the Umpqua estuary in June, July, and early August were feeding and moving along the coast en route to their spawning destinations in other streams. He stated that chinooks marked in the Columbia River have been caught in Winchester Bay in July.

Since this is a bay fishery, it is not included in the ocean catch, although the stocks of fish are probably the same as the ocean fishery takes.

A considerable ocean sport fishery takes place off the Columbia River, but this is rather difficult to evaluate. During the August and September salmon run into the Columbia River, large numbers of cruisers and chartered commercial fishing boats fish in the Columbia River and just outside in the ocean. While fishing primarily for the large chinook salmon, they also take numbers of immature chinook and feeding silver salmon. It would be difficult to tell what percentage of the lower Columbia River sport catch is actually composed of ocean fish, since the same boats fish both inside and outside the river.

Adding together these various estimates, the general magnitude of 700 chinooks and 9,000 silvers were taken by the ocean sport catch on the Oregon coast in 1949. Converted to pounds, on a basis of 13.0 pounds as the average round weight of troll-caught chinooks and 7.8 pounds for silvers, this gives 9,000 pounds of chinook salmon and 70,000 pounds of silver salmon. This estimate does not include the bay fisheries or the outside Columbia River fishery. The 1949 commercial troll season was poor for silver salmon and below average for chinook salmon. In an average or good year, the sport catch would be much greater than this.

At the present time the ocean sport fishery is not of serious consequence compared with the commercial troll fishery, but it is expanding rapidly and promises to become an increasingly important component of the ocean salmon catch in the future.

SUMMARY

1. The Oregon troll salmon fishery developed rapidly prior to World War I to reach a peak of between one and three thousand boats fishing off the mouth of the Columbia River during 1919. The fishery later expanded to the other coastal areas. There has been a decrease in the number of boats fishing, but a great increase in their efficiency. The development of the tuna fishery resulted in the larger trollers fishing for tuna during the late summer and concentrating on salmon during the spring and early summer. There are about 500 trollers which make Oregon ports their base

of operations at the present time. Since 1940 the Oregon troll fishery has landed about 3,000,000 pounds of chinook and silver salmon per year. The troll fishery was practically unregulated until 1948, at which time, preliminary regulations were imposed.

2. Preliminary troll regulations which were imposed since 1948 and altered somewhat in 1949 include a 26 inch minimum size limit and a closed season from November 1 to March 15 on chinook salmon. A closed season for silver salmon extends from November 1 to June 15 to prevent the landing of small silvers during the late spring.

3. This report covers in part the tagging and biological data gathered by the staff of the Oregon Fish Commission during 1946, 1947, 1948 and 1949.

4. There were 506 silvers tagged off Oregon in 1948 and 1949, and 29 (5.7 percent) were recovered. By far the greater percentage were recovered north of their tagging location, indicating a northward migration of silvers in their third and last year to their spawning streams.

5. The recovery of marked silver salmon in the ocean, confirms the findings of the tagging in that early in the season (June) the marked fish were found south of their home streams, and as the season advanced they moved north until during September they were grouped around the mouths of the rivers.

6. The length-weight relationship of troll-caught silver salmon was found to be an exponential type of relationship, and the equation for 1947 is $W = 0.23215 \times 1.0535^{L}$; that for 1948 is $W = 0.27952 \times 1.04949^{L}$.

7. The commercial catch of silver salmon is composed largely of individuals in their third year. There seems to be a considerable difference between the growth rates of different years, but the silvers show an average increase in mean weight from about 4.5 pounds on June first to about eight pounds by November first, dressed weight. They showed an increase in modal length in 1948 from 25.2 inches (total length) in June to 30.4 inches (total length) in November.

8. There were 221 chinook salmon tagged in 1948 and 1949 and eleven recoveries were made. No consistent migration pattern is apparent, but it is apparent that the chinook move both north and south of their natal streams and probably migrate farther than do the silver salmon.

9. The length-weight relationship of the chinook salmon was found to conform to the usual parabolic relationship, $W = AL^{b}$. The equation for 1947 was $W = 0.000013126\ L^{3.17008}$ and for 1948, $W = 0.000009256\ L^{3.24142}$.

10. The age and growth of the troll caught chinook salmon was studied. The 2+ group was the dominant year class in the catch of 1919, 1946, and probably 1948, but in 1947 there was slightly more of the 3+ group. The 3+ group was next in abundance in 1919 and 1946, with the 1+ group age class comprising a relatively small part of the catch. There is a considerable variation in the sizes and ages of chinooks found in the different areas at different times, and also between years.

11. During April and May, trolling is concentrated off the mouth of the Columbia River. Usually there is a slight peaking in average weight in the spring, followed by a decline and a subsequent rise to a peak in August. In all cases average weight dropped appreciably after August.

12. The ocean sport fishery operates mainly out of Depoe Bay and Newport, with smaller fleets out of nearly every port on the Oregon Coast. The estimated ocean sport catch in 1949 was 700 chinooks (9,000 pounds) and 9,000 silvers (70,000 pounds).

ACKNOWLEDGMENTS

This work was carried on under the direction of Donald L. McKernan, Director of Research for the Oregon Fish Commission, with assistance at various times from John T. Gharrett and Donald R. Johnson. George Y. Harry, Jr., and other members of the research staff of the Fish Commission also offered valuable help and advice. Robert Borland was responsible for collecting the data in 1947, and thanks are due to the following individuals who aided with the tagging and sampling: Alfred Morgan, Robert Livingstone, Jr., Eldon Korpela, John Brooke and William Postles. This work could not have been accomplished without the cooperation of the fishermen, fish buyers, and cannery workers.

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RESEARCH REPORT ON THE WASHINGTON STATE OFFSHORE TROLL FISHERY

DONALD E. KAUFFMAN
Washington State Department of Fisheries

BULLETIN 2
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1951

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INTRODUCTION

Since the early days of the troll fishery, the Washington trollers have continually supplied the domestic markets with prime chinook and silver salmon. Through the years the season catches have totaled from six to ten million pounds (see Figure 1) and have been distributed among three main markets: namely, the fresh market, the mild-cure processors, and the canning industry. This fishery has an annual wholesale value of approximately six million dollars, and depends for its existence upon a continuous supply of chinook and silver salmon.

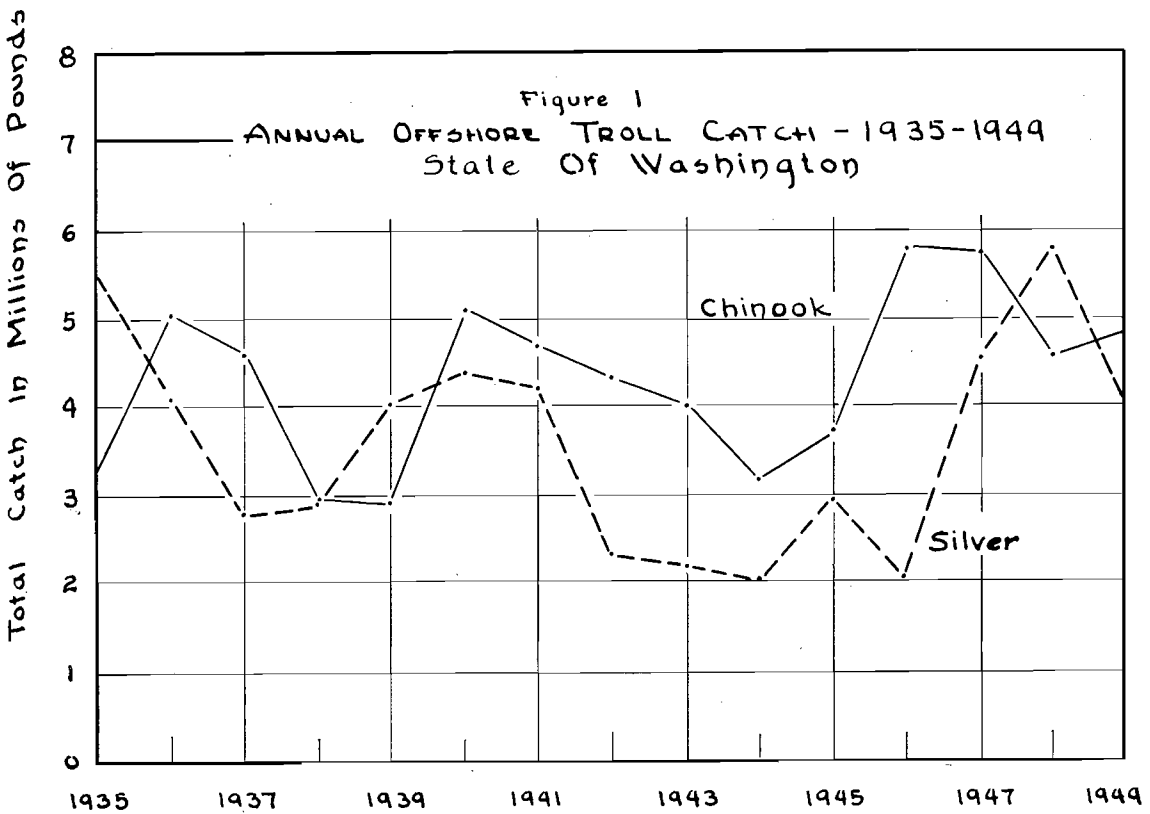

FIGURE 1. Annual offshore troll catch, 1935-1949.

The Department of Fisheries' responsibility is to insure that an annual supply of salmon is available for harvesting. This involves regulating seasons to insure adequate escapement to the streams, patrolling the streams to protect the seed stocks, managing these streams so that the necessary water is available to the spawners and resulting fingerlings, removing and laddering fish blocks to increase the area available to the salmon, and planting artifically reared fish in virgin and depleted areas. In summary, we need to manage the fishery as a crop—harvesting the surplus and nurturing the seed, which is the source of future supply. This briefly is the function of the Washington State Department of Fisheries.

In detail the task is much more complicated, and it is the job of the research division to determine whether the various specific activities of the Department are accomplishing the endpoint of producing adult salmon for the fishery to harvest. To evaluate and to improve the Department's program, the fishery scientist uses certain tools. These tools may be catch statistics, length-weight

data, age and rate of growth data, stream flow and temperature data, and marking and tagging returns. It is with the latter, tagging and marking, that the fishermen play such an important role, for the Department is dependent upon them for the reports of marked and tagged fish. By assessing the contribution of specific streams, the Department is able to measure whether the program is increasing the runs of salmon available to the fishery. For example, marked returns from salmon planted above an obstacle and compared to a similar plant below, illustrate whether the procedure of placing fingerlings above anadromous fish barriers is practicable. This information in many cases is invaluable in combating many salmon destroying dams. Returns of marked salmon from the fishery are also used to improve the planting and rearing techniques of the hatchery so that the artificial and natural produced salmon will both contribute to the fishery.

This report is a progress report of work done by the Department in coordination with other cooperating members of the Pacific Marine Fisheries Commission. Its purpose is to publish all completed work through 1949. Considerable research is in progress at the present time, which is not sufficiently advanced to warrant inclusion in this report.

HISTORY OF THE TROLL FISHERY

Hook and line fishing for salmon by white men was adopted from the Indians who had used this method before the settlers reached the waters of Washington. Cobb (1921) reports that the Indians living at the reservation at Neah Bay had annually caught large numbers of silver and chinook salmon in the Strait of Juan de Fuca by trolling. Cobb says further: "A large number of white fishermen also engage in the fishery at the present time in the same waters, while others troll for the same species, but more particularly silvers, in parts of Puget Sound proper."

It appears, then, that the troll fishery in the early years of the 20th Century was developing simultaneously in the outer waters of the Strait of Juan de Fuca and inside Puget Sound, particularly in the vicinity of Possession Point at the southern tip of Whidby Island.

Cobb (1921) credits the rapid rise of the troll fishery to the demands of the mild-cure processors for chinook salmon in prime condition. Because of these demands, the fishermen began to pursue and catch the salmon throughout the year on grounds far removed from the spawning streams. Previously, the fishermen used nets in the vicinity of the spawning streams during the relatively short period when the spawning migration was in progress.

Licenses for hook and line fishermen were not required prior to 1917 so early catch records are not available. It is known, however, that prior to 1917 fairly large numbers of chinooks and silvers were being taken and the first fairly reliable catch records for 1917 showed that 48,782 chinooks and 75,211 silvers were taken by licensed trollers.

The number of boats trolling in 1918 was estimated by Smith (1919) as 500 off Neah Bay, 20–30 off the mouth of Grays Harbor and upwards of 2,000 off the mouth of the Columbia River. Oregon boats apparently were included in the Columbia River fishery. Smith also reported that in 1919 there were 25–30 trollers fishing off Possession Point in Puget Sound proper. Through the ensuing years the inside trollers gradually turned to more productive grounds offshore, and since about 1937 there have been only occasional commercial trollers fishing inside Puget Sound. At the present time it is estimated that approximately 1,300 boats comprise the Washington trolling fleet.

The trolling vessels of today are, in most cases, a marked improvement over those used by the early fishermen. At the inception of the fishery, small craft of all descriptions were used which were capable only of one day trips during good weather. As the demand for troll-caught salmon increased the fishermen traveled longer distances from their home port as they searched for salmon throughout the year. This resulted in larger, specially designed vessels that could withstand severe weather and carry comfortable accommodations and sufficient ice to last for average trips of nine days duration. It is this type of vessel, 32 to 40 feet in length that makes up the bulk of the trolling fleet today in all of the offshore areas. At the mouth of the Columbia River, about one-third of the boats are converted from the gill-net type of hull of about 28 feet in length. Also included in the fleet are numerous small boats called 'kelpers' that fish the edge of the rugged shoreline near Cape Flattery and along other coastal areas.

Not only have improvements been made in boats, but the gear also has improved to make the commercial troller a very efficient unit. Originally hauled by hand, the main lines are now hauled

by power-driven gurdies on all but the smallest boats, and new materials for lines, lures and hardware add to the life of the gear and its efficiency. The use of sonic depth finders is increasing and most of the larger boats consider it standard equipment. These permit the fishermen to follow easily and accurately the edges of the fishing banks and thereby increasing their efficiency. Radio communication between the boats enables the fleet to quickly learn where the best fishing is located and fast dependable engines allow them to concentrate in these areas rapidly. The methods of rigging the trolling gear and the details of its use are numerous, varying with area and according to the species of salmon sought. See Chapman, Smith and Ellis (1936), pp. 14–18, and Wigutoff (1950) for a good detailed description of the gear and its application.

FISHING AREAS

At various times during the fishing season, the Washington troll fleet fishes the coastal waters from the Columbia River to Cape Flattery and northward along the coast of Vancouver Island to Hecate Strait and Southeastern Alaska. Throughout this extensive area the trollers land their catches at four main buying stations convenient to the fishing grounds. These are Neah Bay at the entrance to the Strait of Juan de Fuca, La Push at the mouth of the Quillayute River, Westport at the entrance to Grays Harbor, and Ilwaco just inside the mouth of the Columbia River. In addition, Seattle, Aberdeen and Hoquiam receive fish from some of the larger boats when the price is more favorable at these cities than at the coastal buying stations. The majority of the fish landed at the coastal stations is trucked to larger cities for processing, the bulk of the catch going to Seattle. The buying stations all maintain groceries, fuel and ice for the convenience of the fishermen.

The concentration of the fleet along the coast is dependent upon the availability of the salmon which changes from time to time during the season. However, these movements of the salmon have for the most part fallen into a definite pattern and distinct fishing areas have developed.

One of the most consistently and heavily fished areas is the waters off the mouth of the Columbia River. Here the Washington and Oregon boats fish from mid-March when the season opens and the spring-run chinooks are available, until late fall when the last of the fall-chinooks and silvers have entered the river. Because the buying station at Ilwaco at the mouth of the river is convenient to the grounds, the majority of the trollers make single day trips, beginning before daylight and returning late in the day. The boats do, however, remain on the grounds for longer periods depending upon fishing conditions.

The next fishing area to the north is centered off the entrance to Grays Harbor and is only a short run from the buying station at Westport. Trollers based here may work many miles north of the entrance and as far south as the Columbia River; however, the southern boundary is usually Willapa Bay. The majority of the trollers fishing in this area are also "day" boats.

Fifty miles north of the Grays Harbor area, the waters off the mouth of the Quillayute River near La Push attract numerous trollers, particularly after June when the silvers are in the vicinity and chinooks are in the Destruction Island area.

The next major fishing area is a center for Neah Bay trollers and embraces a series of separate reefs or banks from Umatilla Reef northward. Generally, several hours' run separates the areas and most are also several hours' run from the buying station at Neah Bay. Consequently, the trollers must stay at sea for several days or more and their activities turn into definite trips. The three most heavily fished grounds are Umatilla reef, a two hours' run from Neah Bay, Swiftsure Bank, also a two hours' run from Neah Bay, and Forty Mile or La Perouse, usually less than five hours from the harbor. Proceeding north along the coast of Vancouver Island, there are several well-fished areas, the main ones being Amphitrite Point, Lennard Island, Sidney Inlet, Rafael Point, Esperanza Inlet and Quatsino Sound. In Hecate Strait the trollers fish the Horseshoe, a horseshoe-shaped bank about two hours east of Ramsey Island, and in the vicinity of Rose Spit. The American trollers mingle with the Canadian fleet in all these British Columbia waters but most stay outside the three-mile limit. Generally, the landings at Neah Bay begin in late May or early June and continue throughout the entire season.

With the discovery in 1937 that albacore could be taken off the Washington coast by trolling methods, the fleet immediately began to take advantage of this new fishery. As a result, each year

a great majority of the fleet turns to albacore fishing in mid-July when the albacore first hit our coast until mid or late August when the fishery ceases. The conversion of gear from salmon trolling to albacore trolling is simple and inexpensive, the boats being well adapted for this changeover.

HISTORY OF THE RESEARCH

Biological studies on troll-caught chinook and silver salmon were initiated as early as 1918 when E. Victor Smith began a study of the troll catch of immature salmon in Washington coastal waters (Smith, 1920). This work demonstrated the rapid growth of the silvers in their third summer and the advantage of delaying their capture until a larger size is reached. From the 1935 fishery additional length-weight data on silvers and a brief analysis of the food habits of chinooks and silvers were published (Chapman, Smith, Ellis, 1936). In the interval from 1936 to 1948, studies were limited to infrequent sampling at the coastal buying stations.

Marking experiments were first conducted by the Department in 1899 at the Kalama hatchery. These early experimenters merely punched V-shaped notches in the caudal fin and the results were subject to so many unknown factors that it was difficult to draw definite conclusions. In the following years very few salmon were marked until the brood years of 1937, 1938 and 1939. Recoveries in general were limited to streams, although in 1940 and 1941 the various fisheries were sampled. The war interrupted the program and it was not resumed until 1949 when 456,114 chinook and 121,138 silver salmon were liberated from four different streams tributary to Puget Sound. In 1950, approximately 900,000 chinooks and 500,000 silvers were marked. These salmon along with those marked by other aganeices are and will be available to the fishery. The coordination of the Pacific Marine Fisheries Commission in allocating marks between the member states to avoid duplication and subsequent confusion has greatly helped the marking program.

The first tagging experiment was begun on a small scale in 1948 to study the movements of the two species of salmon that comprise the catch of the Washington trolling fleet. This was followed by an expanded program in 1949 when considerably more fish were tagged and from which some conclusions can be drawn. The results of both experiments are included in this report and the tag returns are complete through 1950.

ACKNOWLEDGMENTS

The Department is grateful to those commercial trollers who were generous enough to accommodate the biologists during the tagging operations, and wishes to thank all the members of the industry who assisted in returning tags, or facilitated our sampling teams at the various buying stations.

Much credit is due Mr. Robert Parker, former biologist with the Department, who did the 1949 tagging and prepared the initial report. Other biologists assisting in 1949 were Quentin Edson and Emanuel LeMier.

TAGGING METHODS

All of the fish tagged were taken by a commercial troller with standard gear except in 1949 when barbless hooks were used. Experiments revealed that barbless hooks, actually standard hooks with the barb bent down, were equally as efficient as the barbed ones and permitted easy removal from the fish. Fish under the legal size limit were secured without cost and the legal fish were paid for at current prices.

The large chinooks were landed with a dip net while fish of 10 pounds or less were lifted aboard by the leader. Prior to tagging, the fish were held in a canvas-lined live box that was supplied with a constant stream of seawater. Limited available space prevented the holding of the fish for any length of time after tagging. The chinooks were tagged while in the live tank, for it was found that by holding the nose of the fish against the end of the tank and placing the left hand under the ventral fins, exerting slight upward and anterior pressure, the fish would remain quiet during the tagging operation. The silver salmon would not respond in the same manner so they were held against the tagger's chest with the fish's head under the left arm. Plastic Petersen-type tags were used, joined with pure nickel pins and placed at the margin of the flesh immediately below the midline of the dorsal fin.

There were no rewards offered for the return of tags, and stream surveys were not attempted, so the recovery program was dependent upon the close cooperation of the fishing industry.

Since the capture of the fish with hook and line could not be accomplished without a certain amount of injury, each fish was carefully observed for bodily damage and a note made of its behavior as it was liberated. The tagged fish which suffered serious damage and were not expected to live have not been included in this report.

1948 TAGGING — CHINOOKS

In 1948 the Washington Department of Fisheries carried out its first off-shore salmon tagging experiment. The chinooks tagged in most instances, were immature and had an average length of approximately 19 inches. Three tagging areas were involved, the first extending from Swiftsure Bank to Lennard Island, the second defined as Umatilla Reef, and the third extended from Grays Harbor to the Columbia River mouth. The time of tagging varied in each area between May 23 and September 19. Table 1 summarizes the results of these taggings.

TABLE 1. SUMMARY OF CHINOOK TAGGING BY AREA, 1948

Area	Number Tagged	Number Returned	Percent Return
Swiftsure-Lennard Island	88	11	13
Umatilla Reef	34	5	15
Grays Harbor-Columbia River	32	2	6
TOTALS	154	18	12

Swiftsure-Lennard Island Area

The Swiftsure-Lennard Island area includes the 50 miles of coastline extending from Swiftsure Bank at the entrance to the Strait of Juan de Fuca northwest to Lennard Island on the Vancouver Island coast. It is made up of numerous trolling banks frequented by both Canadian and American fishermen. Eighty-eight chinooks were tagged at scattered intervals from May 23 to September 19, the greatest portion (81 percent) were released in the region of Swiftsure Bank. Eleven tags, or 13 percent were returned, and the details of the recoveries are tabulated in Table 2.

TABLE 2. RECOVERIES FROM THE SWIFTSURE-LENNARD ISLAND TAGGING AREA

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Recovery Location
W6005	24.0	5/24	6/30/48	37	0	Cape Beale, B. C.
W6007	24.0	5/24	6/30/49	371	0	Port Albion, B. C.
W6011	23.0	5/26	5/20/49	328	30	South Bank, Ucluelet, B. C.
W6040	15.0	6/14	9/ 2/48	111	345	Celilo Falls, Columbia River
W6093	16.0	6/16	7/28/48	42	23	Barkley Sound, B. C.
W6097	17.0	6/16	9/28/50	834	115	Fraser River, B. C.
9956	20.0	9/17	9/25/50	738	145	Columbia River
9957	18.0	9/17	9/15/50	728	17	Cape Beale, B. C.
9960	21.0	9/17	7/ 6/50	657	125	Kyuquot Sound
9962	20.0	9/18	8/ ?/50	581	90	Lopez Island, Washington Sound
9969	17.5	9/19	5/ 6/49	229	30	Ucluelet, B. C.

Six or 55 percent of the tags were recovered near the tagging area while two were recovered in the Columbia River, one in the Fraser River and one in Washington Sound. A single recovery was made 125 miles northwest of the tagging area at Kyuquot, B. C. As would be expected from the tagging of immatures, 72 percent of the recoveries were made in one or two seasons following the tagging.

Umatilla Reef Area

This area is defined approximately as enclosed by a circle of ten mile radius centered at the Umatilla Lightship, and is one of the productive trolling areas. Tagging occurred here at infrequent intervals from June 11 to September 19, the majority released in late August and mid-September. Thirty-four chinooks were tagged and 5 or 15 percent recovered. Table 3 gives the details on the recoveries.

TABLE 3. RECOVERIES FROM THE UMATILLA TAGGING AREA

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Recovery Location
W6110	17.0	6/22	5/20/49	332	50	Cape Elizabeth
9928	20.5	8/29	8/30/49	366	20	4 miles west Port Renfrew
9931	20.0	8/29	6/ 7/50	647	60	Lennard Island
9932	19.0	8/29	9/18/50	750	140	Columbia River
9945	20.5	9/16	6/11/50	633	40	Southwest Bank

Because of the long periods of time elapsing between tagging and recovery, it is impossible to trace the movements of these fish. The results indicate, however, that these immature chinooks tagged in the Umatilla Reef area are available to the fishery both north and south of the area after one or two years of freedom, and further that the Columbia River contributes stocks of chinooks to this trolling area.

Grays Harbor-Columbia River Area

This area includes the 35 miles of coastal waters between Grays Harbor and the Columbia River and is heavily fished by trollers from Westport and Ilwaco. Most of the vessels are day boats, selling their catch at the close of each day. Tagging was accomplished between June 18 and 27, and on August 31. Thirty-two fish were tagged and 2 recovered, a return of 6 percent. Both of the recoveries were taken during the tagging season, one after 13 days that showed only local movement and one that was out 66 days that had moved 35 miles north to Copalis Rocks. These data are too few to establish any pattern of movement. Table 4 gives the pertinent data on the recoveries.

TABLE 4. RECOVERIES FROM THE GRAYS HARBOR-COLUMBIA RIVER TAGGING AREA

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Recovery Location
W7005	20.0	6/19	7/ 2/48	13	15	Columbia River mouth
W7008	20.0	6/19	8/24/48	66	35	Copalis Rocks

1948 TAGGING — SILVERS

Thirty silver salmon were tagged at the same time as the chinooks and in the same areas, 24 in the Swiftsure-Lennard Island area, 4 in the Umatilla area, and 2 at the mouth of the Columbia River. These fish were in their third year and averaged 18 inches in length. Table 5 summarizes the silver salmon tagging.

TABLE 5. SUMMARY OF SILVER TAGGING BY AREA, 1948

Area	Number Tagged	Number Returned	Percent Return
Swiftsure-Lennard Island	24	4	17
Umatilla Reef	4	0	0
Grays Harbor-Columbia River	2	1	50
TOTALS	30	5	33

Considering only the larger group of fish tagged, 4 have been recovered for a percentage return of 17. These few recoveries showed generally a movement eastward into the Strait of Juan de Fuca. Although one recovery came from Prince Rupert, B. C., it is not clear if the fish was actually caught nearby or recovered at a processing station. See Table 6 for the details of the recoveries from the Swiftsure-Lennard Island tagging. The single recovery from tagging off the Columbia River mouth was out 33 days and showed very little migration.

TABLE 6. RECOVERIES FROM THE SWIFTSURE-LENNARD ISLAND TAGGING AREA

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Recovery Location
W6019	19.0	5/29	9/16/48	110	115	Lummi Island
W6059	20.0	6/15	9/20/48	97	100	West Beach
W6065	18.0	6/15	10/ 9/48	116	415	Prince Rupert
W6078	18.0	6/15	10/18/48	125	130	Fraser River

1949 TAGGING — CHINOOKS

In conjunction with the Pacific Marine Fisheries Commission, the department concentrated its efforts in 1949 on tagging chinook and silver salmon at two offshore stations adjacent to Cape Flattery. The areas selected were identical with the two northern areas used in 1948, Swiftsure Bank to Lennard Island and the vicinity of Umatilla Reef. The average size of the tagged fish was nearly 30 inches, considerably larger than those used in 1948. The period of tagging extended from May 24 to July 19. Table 7 summarizes the results of these taggings by area.

TABLE 7. SUMMARY OF CHINOOK TAGGING BY AREA, 1949

Area	Number Tagged	Number Returned	Percent Returned
Swiftsure-Lennard Island	315	58	18
Umatilla Reef	166	15	9
TOTALS	481	73	15

Swiftsure-Lennard Island Area

The tagging operations were carried out in this area between May 24 and June 8. Of the 315 chinooks tagged, 58, or 18 percent have been recovered that showed both little movement and wide distribution. The details of the recoveries are listed in Table 8.

Sixty-two percent of the recoveries showed little or no dispersion, of which 44 percent were recaptured in 1949 and 56 percent in 1950. The high percentage of fish recovered showing little or no movement may be attributed in part to the preponderance of immature chinooks tagged, for 60 percent of those tagged did not measure more than 29 inches and would be considered as 3 year-olds. The tag returns then indicate that the general tagging area is a feeding ground for the immature chinook salmon.

The recoveries which demonstrated movement came from points northwest, east and south (see Figure 2). Five returns or 31 percent came from the Columbia River, while nine returns came from the northwest and eight from the east. Of the nine from the northwest, five came from the vicinity of Esperanza Inlet, two from Esteban Point and one each from Cape Scott and Bajo Point. Of the eight returns from the east, the Fraser River contributed six, the remainder equally divided between Cowichan Bay and San Juan Island. If we consider the returns from the northwest to be a result of a general feeding movement along the coast of Vancouver Island, then the main migration of chinooks tended to be toward the Fraser River.

TABLE 8. RECOVERIES OF CHINOOK SALMON TAGGED IN THE SWIFTSURE-LENNARD ISLAND AREA IN 1949
(Recoveries through November, 1950)

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Area Recovered
B 4	27.0	5/24	9/27/49	125	140	Columbia River
10	23.5	5/25	9/20/50	483	57	Lennard Island
34	25.0	5/25	7/31/50	431	93	Esperanza Buoy
36	27.5	5/25	5/19/50	358	93	Esperanza Buoy
37	30.0	5/25	5/18/50	357	5	Port Albion
40	28.0	5/25	8/30/49	96	30	Cape Flattery
49	25.5	5/26	4/25/50	333	10	Amphitrite Point
51	27.0	5/26	4/30/50	338	9	9 miles southwest Cape Beale
66	30.0	5/28	7/11/49	43	10	4 miless outhwest Amphitrite Point
68	39.5	5/28	9/21/49	115	345	Celilo Falls, Columbia River
78	31.0	5/28	6/12/49	14	10	Amphitrite Point
79	27.5	5/28	8/22/49	85	10	Amphitrite Point
83	27.0	5/28	8/12/50	440	10	Amphitrite Point
84	25.0	5/28	7/15/50	412	29	9 miles south by west Lennard Island
87	32.0	5/29	5/ 8/50	343	28	10 miles south Lennard Island
101	25.0	5/29	7/12/50	408	0	Amphitrite Point
102	27.5	5/29	5/24/50	359	10	West end La Perouse Bank
104	25.5	5/29	5/12/50	347	10	Amphitrite Point
111	26.5	5/29	9/28/50	487	155	Fraser River (Silverdale)
130	27.0	5/29	8/29/49	91	25	Swiftsure Bank
135	24.5	5/29	5/27/50	362	10	West end La Perouse Bank
140	32.5	5/29	9/24/49	117	130	Cowichan Bay, B. C.
145	22.5	5/30	10/17/50	505	85	9 miles southwest Esperanza
150	24.5	5/30	8/23/49	84	35	Cape Flattery
157	35.0	5/30	9/27/49	119	155	Fraser River
167	26.5	5/30	5/ 5/50	339	10	Lennard Island
174	27.5	5/30	6/18/49	18	10	Amphitrite Point
191	26.5	6/2	7/ 1/49	20	0	Amphitrite Point
198	21.0	6/2	8/13/49	71	30	Pachena Point
201	30.5	6/2	5/17/50	348	0	La Perouse Bank
204	27.0	6/2	6/ 6/50	368	38	Lennard Island
208	40.0	6/2	6/28/49	25	105	Esperanza Inlet
210	29.5	6/2	8/26/49	84	125	San Juan Island
217	28.5	6/2	8/30/49	88	50	Esteban Point
227	34.5	6/3	7/26/49	52	90	Esperanza Inlet
228	32.5	6/3	?/49	?	10	Amphitrite Point
230	28.5	6/3	8/21/49	78	0	La Perouse Bank
232	35.5	6/3	9/14/49	102	150	Fraser River
234	26.0	6/3	8/ 5/50	427	30	Cape Flattery
245	26.0	6/3	8/18/49	75	40	Cape Flattery
246	32.5	6/3	6/16/49	12	150	Fraser River
253	35.0	6/3	9/15/49	103	150	Fraser River
256	34.0	6/3	6/15/49	11	10	Amphitrite Point
273	33.5	6/7	7/22/49	44	30	Cape Beale
282	26.0	6/7	9/ ?/49	?	175	Columbia River
288	30.0	6/7	7/20/49	42	35	Esteban Point
289	31.0	6/7	9/15/49	99	180	Columbia River
291	28.5	6/7	8/ 7/49	60	0	Lennard Island
292	27.5	6/7	7/ 6/49	28	155	Fraser River
325	28.0	6/7	4/20/50	316	10	La Perouse Bank
326	28.0	6/7	7/ 2/50	389	130	Cape Scott
344	29.0	6/8	8/10/49	62	105	Bajo Point
346	21.0	6/8	9/15/50	464	0	North of Swiftsure
347	23.0	6/8	6/ 9/50	365	15	Amphitrite Point
349	31.0	6/8	7/12/49	33	0	Carmanah Point
353	24.0	6/8	9/11/50	460	345	Celilo Falls, Columbia River
354	25.0	6/8	6/ 3/50	359	20	Lennard Island
366	25.0	6/8	6/16/50	372	15	Amphitrite Point

Umatilla Reef Area

In this area, 166 chinooks were tagged between June 28 and July 19. Fifteen have been recovered, a return of nine percent. The details of the recoveries are listed in Table 9.

Recoveries from fish tagged in the Umatilla area demonstrated widespread distribution, 93 percent showed definite movement, some traveling long distances (see Figure 3). A single recovery was made in the tagging area and this fish had been free for only 18 days. Eight chinooks, representing 53 percent of the total recovered were taken south of the tagging area, five in the Columbia

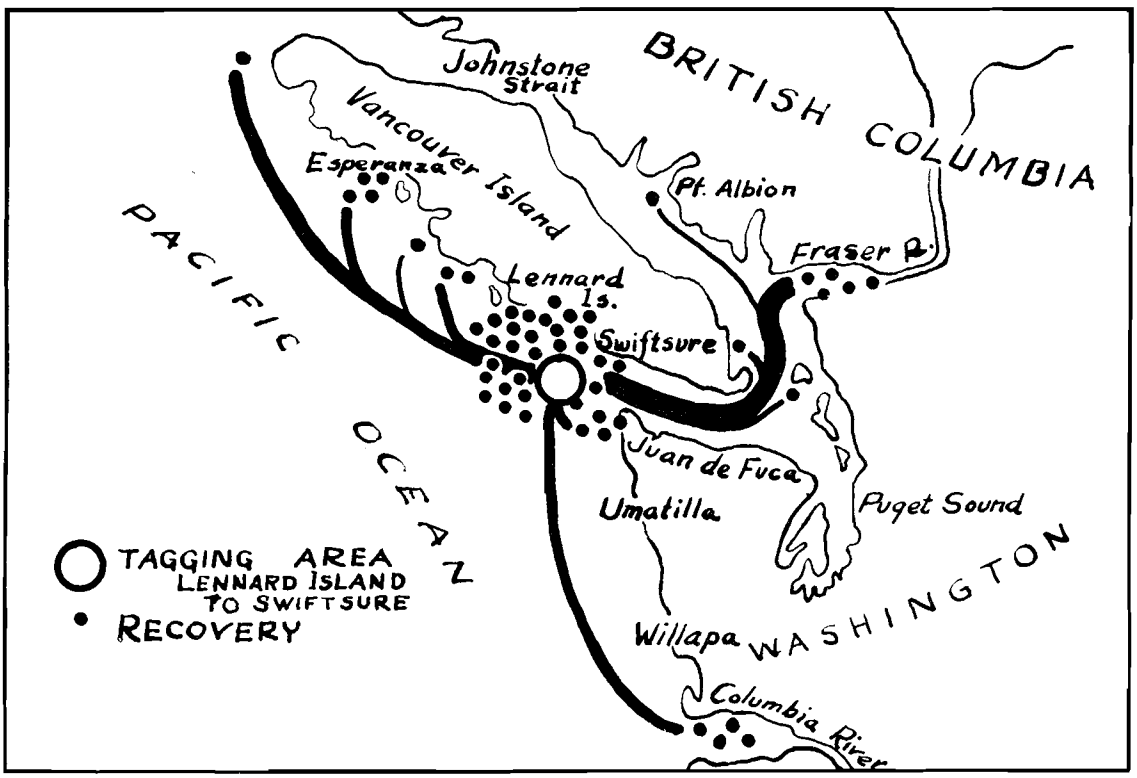

FIGURE 2. Dispersal of Chinook Salmon tagged in the Swiftsure-Lennard Island Area, 1949.

TABLE 9. RECOVERIES OF CHINOOK SALMON TAGGED IN THE UMATILLA AREA IN 1949
(Recoveries through November, 1950)

Tag No.*	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Area Recovered
Series						
B 393–4	31.0	6/29	8/26/49	57	130	Columbia River
449–0	30.0	6/29	8/23/49	54	135	Columbia River
475–6	33.0	6/30	8/16/49	46	140	Columbia River
499–0	32.0	6/30	11/ 2/49	124	645	Sacramento River
503–4	32.5	6/30	8/22/49	52	90	Cape Shoalwater
533–4	31.5	6/30	8/28/49	58	100	Point Wilson
561–2	34.5	6/30	9/20/49	81	140	Columbia River
587–8	36.0	6/30	7/19/49	18	0	Umatilla
591–2	32.5	6/30	8/28/49	58	125	Columbia River
605–6	29.5	7/1	10/29/49	119	140	Duwamish River, Seattle
611–12	29.5	7/1	9/ 5/49	65	135	Elliott Bay, Seattle
627–8	27.5	7/1	8/18/50	412	95	Willapa Bay
647–8	25.5	7/1	9/ 6/50	432	160	Puyallup River
657–8	28.0	7/17	9/13/49	57	125	Esperanza Inlet
659–0	28.0	7/17	5/27/50	313	45	Amphitrite Point

* Both discs attached were numbered, i.e., B393 on one side and B394 on the other.

River, two at Willapa Bay and one as far south as the Sacramento River in California. Four, or 27 percent showed easterly and then southerly movement into the Puget Sound area. Two of these were recovered in Elliott Bay at Seattle, one had reached only to Point Wilson at the entrance to the Sound while the fourth was recovered from the Puyallup River in southern Puget Sound. Two chinooks were recovered northwest of the tagging area, one at Amphitrite Point and one off Esperanza Inlet.

According to this distribution of the recoveries, the main direction of migration was southerly to coastal streams and to a lesser extent east and south into Puget Sound. Although 33 percent of

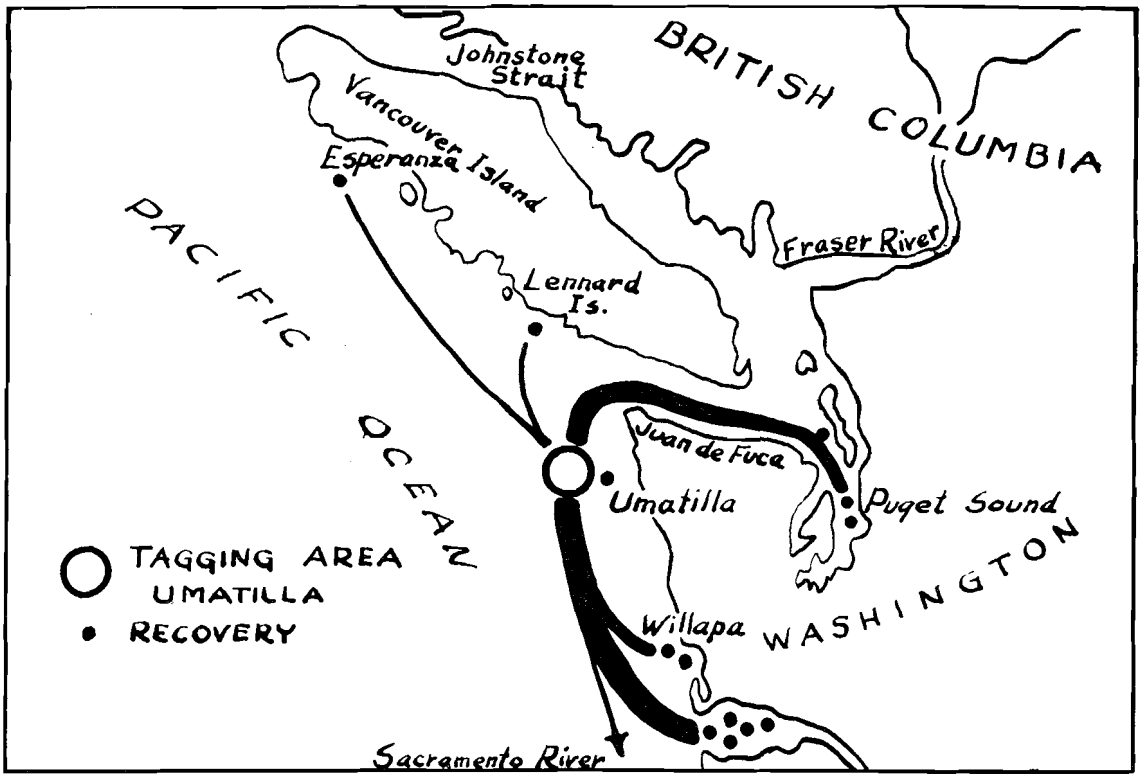

FIGURE 3. Dispersal of Chinook Salmon tagged in the Umatilla Reef Area, 1949.

the fish tagged were immatures less than 29 inches long, the absence of recoveries from the vicinity of the tagging area in the face of heavy fishing intensity seems to indicate that the area around Umatilla Reef has a transient type of chinook population that is moving predominantly southward and to a lesser extent into the Strait of Juan de Fuca.

1949 TAGGING — SILVERS

Thirty-five silver salmon were tagged in the Swiftsure-Lennard Island area between May 29 and June 7. Eleven recoveries have been made for a return of 31 percent. Their size range when tagged was 20 to 27 inches. The details on the recoveries are included in Table 10.

TABLE 10. RECOVERIES OF SILVER SALMON TAGGED AT LENNARD ISLAND IN 1949
(Recoveries through November, 1950)

Tag No.	Fork Length Inches	Date Tagged	Date Recovered	Days Out	Minimum Miles Traveled	Area Recovered
B 276	24.0	6/7	8/ 6/49	59	280	Camp Point, Johnstone Strait
B 284	22.5	6/7	7/23/49	45	425	Cape Naden, Graham Island
B 290	22.0	6/7	8/26/49	79	45	Swiftsure Bank
B 294	23.5	6/7	10/ 7/49	121	150	Stuart Channel, B. C.
B 297	23.5	6/7	8/ 4/49	57	95	Cape Cook, B. C.
B 299	23.5	6/7	9/27/49	111	60	Cape Flattery
B 304	22.5	6/7	12/ ?/49	175	170	Lillooet River, B. C.
B 305	23.0	6/7	7/17/49	39	100	Destruction Island
B 309	24.0	6/7	11/ 2/49	147	175	Naselle River, Willapa Bay
B 313	22.0	6/7	5/ 5/50	331	380	Butterworth Rocks, B. C.
B 336	23.0	6/7	9/15/49	99	60	Cape Flattery

Although the numbers tagged were small, the resultant recoveries showed a very interesting dispersion characterized by long migrations in relatively short periods of time (see Figure 4). The

best example was the silver that traveled 425 miles in 45 days for an average movement of 9.4 miles per day. Ninety-one percent of the recoveries were taken in 1949 within 39 to 175 days after tagging. All of the silvers recovered were tagged on the same day within an area of four square miles and showed movement as far south as Willapa Bay and as far north as Cape Naden on the north coast of Graham Island, British Columbia. Other recoveries from British Columbia included Johnstone Strait, Stuart Channel, Cape Cook, Lillooet River of the Fraser system and Butterworth Rocks near Dixon Entrance. A single recovery was made off the Washington Coast near Destruction Island and three were recovered in waters adjacent to the tagging area. This wide dispersion shown by the silvers tagged on the same day and from the same area is evidence that the waters between Swiftsure Reef and Lennard Island are a mixing ground for silvers from very diverse river systems.

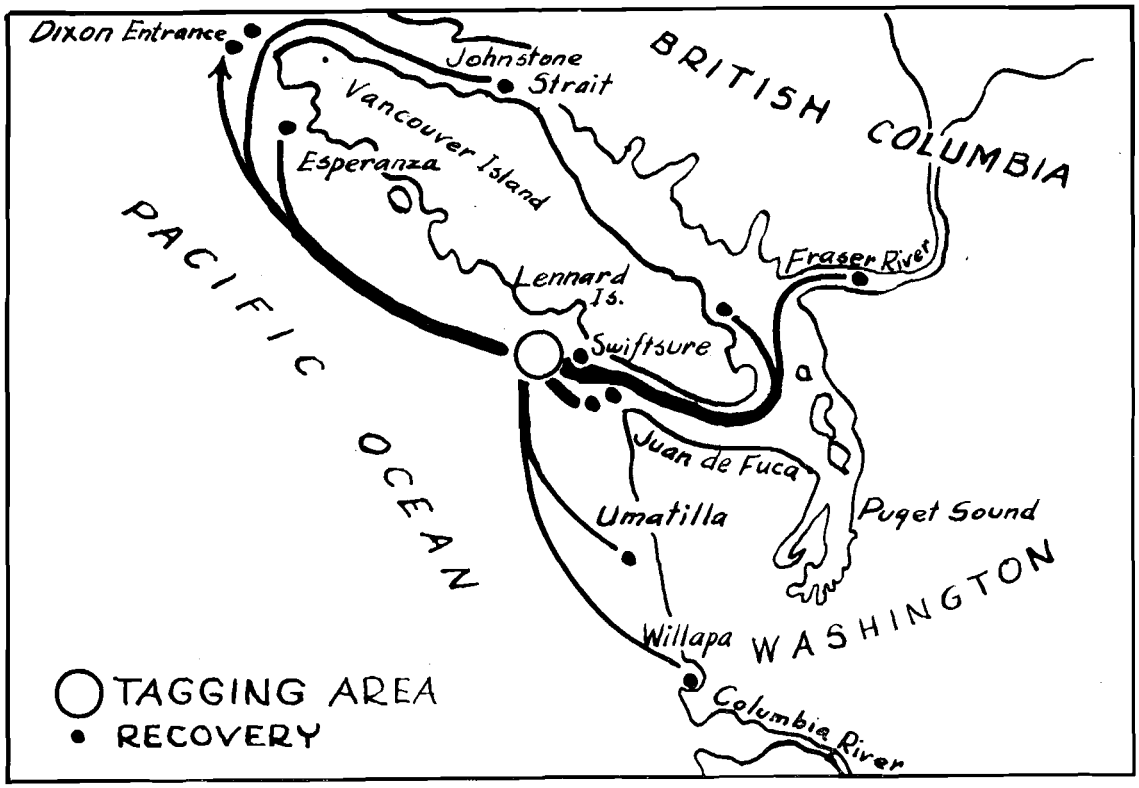

FIGURE 4. Dispersal of Silver Salmon tagged at Lennard Island Area, 1949.

SPORT FISHERY

The sport fishery for salmon in Washington waters has been growing very rapidly in recent years and at present is one of the most valuable fisheries in the State from both a recreational and economical standpoint. No license fees are required and there are few restrictions other than catch limits.

This fishery has been concentrated in two general inshore areas, the largest consisting of year-round fishing in saltwater from southern Puget Sound to the San Juan Islands and seaward to Neah Bay. The other area consists of river fishing in the late summer and fall inside the Columbia River estuary and at the mouths of its major tributaries, the Cowlitz, Kalama, Lewis, and Washougal rivers.

Until 1950, very few sport fishermen ventured offshore in the ocean in search of salmon, except in the vicinity of the mouth of Grays Harbor where a small sport fishery has existed since about 1947. However, in 1950 a very active sport fishery developed in the Cape Flattery area when good catches were made in Mukkaw Bay on the ocean coast. During favorable weather the sport fishermen fish the entire shoreline from Neah Bay to Cape Flattery and south to the Point of Arches. This area produced large numbers of big chinooks during 1950. Kicker boats are available at Neah Bay or the fishermen bring their own boats on trailers and launch them at Mukkaw Bay.

The sport fishery in Puget Sound occurs throughout the year, the heaviest period generally summer and fall. Many fishing contests, or derbies, stimulate the fishermen. In 1949, more chinook salmon were taken (93,540) by sport fishermen than the entire catch by all gear of the commercial fishermen (56,365) inside Puget Sound. Besides chinooks, large numbers of silvers are landed.

In the Columbia River area, the greatest concentration of sport fishermen fish the Columbia River estuary from August 26 to September 10 when the river is closed to commercial fishing. A fishing derby during this period at Astoria, Oregon, helps to encourage the numbers of people fishing. It was estimated that during the closed commercial season of 1949, 14,000 salmon, mostly chinook, were taken by sport gear in the area near the river mouth. Along with this concentrated fishery in the estuary, hundreds of fishermen fish the mouths of the largest tributaries emptying into the Columbia from the ocean to Bonneville Dam.

CONCLUSIONS

Mature chinooks in the Swiftsure-Lennard Island area during the time of tagging showed movement predominantly eastward toward the Fraser River and southward to coastal streams. Immature chinooks use the same area for a feeding ground during a part of their stay in the ocean.

Mature chinooks from Umatilla Reef moved predominantly southward and to a lesser extend into Puget Sound. Immatures released in this area showed evidence of northerly movement.

It was apparent that the Swiftsure-Lennard Island area is a mixing ground for silvers from very diverse river systems.

TABLE 11. TROLL SILVERS AND KINGS LANDED FROM OUTSIDE WATERS BY DISTRICTS
(Number of Pounds)

Year	PUGET SOUND		GRAYS HARBOR		WILLAPA HARBOR		COLUMBIA RIVER		STATE TOTAL	
	King	Silver	King	Silver	King	Silver	King	Silver	King	Silver
1935	2,395,946	3,458,008	938,910	1,501,152	11,305	48,320	41,395	484,883	3,387,556	5,492,363
1936	3,914,607	2,445,560	835,414	1,071,440	170	144	332,778	600,489	5,082,969	4,117,633
1937	3,392,707	1,585,624	1,053,677	825,720	.....	.....	197,890	407,752	4,644,274	2,819,096
1938	1,987,334	1,395,496	883,592	692,128	.....	.....	116,726	870,029	2,987,652	2,957,653
1939	2,080,834	1,748,856	697,136	1,603,160	17	64	180,261	697,324	2,958,248	4,049,404
1940	3,931,488	2,238,656	970,751	1,500,152	1,887	6,368	255,169	652,139	5,159,295	4,397,315
1941	2,977,958	2,045,432	1,310,887	1,882,808	22,984	24,688	415,694	277,640	4,727,523	4,230,568
1942	2,694,466	962,848	1,273,147	1,016,296	7,531	10,616	389,099	361,743	4,364,243	2,351,503
1943	2,631,597	834,056	1,328,584	1,098,232	187	304	122,662	297,945	4,082,030	2,230,537
1944	1,679,311	359,336	1,234,353	1,046,312	2,584	37,816	288,992	588,991	3,205,240	2,032,455
1945	2,012,698	588,952	1,403,401	1,983,000	10,693	5,400	321,465	378,383	3,748,257	2,955,735
1946	3,739,830	693,808	1,493,960	984,888	4,250	4,592	578,521	486,258	5,816,561	2,169,546
1947	3,960,294	2,001,472	1,331,269	1,671,279	3,727	5,529	489,047	834,669	5,784,337	4,512,949
1948	2,422,095	2,187,196	1,848,828	2,549,692	10,101	26,178	434,701	1,052,803	4,715,725	5,815,869
1949	2,894,005	1,860,293	1,509,454	1,856,842	2,981	12,204	427,821	460,043	4,834,261	4,189,382
1950	1,981,840	1,433,940								

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OBSERVATIONS ON TROLL-CAUGHT SALMON OF THE WEST COAST OF VANCOUVER ISLAND, 1949

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BULLETIN 2
PACIFIC MARINE FISHERIES COMMISSION
Portland, Oregon, 1951

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INTRODUCTION

The salmon troll fishery of the west coast of Vancouver Island was investigated in 1949 by the Fisheries Research Board of Canada through the charter of a commercial trolling vessel. Fishing was carried out on the offshore banks in the general vicinity of Amphitrite Point (referred to in this account as "Ucluelet area") from May 10th to July 2nd and on August 3rd and 4th; and in or near Quatsino Sound from July 5th to August 1st.

Ordinary commercial fishing practices were employed except that barbs were removed or rendered inoperative on the gear used. In the opinion of the operators this did not significantly affect the number of fish secured. Six lines were used, with 3 to 5 lures on each line.

All fish caught, with minor exceptions, were measured for length. Scale samples were taken from those tagged. For untagged fish, the length, round and dressed weight, sex and color were recorded.

Acknowledgments are due to Mr. P. W. Martin, owner and operator of the "Wandelaine", whose practical fishing experience and local knowledge were combined with biological training, and to Mr. H. W. Spencer who, in addition to taking part in most of the field operations, was responsible for tabulating many of the data obtained.

CHINOOK SALMON

Size Composition

A total of 1,204 chinook salmon was taken during the indicated period.

On the basis of length measurements, these fish were divided into groups representing approximately the weight-categories recognized by the industry.

TABLE 1. PERCENTAGE SIZE COMPOSITION OF CHINOOK CATCH

Category		1	2	3	4	Number of Individuals
Fork Length		Below 24½"	24½"-28½"	29"-31"	Above 31"	
Approximate Dressed Weight		Below 5 lbs.	5–10 lbs.	10–14 lbs.	Above 14 lbs.	
	Week ending					
Ucluelet	May 13	34.4	59.4	3.1	3.1	32
	20	34.2	49.8	8.7	7.3	231
	27	17.3	60.0	16.0	6.7	75
	June 3	23.6	47.1	15.9	13.4	157
	10	20.0	38.0	22.0	20.0	50
	17	29.6	46.5	8.9	15.0	179
	24	15.4	46.1	21.9	16.6	187
	July 1	5.7	54.6	17.0	22.7	106
Quatsino	July 8	2.1	16.6	35.4	45.9	48
	15	0.0	9.5	19.0	71.5	21
	22	7.7	7.7	23.1	61.5	13
	29	6.9	10.3	31.0	51.8	29
Mainly Ucluelet	Aug. 5	8.8	32.3	19.0	39.9	68

Age Composition

Scale samples were taken from those fish which were tagged. Seven hundred thirty-seven of these samples were considered to be readable and the distribution of these is recorded in Table 2.

The subscript "2" indicates that the fish had spent a full year in fresh water before going to sea.

TABLE 2. AGE COMPOSITION OF TAGGED CHINOOK SALMON

Year of life	2_1	3_1	3_2	4_1	4_2	5_1	5_2
Number of individuals	23	600	16	67	28	0	3
Percentage	3.1	81.4	2.2	9.1	3.8	0	0.4

It is evident that the scale samples were taken almost entirely from fish in their third and fourth years of life, with an insignificant number in their second and fifth years. The percentages recorded, however, cannot be applied to the total catch, since the fish from which the scale samples were taken were to some extent selected from the smaller size categories. Examination of the recorded lengths of all fish suggests that third year chinooks constituted 65% to 70% of the total number caught. In the Quatsino catches, fourth-year fish probably predominated.

The relation between age and size, as revealed by the sampled fish, is expressed in Table 3.

TABLE 3. AGE AND SIZE OF CHINOOK SALMON, BY MONTHS OF CAPTURE

Age group	2_1	3_1	3_2	4_1	4_2	5_2
May:						
Number	11	235	4	21	9	.....
Length range	12.25–19.0	18–31	18–26	23.5–34	22–29.5	.....
Average	15.5	24.4	21.6	29.2	26.6	.....
June:						
Number	9	311	10	33	14	3
Length range	12.25–22	19.5–31	18.5–27.5	25.5–35	23–33.5	31.5–34
Average	17.0	25.8	23.0	31.5	28.7	32.0
July:						
Number	1	37	.....	11	4	.....
Length range	.....	23–33	.....	27–35	26–31	.....
Average	(18.0)	27.7	.....	31.2	28.1	.....

Tagging

Table 4 shows the number of fish tagged during 1949 and the total number of recoveries up to September 15, 1950.

TABLE 4. CHINOOK SALMON TAGGED AND RECOVERED

Area	Tags Applied	Tags Recovered	Percent Recovered
Ucluelet	772	57	7.38
Quatsino	45	11	24.40
All	817	68	8.32

The difference between the percentage recovered from the Ucluelet and Quatsino taggings is striking. Other differences in recovery rates become apparent, however, when the fish are grouped according to size categories and year of recapture, irrespective of the tagging area (see Table 5).

The larger fish have evidently yielded higher returns and the discrepancy between Ucluelet and Quatsino recoveries may be due in part to the larger average size of the fish tagged in the latter area. There is a possibility that further returns of tags may necessitate some revision of these

figures. Tag returns in 1951 are not expected to be numerous in view of the apparent scarcity of fifth year fish in the commercial catch.

TABLE 5. RECOVERIES OF TAGGED CHINOOK SALMON ACCORDING TO SIZE OF FISH WHEN TAGGED AND YEAR OF RECOVERY

Size Category (see Table 1)	1	2	3	4
Number of fish tagged	256	424	91	38
Percent distribution of fish tagged	31.6	52.4	11.2	4.7
Number of fish recovered in 1949	7	14	10	7
Percent distribution of 1949 recoveries	18.4	36.8	26.4	18.4
Number of fish recovered in 1950	1	26	3	0
Percent distribution of 1950 recoveries	3.3	86.7	10.0	0
Percent distribution of all recoveries	11.8	58.8	19.1	10.3
Percent recovery of fish tagged	3.1	9.1	14.3	18.4

The increased number of recoveries in 1950 of fish which were placed in category 2 at the time of tagging, demonstrates the immaturity of a large portion of the original catch and the increased susceptibility to capture with increasing size or age.

The recoveries, grouped according to age of fish when tagged, were as follows:

TABLE 6. RECOVERIES OF TAGGED CHINOOK, BY AGE WHEN TAGGED AND SEASON OF RECAPTURE

Age, 1949	2	3	4	Doubtful
Number recovered 1949	0	23	11	4
Number recovered 1950	0	28	1	1

Distribution of Recoveries

The localities from which tagged fish were recovered are shown in Figure 1.

A striking feature of the Ucluelet fish is the high proportion of recoveries made in or near the area in which the fish were tagged. These recaptures took place after an interval varying from 16 to 457 days, so that in each case there was plenty of time for the salmon to move elsewhere. This result, coupled with the evidence of the presence of large numbers of immature fish, increasing in average size during the fishing season, suggests strongly that the banks in this area provide feeding grounds for chinooks over a prolonged period of their ocean existence.

Other recoveries of Ucluelet chinooks show fish proceeding both into Juan de Fuca Strait and to the Columbia River. The extreme range of recorded dispersal is from Graham Island (about 450 miles north-west of the tagging area) to Point Ano Nuevo, California (some 900 miles south of Ucluelet).

The Quatsino fish, on the other hand, have yielded no recoveries from the tagging area. This fact, together with the apparent scarcity of small salmon (see Table 1) is taken as an indication that chinooks caught in this district are mainly migrating fish.

Recoveries from Quatsino taggings again show fish traveling both to Juan de Fuca Strait and the Columbia River.

Comments

The conclusions and inferences drawn from the available data may be summarized as follows:

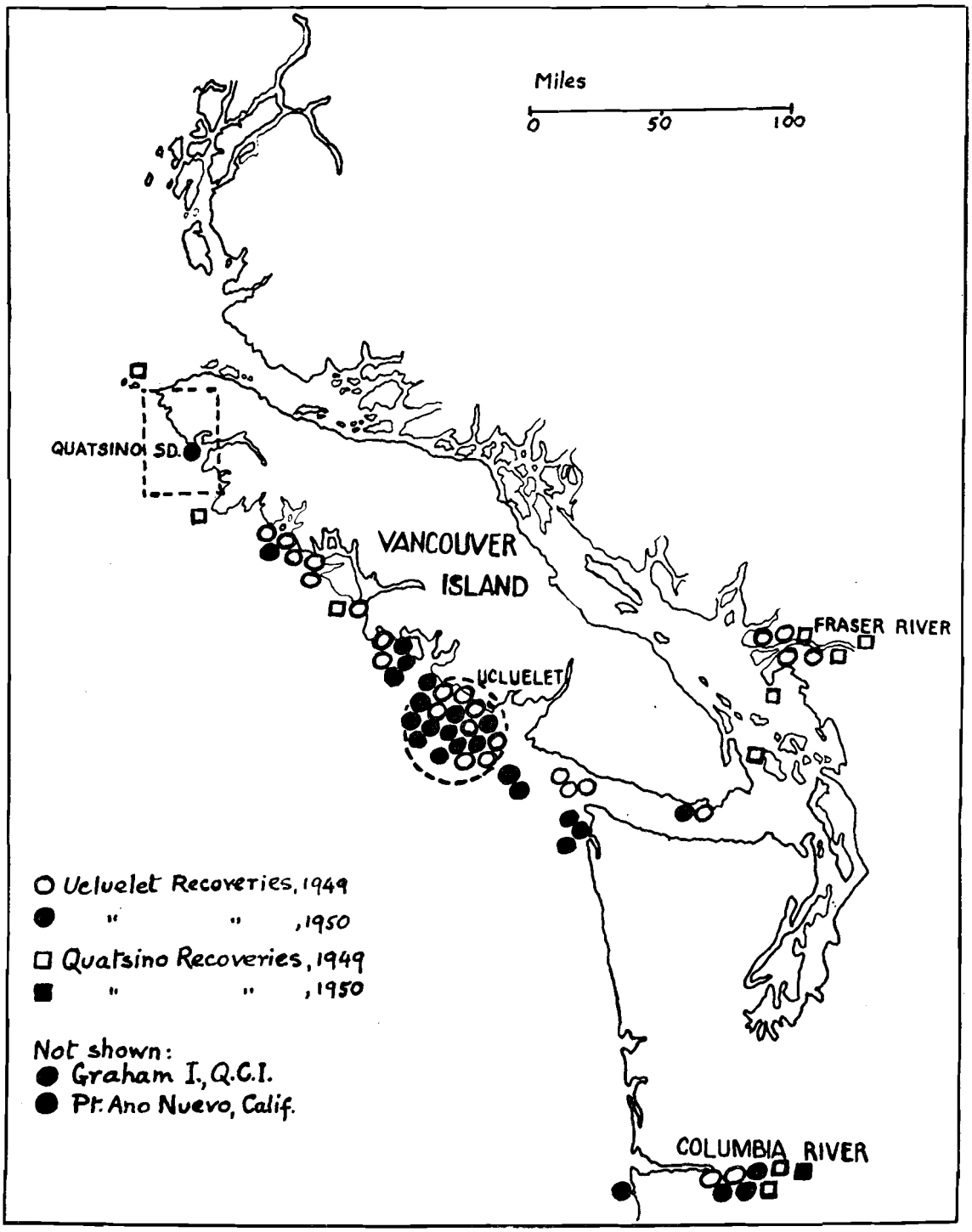

FIGURE 1. Chinook Salmon taggings and recoveries.

1. The chinooks available in 1949 in the Amphitrite Point-Tofino offshore area were predominantly fish in their third year of life, i.e., of the 1946 year class. In the Quatsino Sound area, older fish predominated.

2. Most of the third-year fish available would not have matured until the following year. Chinooks, at least in some areas, are therefore subject to exploitation during at least two full fishing seasons. (The other species of Pacific salmon are, for the most part, exploited during only one season of their life cycle.)

3. The overall percentage return of tags does not demonstrate a high rate of exploitation. Hasty conclusions to this effect should be avoided, however, in view of the following considerations: (a) The fish had already become available for capture before being tagged—in the case of the fourth year fish for a period of at least a year. (b) Loss of tags, non-return of tags and differential mortality of tagged fish may have affected the record to a considerable degree, especially in view of the long period over which fish are available to the fishery. (c) Considerable differences are apparent in the tag returns for fish of different sizes, ages and localities. (d) The majority of the fish were tagged in an area which may be somewhat peculiar in respect to the age and size composition of the available fish.

4. The banks situated offshore from the Amphitrite Point-Tofino section of coastline appear to provide feeding grounds during a prolonged period for chinook salmon from divers freshwater areas. On the other hand, the Quatsino Sound area appears to depend largely on migrating fish.

5. The dressed weight of 14 lbs. or above which is recognized by the industry for "mild-cure" purposes practically limits this product to fourth-year, or older, fish. The records of fishing companies may therefore give useful indications of the relative strength of year-classes in different seasons.

The present British Columbia minimum weight of 2½ lbs. dressed weight excludes second-year fish from the catch. To effectively exclude third-year fish throughout the season (on a size basis) it would be necessary to raise the minimum dressed weight to at least 10 lbs. or 12 lbs., representing a fork length of 28½ to 30 inches.

6. If the existence and location of definite long-period feeding areas can be confirmed or established, recognition of these might well enter into conservation regulations or practices. If, for example, it should be found desirable to protect immature fish in order to permit further growth before capture, the closing of such areas might be more effective than a general upward revision of the size-limit. Because of the growth which takes place during the course of a fishing season and the varying sizes at which chinooks mature, any fixed size- or weight-limit can only effect a very rough segregation. If, as seems possible from these taggings, fish tend to remain in certain areas until growth is nearly completed, they would become available at whatever size they began to move towards the spawning grounds.

SILVER SALMON

In all, approximately 700 fish were caught. Of this total, only 51 were taken in the May and June operations based on Ucluelet. The remainder, with three exceptions, were caught in the Quatsino area.

Some deviation from a strictly commercial sampling of the catch may have been introduced by the fact that at times of heavy fishing the exigencies of tagging prevented full exploitation of the availability of fish.

Size Composition.

Marked increase in the average size of fish was apparent during the course of the season (see Table 7).

TABLE 7. LENGTH-FREQUENCIES OF SILVER SALMON, BY MONTH OF CAPTURE

Length (fork)	May	June	July	Totals
18″ and under	4	.....	.....	4
19″ and under	6	1	1	8
20″ and under	4	2	5	11
21″ and under	4	2	11	17
22″ and under	3	3	17	23
23″ and under	4	6	33	43
24″ and under	1	2	62	65
25″ and under	.....	2	162	164
26″ and under	.....	2	160	162
27″ and under	.....	.....	112	112
28″ and under	.....	.....	58	58
29″ and under	.....	1	18	19
30″ and under	.....	.....	1	1
31″ and under	.....	.....	2	2
Totals	26	21	642	689

Tagging

TABLE 8. SILVER SALMON TAGGED AND RECOVERED, 1949

Area	Period	Number Tagged	Number Recovered	Percent Recovered
Ucluelet	May 12–July 2	40	5	12.5
Quatsino	July 5–Aug. 1	470	38	8.1
All	.....	510	43	8.4

Since this species tends to struggle violently when on the hook and in the hand, the problem of returning tagged fish to the water in good condition is more serious than in the case of the chinook. In the majority of instances, the condition of each fish released was recorded as "good", "fair" or "poor". On this basis, the recoveries were as follows:

TABLE 9. RECOVERY OF SILVER SALMON TAGS IN RELATION TO CONDITION OF FISH WHEN TAGGED

Condition	"Good"	"Fair"	"Poor"	Unrecorded
Number of fish tagged	336	61	31	82
Number of fish recovered	30	3	1	10
Percent recovered	8.9	4.9	3.2	12.2

While the proportion of recoveries appears to be less in the categories representing a less favourable condition, the relatively high recovery rate for the unrecorded fish indicates that the percentages cannot be applied rigidly.

Distribution of Recoveries

The time-interval between tagging and recapture varied from 6 to 115 days.

While the recovered tags did not show as extreme a north-south range as those of the chinooks, a greater dispersal was evident within the waters of central and southern British Columbia and northern Washington, indicating that silver salmon spawning in many freshwater areas are closely associated during at least part of their ocean existence. The collective importance of numerous small rivers and streams in contributing to the offshore troll fishery is evidenced. No recoveries were reported from the Columbia River (see Figure 2).

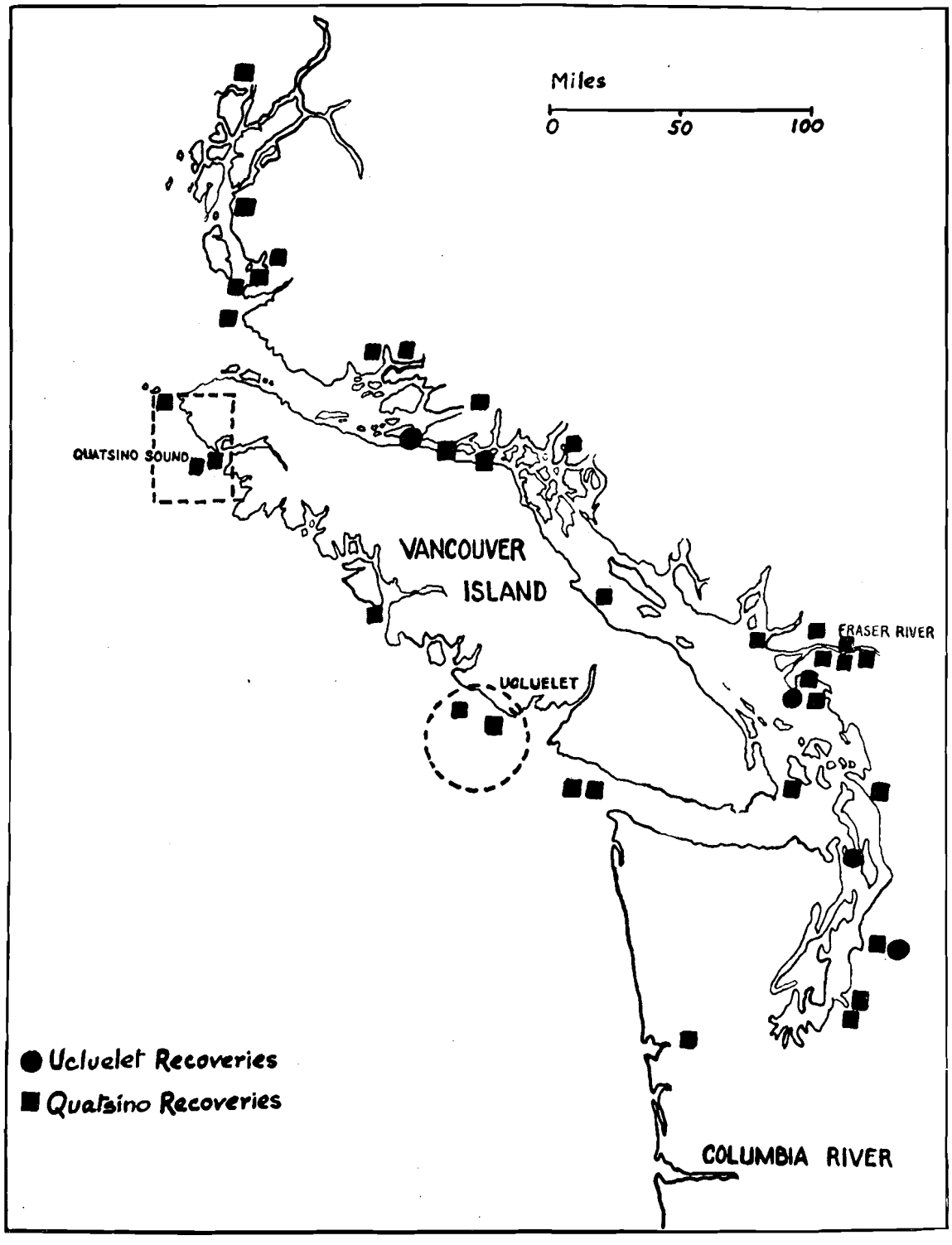

FIGURE 2. Silver Salmon taggings and recoveries.