CALIFORNIA'S PART IN A THREE-STATE SALMON FINGERLING MARKING PROGRAM[1]

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ACKNOWLEDGMENTS

In the course of the first two years of the marking program, many people contributed to its success. To them we wish to acknowledge our indebtedness and to extend our sincere appreciation and thanks.

To Mr. John Pelnar, District Supervisor, United States Fish & Wildlife Service, we owe perhaps the most. It was largely through his efforts that nearly a quarter million fingerling salmon were made available to the State for marking. He also placed at our disposal the facilities at Coleman Hatchery for the marking of both hatchery-raised and wild fish.

Mr. Stephen C. Smedley, Foreman of Prairie Creek State Fish Hatchery, gave extensive assistance in the handling of fish, and much valuable

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information about the silver salmon spawning streams in Humboldt and Del Norte Counties.

Mr. Frederick K. Cramer, and Mr. William A. Davenport of the Fish & Wildlife Service gave detailed information about salmon in the Red Bluff area and contributed captured salmon from the Sacramento River for marking.

Captain Leslie E. Lahr and other state fish and game wardens in the north coast area volunteered much valuable information concerning silver salmon streams.

Many members of the staff of the Bureau of Marine Fisheries labored long and odd hours to construct equipment and capture fingerling salmon in the numbers required. Messrs. Don L. Stoffer, Otis F. Corley, Robert F. Elwell, and Joe F. Patterson were key men in this work. To them and to the others we extend our heartiest thanks.

INTRODUCTION

The problems of fisheries management are requiring ever increasing knowledge of the behavior of our more important fishes. Some of the fisheries are interstate or international in scope, but for many years research and management on some of the species was conducted with little coordination between states and much resulting loss of efficiency. In 1946, official representatives of California, Oregon, and Washington formed a compact creating the Pacific Marine Fisheries Commission to make such coordination possible. The Congress of the United States granted its consent and approval on July 24, 1947. Meetings conducted by the commission are rotated among the three states and are attended by representatives of the fishing industry, fishermen, and biological staffs of the three states. Representatives from Canada, Alaska, and the U. S. Fish & Wildlife Service also attend. Meetings of a small number of fisheries biologists from the three states are held annually and are attended by Canadian and Fish & Wildlife Service staff members.

One of the problems of the commission has been that of the ocean fishery for king and silver salmon (*Oncorhynchus tschawytscha* and *O. kisutch*). Of the five North American species of Pacific salmon, only these two are commonly taken as far south as California, and only these two are regularly taken by sportsmen or by commercial trollers. These species present problems that cannot be solved by one state at a time. For example, most of California's commercial silver salmon catch appears to come from Oregon streams; Sacramento River kings are taken off Oregon and Washington; and Columbia River kings move to Alaska in quantity. Obviously the ocean fishing regulations in one state can affect the ocean and stream fisheries of its neighbors and, conversely, what happens in the streams of one state can be equally far reaching.

One of the first steps in the coordinated salmon study was a tagging (Petersen disc) program intended to give a start towards a more complete and quantitative knowledge of the movements of salmon, and to learn if there have been any important changes since earlier tagging experiments were conducted. Fisheries workers of California, Oregon, Washington, Canada and Alaska have all engaged in tagging ocean-caught salmon and *in the recovery of these tags*. Uneven effort at tag recovery has been one of the greatest faults of earlier experiments.

A second experiment, intended to supplement the tagging, is involving the *marking* of king and silver salmon fingerlings, and the recovery of these marked fish. To summarize the differences between the experiments: The tagging has involved putting numbered tags on thousands of relatively large ocean-caught salmon. The fish are recovered in the ocean and in the streams. The stream of origin of an individual fish cannot be determined with certainty if the fish is retaken in the ocean. Marking will involve the clipping of two fins from each of several million fingerlings in fresh water, using a different combination of fins for each of the groups of fish marked during any one season. Obviously, the stream of origin of an ocean- caught marked fish can be determined. Only a limited number of groups can be marked in any season because there are relatively few combinations of fins which are suitable.

Extent of the Marking Program

Representatives of the biological staffs of the three states met with biologists of Canada and the U. S. Fish & Wildlife Service on November 21-22, 1949, to discuss several fisheries problems and to organize the salmon-marking program. The Canadian and federal men did not intend to participate in this marking experiment, but previous experience in similar work enabled them to give valuable assistance in the planning.

It was decided that in order to obtain adequate numbers of recoveries, it would be desirable to mark about 100,000 silver salmon or 200,000 king salmon in each group released (one mark for each group). The numbers selected were based on the rate of return from previous marking experiments. The reason for proposing the marking of a smaller number of silver salmon is that fishes of this species could be released as yearlings and would probably have much higher survival rate than the kings, most of which would be released when only a few months old.

Eight two-fin and two three-fin marks [2] were selected as being suitable for an experiment of this magnitude. The purpose of the experiment was explained by letter to all other organizations which might be interested in marking king or silver salmon, and exclusive use of these marks was requested. This was granted by all organizations concerned.

As a by-product of this experiment, the research coordinator of the Pacific Marine Fisheries Commission has taken over the thankless job of acting as a clearing house for marking experiments. Any organization which wishes to mark any trout or salmon now contacts the Pacific Marine Fisheries Commission, states its needs, and asks for the use of a mark or marks. It is then assigned marks which will not interfere with other experiments. This arrangement is entirely voluntary, but it works satisfactorily.

Reasons for Use of "Wild" Fish

In carrying out this investigation, one important question involves the use of hatchery-reared fingerlings. Can salmon which spend their first few months in a hatchery be used to determine the movements of the "wild" fish which hatch in the streams of the same area? The indications from earlier marking experiments are that the hatchery fish can be so

[2] Adipose and left ventral, adipose and right ventral, adipose and anal, dorsal and left ventral, dorsal and right ventral, dorsal and anal, anal and left ventral, anal and right ventral, adipose and both ventrals, dorsal and both ventrals.

used, but the evidence is not sufficiently complete to remove all doubt. To check on this point, California agreed to mark a minimum of 200,000 wild king salmon and 200,000 hatchery kings in the same area.

To mark California's first year's quota of silver salmon required the use of wild fish for another reason—there were no hatchery-reared silvers available in the State.

Sources of Hatchery Salmon in California

The available sources of hatchery salmon in California are limited. At present, there are only three hatcheries in the State which regularly handle salmon. Coleman Fishery Station is a large federal king salmon hatchery. It is on Battle Creek near the Sacramento River. Mt. Shasta Hatchery is a large Department of Fish and Game trout hatchery which handles some salmon. It is near the headwaters of the Sacramento River, many miles above the farthest point which salmon can now reach. All salmon eggs must be transported to the hatchery. The Prairie Creek Hatchery in Humboldt County is another Department of Fish and Game trout hatchery which handles some salmon. It is not large but it is the only one of the three within a reasonable distance of a source of silver salmon eggs. When the marking experiment was started, all of Prairie Creek Hatchery's available space was being utilized by trout and king salmon. It is now rearing some silver salmon which will be marked and released in the spring of 1953.

Scope of This Report

This report covers the first two years of salmon marking by the California Department of Fish and Game, and is primarily concerned with the problems involved in capturing and marking "wild" or naturally spawned salmon, king and silver.

Brief Comparison of King and Silver Salmon

The common range of both king and silver salmon is from Monterey Bay north to Alaska and south on the Asiatic coast to the Amur River. Each is occasionally taken as far south as Southern California. There are no king salmon spawning runs of any consequence in streams south of the Golden Gate. King salmon do not spawn in many of California's smaller coastal streams; they do prefer the larger streams and are most abundant in the Sacramento-San Joaquin River System. Silver salmon utilize many of the small coastal streams from Monterey County northward, but only rarely is even a single stray taken in the Sacramento-San Joaquin system. Several of the State's larger coastal rivers such as the Smith, Klamath, Mad, Eel, Van Duzen, and Mattole Rivers have runs of both species. In general, the kings spawn in the gravel bars of the main stem or larger tributaries while the silvers use the smaller branches.

Wherever spawned, the silvers spend their first year in the smaller streams and migrate to sea at an age of about 15 months. At this time most of them are about five or six inches long. The majority return to spawn at the age of three years, and they will usually weigh between 7 and 12 pounds at this time. The remainder of the spawners are two-year-old "jacks." In more northern waters (especially Canada and Alaska) there are some four-year-old silvers.

Most California king salmon migrate to sea during their first year. Many leave the streams when less than two inches long. Some kings remain in fresh water over a year, but in California the proportion is low. The greatest number return to spawn at four years; next in abundance are three-year-olds. Five- and two-year-old spawners are common; yearlings and six-year-olds relatively scarce. A four-year-old fall run Sacramento River king salmon will weigh about 20 pounds.

CAPTURING WILD KING SALMON FINGERLINGS

The salmon marking program in 1950 called for the fin clipping of 200,000 young king salmon native to the Sacramento River. No attempts had been made before in California to capture wild salmon in any such quantity. However, small numbers of young kings had been taken by various means during the course of salmon investigations on Central Valley streams, and the behavior and habits of these fish were well understood.

Most young king salmon start their migration from the spawning beds to the sea in the early spring months, shortly after emerging from the gravel. A few kings remain in fresh water during their first year of life if summer water temperatures are low enough to permit survival. Small kings migrate principally with the water currents. If the water is clear, most of the fish will move at night and spend the day hiding along brushy banks or in other protected places. If the river rises suddenly or becomes extremely muddy, the daytime movement increases and may equal the nocturnal migration. A limited number of experiments with nets set at different depths indicate that in California streams, most migrants travel close to the surface even in deep areas of the river.

Fishing Methods Previously Used

When the marking program was started, anchored fyke nets had been in use for years to sample downstream migrating salmon in the Sacramento-San Joaquin and other river systems. A fyke net is essentially a tube or cone of netting, open at one end, and closed at the other. (Figure 2.) One or more funnel-shaped "fykes" in this tube make it easy for the fish to get in and hard for them to get out. When used to catch downstream migrating salmon, such nets are fished with the open end upstream and simply strain the fish out of the water as they drift with the current. If it is to be used in deep water, the webbing is hung on circular hoops. If it is to be used on the bottom in shallow riffle areas, the frames are rectangular. Both types of net are highly size selective as most salmon over 45 mm. in length will avoid being trapped unless the net is fished in very swift water. Water velocities high enough to capture larger fish will cause a high mortality in the catch.

Two-man seines of one-half inch stretched mesh (one-fourth inch bar mesh), 15 feet long by 3 feet deep, were used successfully on several occasions in netting small salmon in the Tuolumne and American Rivers. A smaller one-man seine, about three feet square, mounted between two poles had also proved effective for capturing fish that were concentrated under overhanging banks or in small pockets in the brush close to shore. Unlike the fyke nets, the seines sampled almost all the sizes of salmon

fingerlings present in the river at the time. Salmon collected by seining were usually unharmed by the operation.

A few salmon had been trapped at night by using a light and a hoop net during the testing of electric fish screens at Mendota on the San Joaquin River. This net consisted of an iron ring three feet in diameter on which a bag of one-half inch stretched mesh netting had been laced. Heavy twine attached to three points on the ring formed a bridle for lifting the net. This device was lowered from the end of a pier and fished about two feet under the water surface. A spotlight directed on the water attracted young salmon. When a school had accumulated, the light was slowly dimmed. This had the effect of concentrating the fish closer to the light. The net was then raised quickly. Salmon caught in this manner were in excellent condition since it took only a matter of seconds to pull up the net and empty any fish caught into a container. This gear required the constant attention of one or preferably two men and was rendered much less effective by windy or stormy weather or by muddy water.

Fishing Methods Tried on the Sacramento River

Seining seemed a logical method to try first on the Sacramento River. Red Bluff was selected as the site of operations. This locality was upstream from the main tributaries of the Sacramento River and most of the salmon caught here would be natives of the main stream. This site was also close to Coleman Hatchery where the fish were to be hauled for marking. The area is shown in Figure 1.

Seining started on February 1, 1950, but was discontinued a week later. During this week, only 400 salmon had been taken by a crew of six men using seines of various lengths. A number of difficulties were encountered which made it impossible to use seines with any degree of success. The bottom of the Sacramento River was far rougher than that of the Tuolumne and American Rivers where seining had previously been successful. Seine hauls could not be made without snagging the lead line on the rubble and boulders in the stream bed, and most of the salmon made their escape while the lead lines were being freed. There were very few bays, pockets or side channels where seines could be used effectively. The bottom was so rough that the maximum life of a fine-meshed seine was only a few hours.

Attempts were made at night to trap salmon by suspending a light over a submerged hoop net as previously described. The net was fished off an old car ferry tied up at Red Bluff. This method of trapping fish was abandoned after a few nights when it became evident that the catch would not exceed 10 to 20 salmon per hour.

On February 5, 1950, two riffle fyke nets were set out for a night's fishing at the downstream end of a shallow riffle near Red Bluff. They were placed in a current that seemed to be swift enough to trap fish and yet not kill them. The results of the night's fishing were gratifying; there was a catch of more than 1,200 live salmon in the two nets. These fish were small, averaging about 40 mm. (slightly over 1½ inches) in length; however, they were large enough to mark successfully. From this test it appeared that by fishing a number of fyke nets, it would be possible to obtain the required salmon for marking in a reasonably short time.

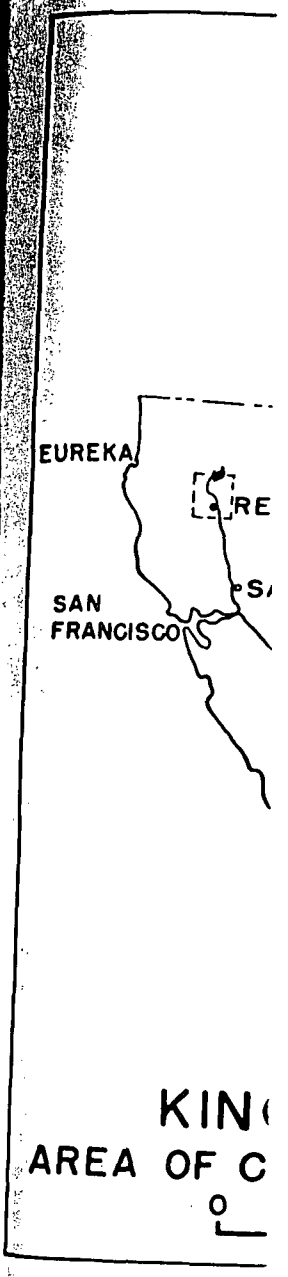

FIGURE 1. Map

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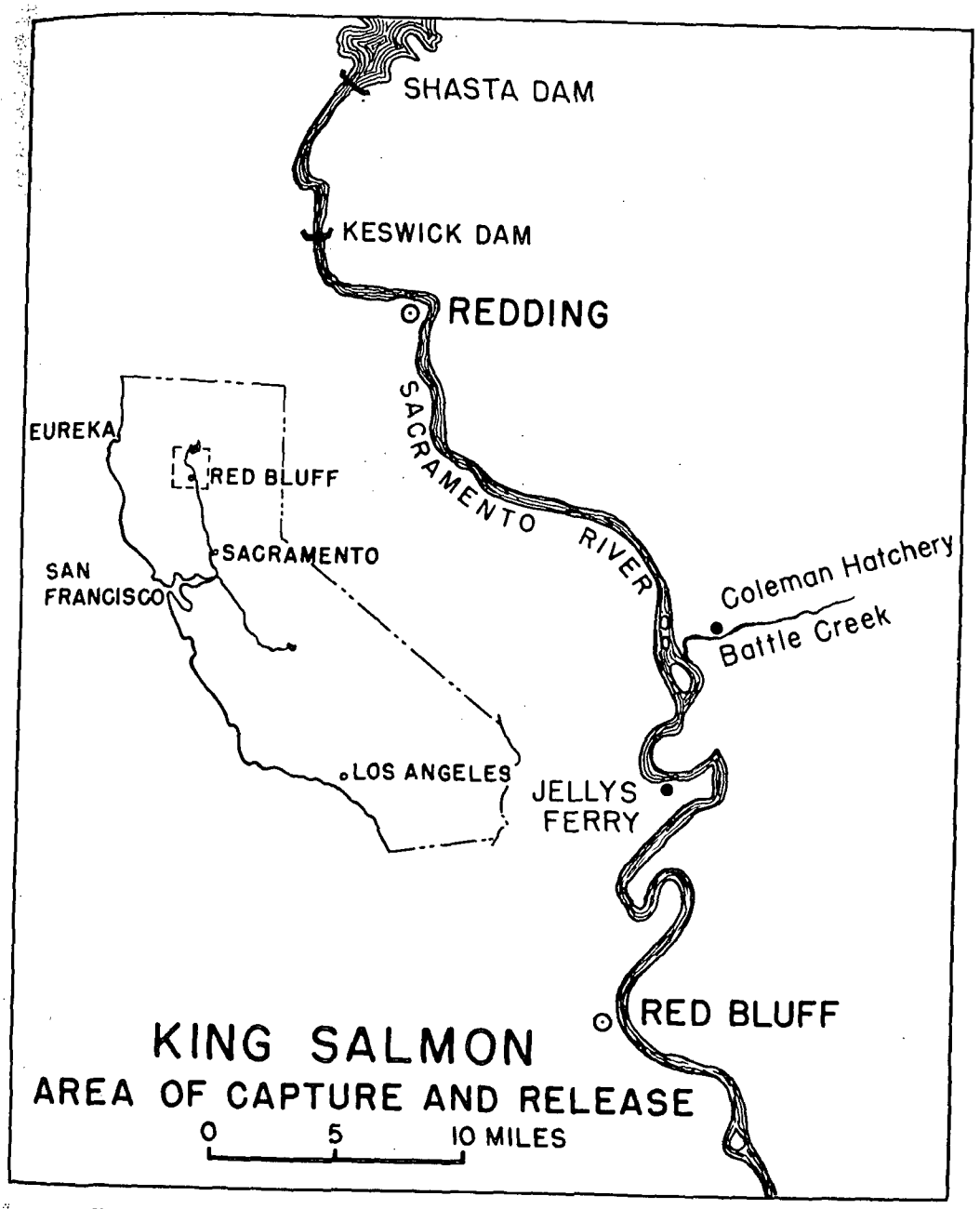

FIGURE 1. Map of the portion of the Upper Sacramento River where king salmon were trapped, marked and released

Use of Fyke Nets

Construction of Nets

Work was begun at once on 20 more riffle-type fyke nets of the design shown in Figure 2. The nets were made of one-half inch stretched mesh, six-thread cotton webbing. This mesh size allowed the smallest fish to pass through the net and escape, but finer material would not hold up in a current for any length of time, and the fish which did escape were, in general, too small to be suitable for marking. A sock or cone was formed first by sewing together the sides of a piece of webbing 300 meshes deep. The sock was 560 meshes in circumference on one end and tapered

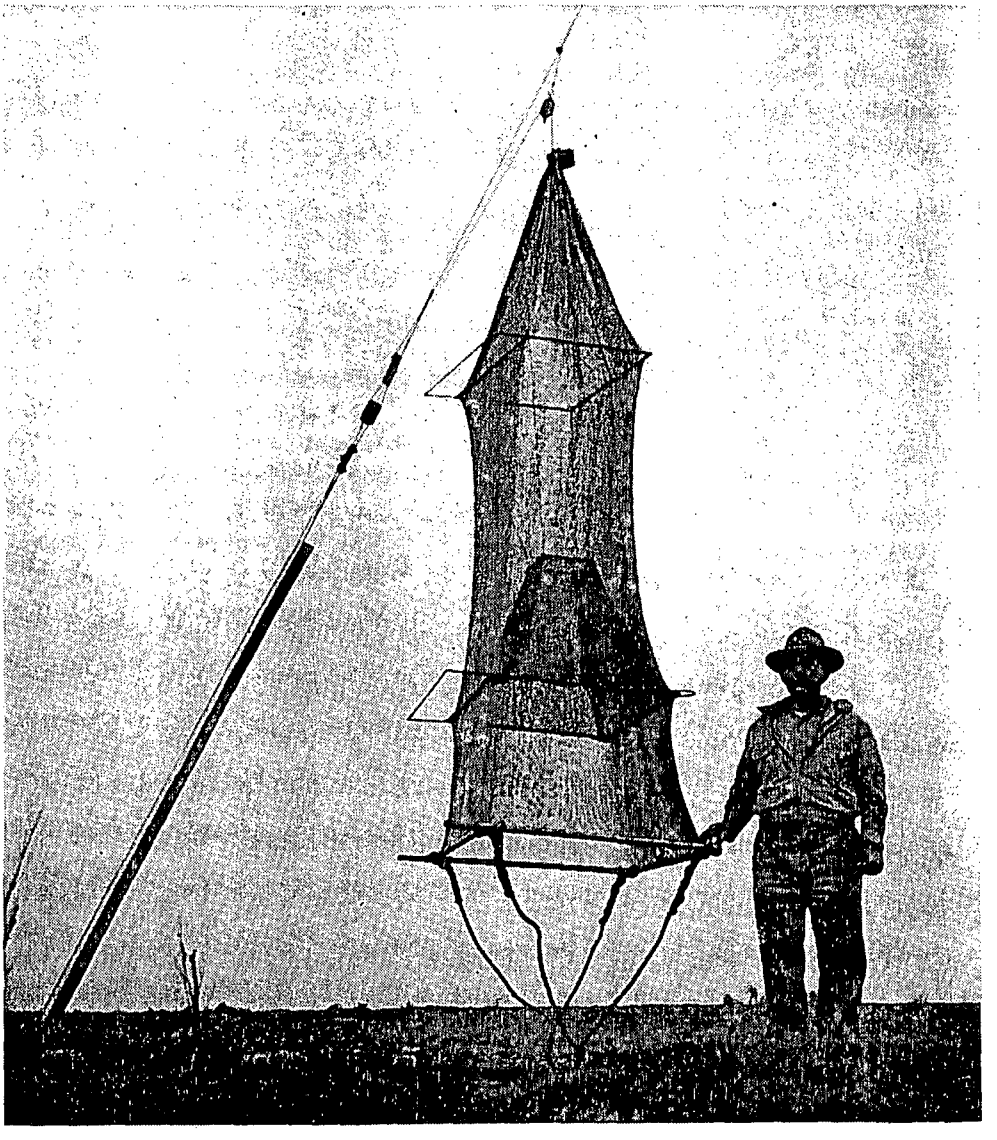

FIGURE 2. Fyke net of the type used to capture wild king salmon fingerlings for marking. Note the handles and the legs. The handles make it much easier to wrestle the net in midstream. The legs serve to keep the webbing from chafing on the bottom and result in its lasting several times as long. *Photograph by R. J. Hallock.*

to 320 meshes in circumference at the other end. The large open end of the sock was hung on a three- by five-foot rectangular frame of three-fourths inch galvanized pipe. The pot of the net where the fish were collected was formed by closing the small opening in the sock with a puckering string. The fyke funnel of webbing tapered to a six-inch by eight-inch rectangular opening, and was installed inside the sock 120 meshes back of the pipe frame. This funnel enabled the fish to enter the net and prevented their escape once they were trapped.

To hold the shape of the net, two additional rectangular frames were constructed of three-eighths inch round iron. One, 29 inches by 48 inches, was hung on the outside of the sock at the point where the funnel had been sewed in. The other, 22 inches by 34 inches, gave support to the pot

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100 meshes from the puckered end of the net. Handles were welded to the top corners of these iron rectangles for ease in pulling the nets. Six-inch legs were attached to the pipe frame as well as to the smaller frames to keep the webbing from chafing on the stream bed. A bridle of five-eighths inch rope attached to the pipe frame completed the net. Using assembly line methods, 20 nets were finished and treated with copper napthanate preservative in eight days by a six-man crew.

Placement of Nets

Finding suitable locations to fish 20 additional nets was more of a problem than had been anticipated. At first the nets were strung out in a line parallel to shore on a series of riffles near Red Bluff. Each net was fished at the end of a length of eight gauge galvanized wire (0.165-inch diameter) which had been attached to an overhanging tree or to a metal stake driven into the stream bed. The distance each net was placed from shore was governed by the depth and velocity of the water. Sufficient debris accumulated inside the nets to kill the catch if this trash were churned around by a fast current. A flow just swift enough to keep the nets stretched out and a depth of two and one-half to three and one-half feet produced the greatest catches of live salmon. Fortunately there was relatively little fluctuation in water level to complicate the fyke netting. The river flow past Red Bluff varied little from 5,000 cubic feet per second while fyke nets were being fished.

The numbers of fish taken by different nets varied greatly. Nets in locations where catches were consistently poor were moved to new sites. Oddly enough, when several nets were fished only a few yards apart in a line parallel to shore, the net farthest downstream often made a larger haul than nets immediately above it.

After more than a week of changing netting sites, an ideal riffle was discovered about one mile downstream from the 99-E highway bridge over the Sacramento River at Red Bluff. Here the stream possessed a regular cross section with a depth which did not vary greatly from three feet, and it was possible to fish all the nets side by side at right angles to the shore. The row of 22 nets extended from shore to midstream. Part of the nets on this riffle are shown in Figure 3A.

Tests showed that seaward migrant salmon moved mainly at night in this area. Accordingly, the fyke nets were placed in the water near evening and left in position until the following day. Each morning the nets were brought ashore, one at a time, by a three-man crew. Heavy rubber waist waders proved invaluable to these men since the water was too deep for hip boots and it was not practical to use a boat for servicing nets in riffle areas.

As soon as a net was landed on the bank, the puckering string was released. The contents of the pot was then emptied into a tub of water, and all debris removed by hand (Figures 3B and C). Species other than king salmon were returned to the river. The salmon were then placed in aerated 12-gallon cans. The empty net was carried back into the river where it was washed. After cleaning, each net was stretched between trees on the bank for drying and mending.

FIGURE 3. Fyke netting for king salmon fingerlings in the Sacramento River near Red Bluff, Californi
A—Part of the line of fyke nets. B—Emptying net into a washtub. C—Sorting out the trash. A gall
of trash to a pint of fish is a crude estimate of the usual ratio. *Photographs by George H. Warn*

Since king salmon were the only salmonoids captured in the ne sorting out other species was not difficult. The principal fishes oth than the salmon were suckers (*Catostomus*), catfish (*Ameiurus*), Sa ramento squawfish (*Ptychocheilus*), riffle sculpins (*Cottus*), and blu gills (*Lepomis*). Steelhead trout (*Salmo gairdneri*) were not a proble The fish of the year had not yet hatched, and the yearlings were too lar and active to be taken.

Catches of the Fyke Nets

Between February 14 and March 10, 1950 (25 days), the 22 fyke n captured 227,000 live salmon, an average of a little over 9,000 per da However, at the time that marking was completed, between 15,000 a 20,000 live salmon were being trapped each day. The U. S. Fish & Wil life Service was using a fyke net to sample the seaward migration of ki salmon past Balls Ferry on the Sacramento River, and contributed 14,0 live fish for marking.

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Selectivity of the fyke nets was very high since fishing was conducted in only moderately fast water to insure a live catch. Throughout the program, the average total length of salmon caught varied only slightly from 41 mm. Numerous salmon up to five or six inches in length could be observed feeding around the nets every morning and evening, yet these fish never appeared in the catches. Many small salmon just out of the gravel escaped from the nets. These small fish could be seen wiggling through the meshes while the nets were being carried from their fishing position to shore. Their loss was of little importance since they were too small to mark successfully.

Transporting the Catch

As soon as a milk can was filled with live salmon (up to 2,000 per can), it was placed in a two-wheeled box trailer. This metal trailer could accommodate 12 cans in addition to aeration equipment. A single cylinder air compressor turned by a three-fourths horsepower gasoline engine supplied air to each can through lengths of rubber tubing. Air was forced through a porous stone at the end of each piece of tubing, breaking the air stream into fine bubbles for greater oxygenation of the water. Since there were no roads in the area where the nets were located, a Jeep was used to pull the trailer cross-country over rough terrain to the river's edge. With this equipment, as many as 20,000 young salmon were hauled at one time some 27 miles to Coleman Hatchery. Marked salmon to be released were taken back to the river in this trailer. The same trailer with only six cans was later used to transport silver salmon. It is shown in Figure 5F being loaded with silvers.

Time Spent at the Hatchery

Wild salmon were marked as they were brought in to make their stay at the hatchery as short as possible. They remained at the hatchery until the mortality caused by marking was no longer evident. The time spent at the hatchery by an individual day's catch averaged about three days with a minimum of two days and a maximum stay of 10 days for one small group captured before marking actually got under way.

While at the hatchery, wild salmon were offered food at the same time the hatchery fish were fed. Some wild fish started eating on the day of arrival. Those remaining at the hatchery three days were almost all feeding but ate less than hatchery fish. Many wild salmon fed immediately after fin clipping, especially if they had been in the hatchery troughs for a day before marking.

Movement of Marked Kings in Sacramento River

When marked wild king salmon were returned to the Sacramento River, they moved rapidly downstream from the release point. These fish were set free at Jelly's Ferry, about 15 miles upstream from Red Bluff. Jelly's Ferry was selected as a planting site as it was the nearest place to the fyke net area where a surfaced road led directly to the river's edge. The first group of 5,704 marked kings was released on February 17th at about 2 p.m. The next morning, six of these fish were captured in the fyke nets at Red Bluff. No attempt was made to determine whether or not there was any migration other than towards the sea.

CAPTURING SILVER SALMON

California has no hatcheries devoted to raising silver salmon, althou
small quantities of these fish are occasionally reared at Prairie Cr
Hatchery. No silver salmon were available at this hatchery in 1951; co
sequently, the fish to be marked had to be obtained from some of t
coastal streams where silver salmon runs occur. Since Prairie Cr
Hatchery afforded facilities for fish marking and a number of streams
the vicinity were known to contain silvers, operations were conducted
this area.

Capturing wild silvers in small streams was a far different probl
than trapping migrating king salmon in the Sacramento River. Unli
most kings, silver salmon remain in fresh water during their first ye
and move into the ocean in the spring of their second year. The captu
of yearling silvers was greatly to be preferred because these fish co
be directly compared with hatchery yearlings released by the other stat
and would be past the period of greatest mortality.

The possibility of trapping yearling silvers as they migrated past B
bow Dam on the Eel River was considered. A survey of the site indicat
that the heavy spring run-off would make it difficult or impossible
install and maintain any trapping device large enough to capture t
numbers needed.

Plans were then made to capture the fish in smaller streams farth
north. It was realized that this change would probably give us adequa
numbers of fish of the year but would not provide enough of the mo
desirable yearlings. Unfortunately, no other procedure seemed likely
do any better. Provision had already been made to use one mark on 19
brood year fish (yearlings) and another on fish of the year (1950 bro
year).

Testing Different Fishing Methods

Several methods of obtaining young silver salmon were tested in Prair
Creek. Riffle fyke nets, never seriously considered for the project, prov
worthless since the fish were not migrating. The few fish trapped we
probably caught as they moved around on riffles in search of food. On
in a fyke net, they seemed much less hardy than the king salmon trapp
in the Sacramento River. Even at low flows, silvers would not survive
left in the net all night.

A one-man electric fish shocker apparently effective in some sm
streams was assembled for testing. This equipment was patterned afte
shocker described by Morris (1950, pp. 39-42) and used by him with su
cess. The device consisted of a six-volt hot shot battery and a model T Fo
coil which were carried in a knapsack on the operator's back. Copper el
trodes mounted on the ends of two eight-foot bamboo poles were connect
to the battery and coil with flexible insulated wire. The operator grasp
a pole in each hand, and with the electrodes about four feet apart, push
them ahead of him in the stream. Fish swimming between the electrod
were supposed to be temporarily stunned so they could either be dipp
up in a scap net or collected in a seine stretched across the stream below t
shocker. This outfit was not successful in paralyzing large numbers
small silver salmon in Prairie Creek. If the distance between the el
trodes was decreased to about 18 inches, a salmon directly between th
would either be stunned or show distress, but if the fish was in any oth

position, it would show no indication of feeling the current. Bio-electrical experiments have a way of consuming much time so we retired the device instead of attempting to modify it.

Seines were tried in Prairie Creek and it was demonstrated that young silver salmon could be taken in fairly good numbers by this means. Seining, then, seemed to be the most practical way to obtain fish in the quantity needed for marking.

Seining Fingerling Silver Salmon

Construction of Seines and Other Equipment

A variety of seines were constructed ranging from a three-foot square one-man type to a 40-foot two-man style. Seines 10 to 20 feet long by six feet deep proved more useful than the larger nets. Tests showed that cork floats three inches in diameter and spaced 12 inches apart were sufficient to hold up the seine, and two ounce leads spaced eight inches apart made a satisfactory lead line. A five-foot pole on each end of the net made seining easier.

Japanese cotton netting one-half inch stretched mesh, 20/6 cable laid twine, was found to make a light seine, easy to pull even in a fast current. However, sharp rocks and snags ruined this neeting in short order. One-half inch stretched mesh webbing of six-thread medium-laid seine-twine made a more durable net, although it was heavier and harder to pull through the water. At best the webbing lasted only a few days, and it was necessary to keep one man engaged solely in turning out new seines in order to have replacements available as needed.

The first seines were treated with copper napthanate to lengthen their lives. This was found to be an unnecessary precaution since the nets were worn out from hard use long before they would become weakened by rotting. The white, untreated nets frightened fish more than nets that had been dyed green with copper napthanate. This tended to keep fish ahead of the white seine and fewer fish escaped by dodging under the lead line.

Other equipment was necessary in carrying out the seining program. Lives boxes were essential to hold fish until the end of the day when they could be picked up and hauled to the hatchery. These boxes were made of hardware cloth fastened to a wooden frame, and were constructed in sets of five. The laregst measured two feet high, three feet wide, and four feet long. Four other progressively smaller boxes nested inside the largest box for ease in transportation.

Several three- and four-gallon buckets were used by a seining crew to collect fish and transport them to the closest live box. Two hundred silver salmon could be handled in a bucket if the trip to a live box was reasonably short.

Waist waders for each member of a seining crew were indispensable. There was very little area in any of the streams covered that could not be seined by men wearing these waders.

Young silver salmon were transported from streams to the hatchery in the same trailers that were used on the Sacramento River in 1950. A Jeep was essential in getting the trailer into some of the areas where old logging roads, or no roads at all, made travel with an ordinary vehicle impossible.

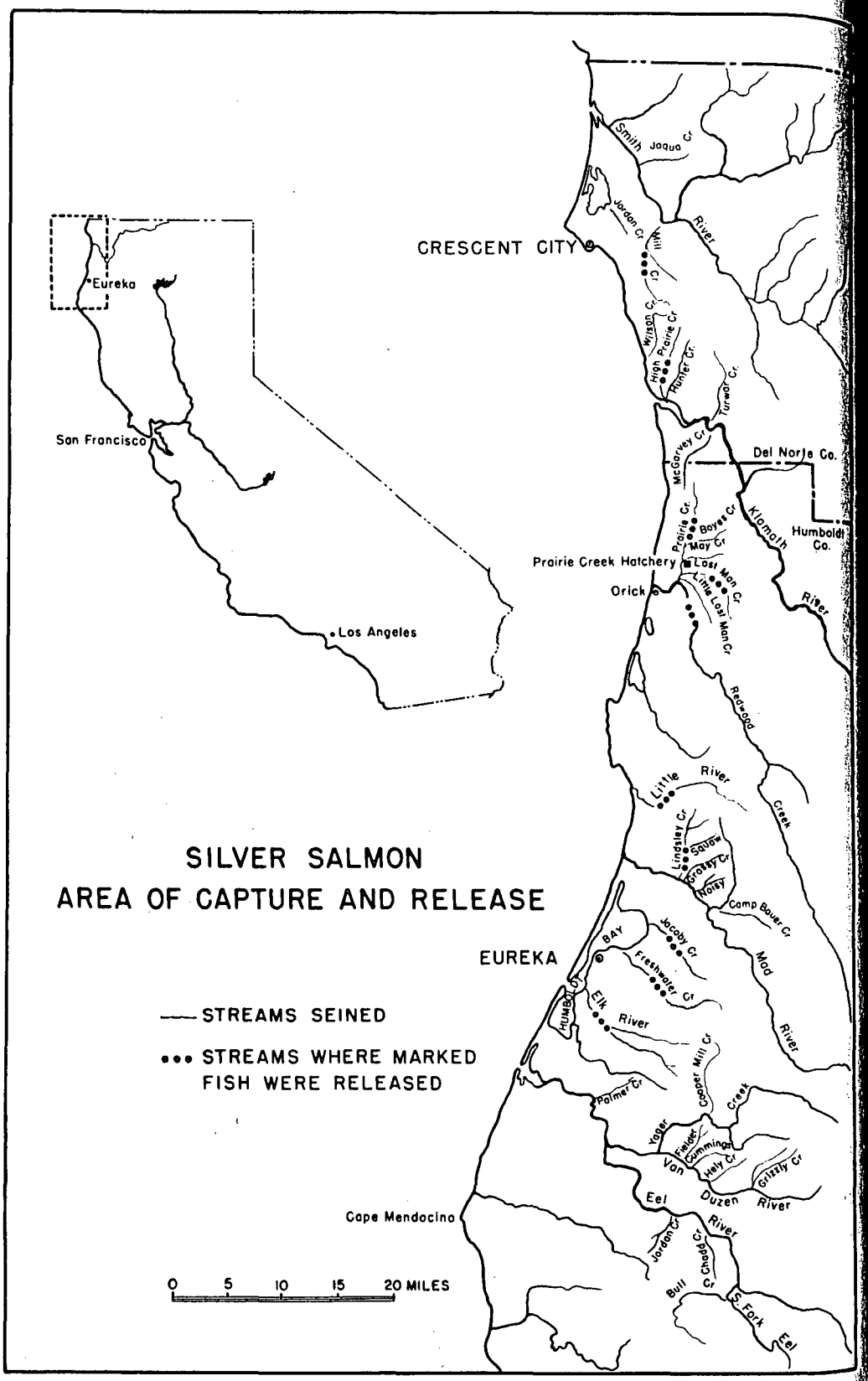

FIGURE 4. Map of the area where silver salmon were seined, marked and released.

Area Seined (Figure 4)

Seining for silver salmon was confined to the coastal streams of Humboldt and Del Norte Counties, between Bull Creek, a tributary to Eel River, and Mill Creek, a tributary to Smith River. Very few salmon were taken south of Humboldt Bay because of the long hauling distance to Prairie Creek Hatchery. All releases of marked fish were made in permanent streams between Elk River, a tributary to Humboldt Bay, and Mill Creek in Del Norte County.

Seining Procedure (Figure 5)

Before a seining crew worked a stream, a man was sent ahead to scout the area. He first determined if young silver salmon were present by making hauls with a one-man seine at various places along the stream. Then on a county map, he marked the access roads, if any, and obtained the landowner's permission if it were necessary to use private roads, or to trespass on private property. By contacting local state fish and game wardens for information, the scout often saved much time in locating streams and roads.

If the scout's report was favorable, a seining crew moved into the designated area, placed live boxes at about 400-yard intervals along the selected stream and started seining. Five live boxes per crew were usually sufficient for a day's netting. During most of the operation, it was possible to keep two seining crews in the field. At times, these crews worked different streams, but often they covered different sections of the same stream.

The seining procedure did not follow a definite pattern. In most streams, the current was not strong enough to collapse a seine even when it was pulled downstream. Usually the seiners looked over a pool to decide where a net could be best landed or beached, and the seine was worked in that direction. Several seines of different lengths were carried by each crew, and the choice of net was governed by the size of a pool to be seined. The physical characteristics of the stream limited the effectiveness of the seine more than did the wariness of the fish. Many young silvers made no attempt to avoid the net; others even swam out from inaccessible places to see what was going on and were collected in the seine.

A three- or four-man crew could effectively seine most streams. On a stream where fish were not too plentiful, two men would pull a seine and a third man would carry buckets of fish to the nearest live box as the seiners worked from pool to pool past each box in turn. In waters where salmon were more concentrated, it was desirable to have two men shuttling buckets between the seiners and the live boxes.

Proper placement of each live box in the stream was important in keeping the fish alive. Quiet water with only a slight current kept fish in the best condition. Twice, live boxes were located in places where water currents proved to be too strong. In a short while the salmon became tired from swimming against the stream and were plastered against the downstream side of the box. Each time this was quickly discovered and the box moved.

On several streams, it was not possible to pull a trailer close to all the live boxes in a stream. In such places, a "bucket brigade" was formed

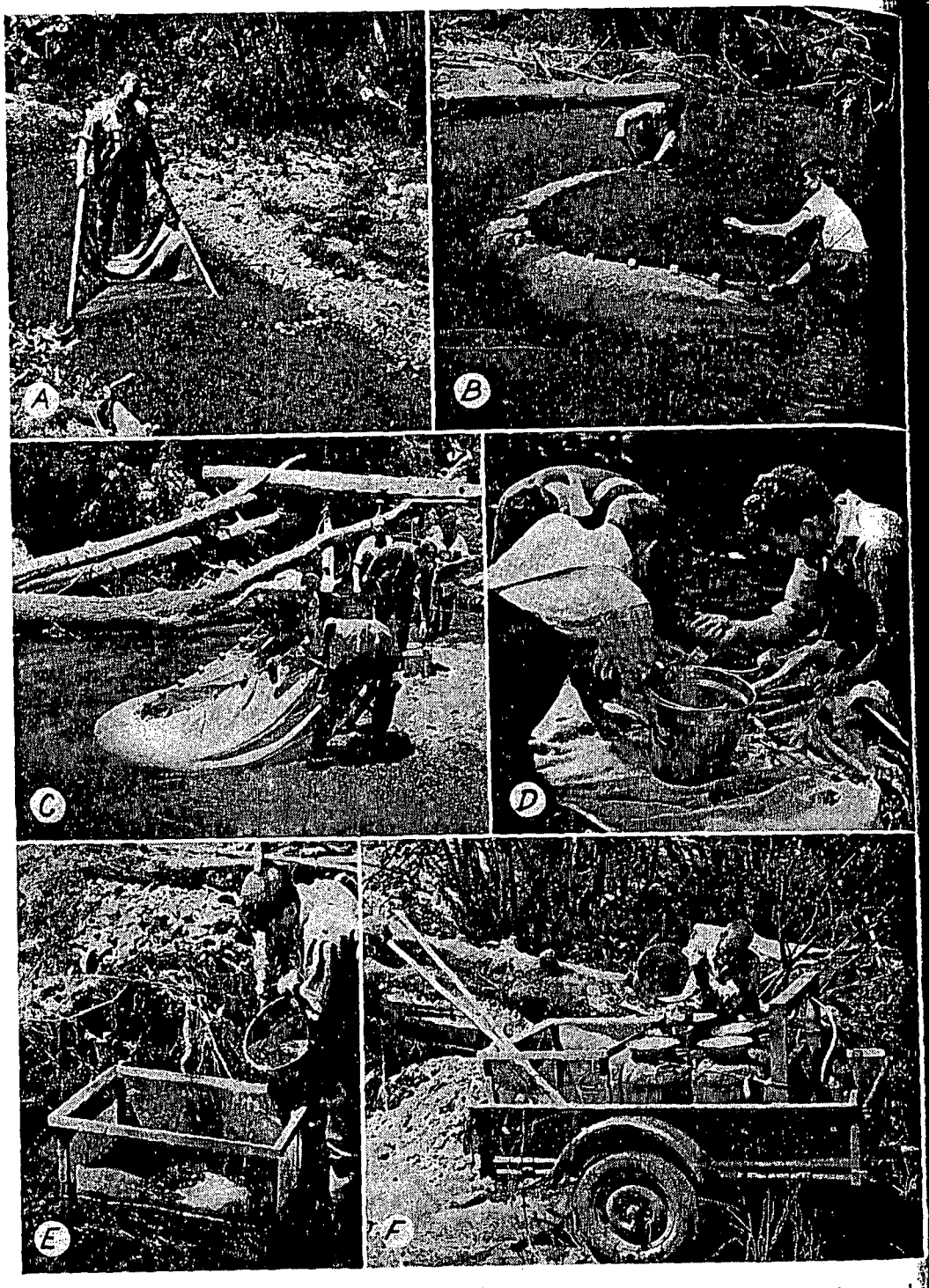

FIGURE 5. Seining silver salmon for marking. A—A one-man seine as used in small pockets under banks, etc. B—A two-man seine in operation. The men had little trouble herding silver salmon across large pools with nets which seemed much too small for the job. C—Beaching a two-man seine. A second seine crew has just appeared, and on this occasion the two groups will combine forces to transport their catches to the hatchery for marking. D—Sorting the catch. In this stream only silver salmon and trout were present. E—Pouring a bucket of fish into the live box. F—Loading fish onto the trailer for transportation to the hatchery. The gasoline-powered aerator pump can be seen at the forward end of the trailer. *Photographs by D. H. Fry, Jr., and R. J. Hallock.*

to move the fish from live box to live box until all salmon were concentrated in the one box closest to the Jeep and trailer. From here, bucket carriers worked at top speed to move the catch to the trailer. The trailer is shown in Figure 5F.

The Catch

Seining was started on May 8th and concluded on July 20, 1951, when a total of 168,362 silvers had been captured. During this period, 56 days were spent in seining for an average catch of 3,000 salmon per day. The maximum day's catch was slightly over 9,000 fish.

Most yearling silvers appearing in the catch were taken early in May near the mouths of streams. They represented the last of the seaward migrant yearlings still in fresh water. A few yearlings that had become trapped in drying streams and potholes were netted throughout the seining program.

Sorting silver salmon from the variety of species captured in the seines took time. When seining was done on a stream with a permanent flow, much of this sorting was done by the seiners (Figure 5D). After each haul of a net, the silver salmon were picked out and placed in a pail. The remainder of the catch was set free. However, much of the seining was done in small streams which were going dry, and all fish captured were transported to the hatchery for sorting. The trout and king salmon were released with the marked silver salmon in suitable streams. The principal fishes captured in addition to silver salmon were king salmon, steelhead trout (*Salmo gairdneri*), coastal cutthroat trout (*Salmo clarki*), sculpins (*Cottus*), and suckers (*Catostomus*). A few green sunfish (*Lepomis cyanellus*) were also captured in Turwar Creek, a tributary to the Klamath River.

Over 48,000 of the silvers marked were saved from certain death in drying streams. At least twice this number of steelhead and cutthroat trout were transferred to permanent waters as a result of the silver seining. In one day alone, June 25, 1951, approximately 24,000 trout and 2,000 silver salmon were rescued on Wilson Creek in Del Norte County.

Silver Salmon at the Hatchery

Each daily catch of silver salmon brought to the hatchery remained there about two days. Marking was usually done on the first day, but marked fish were held an additional day to observe the effects of marking and handling. While at the hatchery, wild silvers were offered food at the same time that hatchery raised fish were fed. A few silvers took food during their first day in the troughs, and by the second day, many fish were feeding, but not so voraciously as hatchery fish. The yearling silvers ate but little even after several days. As a whole, the silvers did not appear to adapt themselves to hatchery life as readily as the king salmon captured in the Sacramento River in 1950.

Movement of Marked Silver Salmon in Streams

The marked silver salmon spread rapidly when returned to a stream. On the North Fork of Elk River, a tributary to Humboldt Bay, 1,572 silvers were released late one morning and 47 were recaptured a mile

upstream the next day. On the South Fork of Elk River, 3,856 silvers were released about 10 a.m., only to appear in the seines about three-fourths of a mile downstream at 3 p.m. the same day. The majority of the fish released in Prairie Creek, Humboldt County, were planted at the south end of the Prairie Creek State Park campgrounds. Some of these fish were captured in seines about three miles upstream from this release point, three days after the initial planting. This same rapid movement of marked silvers, in both directions from the release point, was noted in Mill Creek, in Del Norte County, where the fish distributed themselves fairly evenly along the upper lengths of the stream in a short time. The better producing streams were seined more than once, and this self-distribution by the silvers was so rapid and so complete that careful planning was necessary to avoid recapturing many marked fish.

Test hauls were made on several streams where marked fish had been released. This was done to learn if it was still possible to seine without recapturing large quantities of marked fish. On sections of Mill Creek, the seine hauls captured silvers of which an estimated one-third to one-

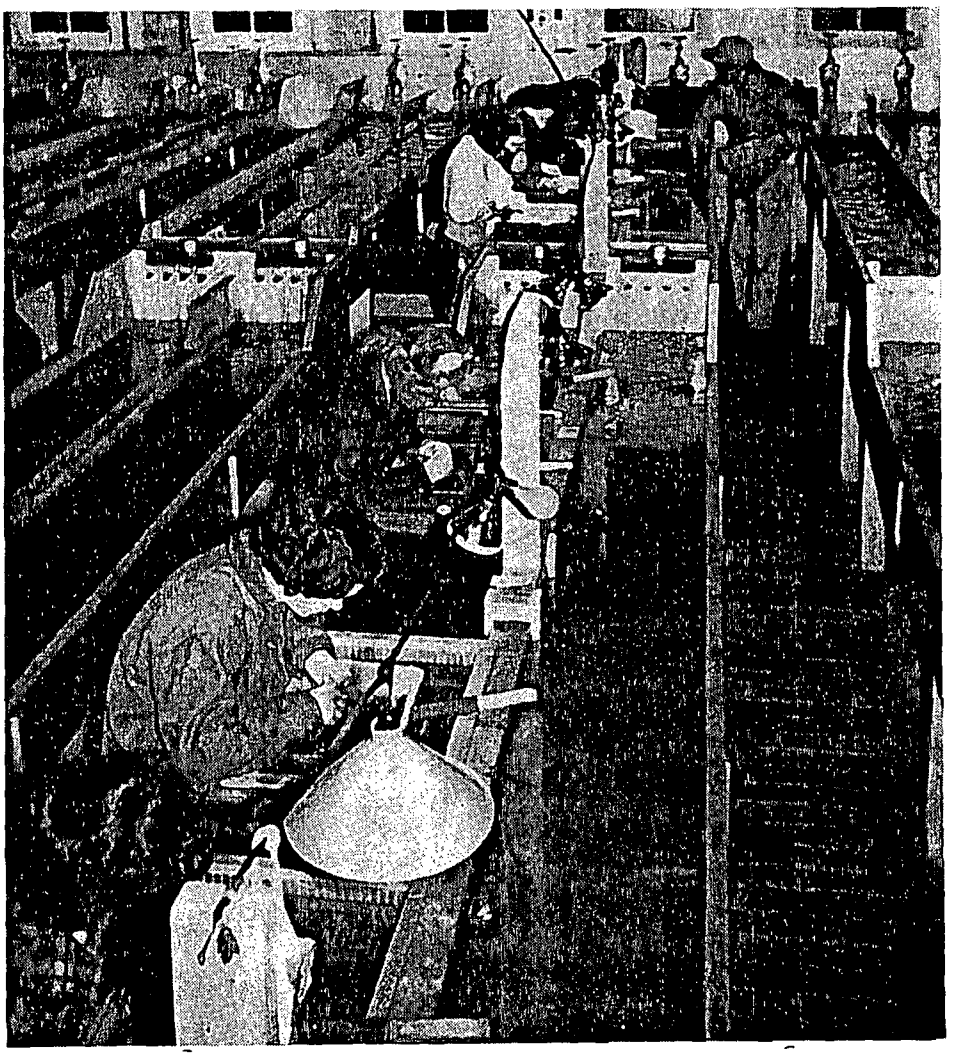

FIGURE 6. Women markers clipping fingerling salmon at Prairie Creek Hatchery. A larger crew was used at the Coleman hatchery. *Photographs by D. H. Fry, Jr.*

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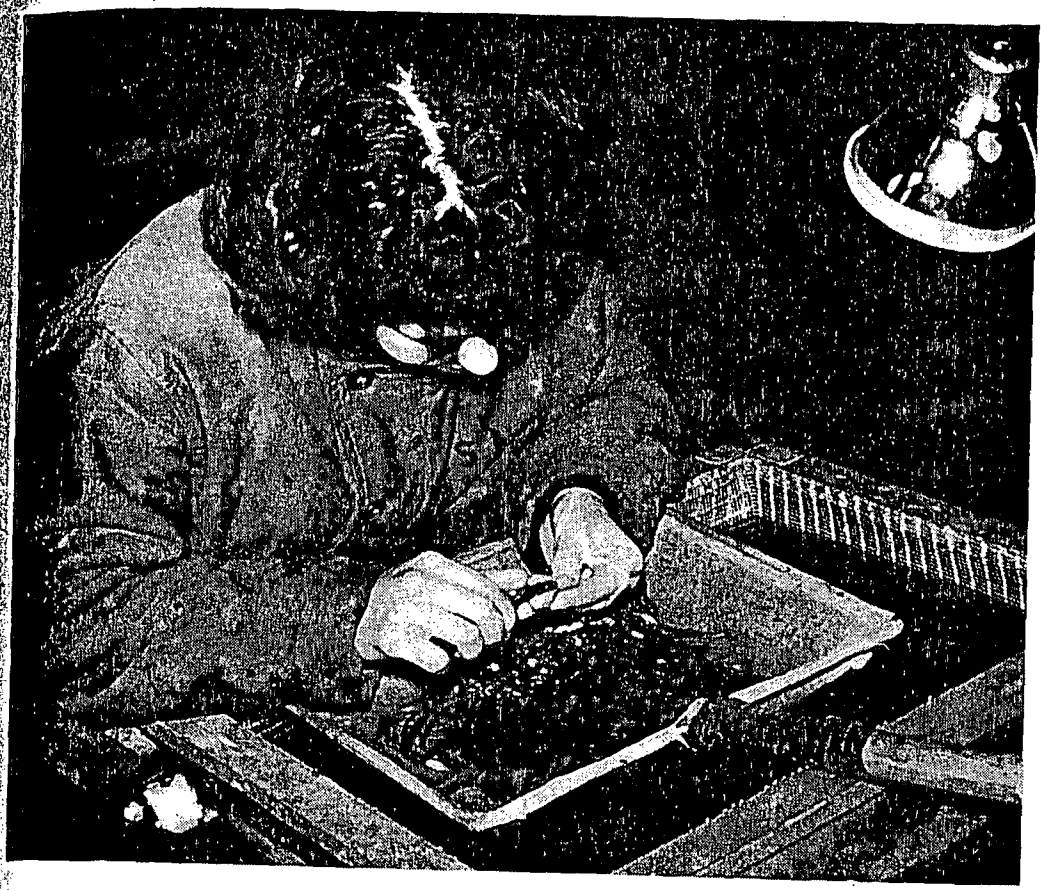

FIGURE 7. Closeup of a woman marker with a scap net; fingerling king salmon in front of her. Note the hand tally near the lower left corner of the picture. *Photograph by D. H. Fry, Jr.*

half were marked. In Prairie Creek on June 13, 1951, a total of 2,039 silver salmon were taken of which 442 were already marked.

Other test hauls were made in Mill Creek and Prairie Creek during the latter part of the marking period to observe the condition of the fish. There was no sign of any infection and the fin scars seemed entirely satisfactory.

MARKING KING AND SILVER SALMON

Both at Coleman and Prairie Creek Hatcheries, practically all of the fin clipping during these first two years was done by women hired as seasonal employees. Most were housewives living in the vicinity of the hatcheries. Whenever possible, local residents were hired so that in succeeding years, the likelihood of obtaining experienced employees would be increased.

Women become quite adept as markers. Fin clipping requires a nimbleness of fingers which many men do not have. It also requires perseverance and excellent eyes.

Each marker wore a special glove made of bobbinet. This covered the thumb and first two fingers of the hand used to hold the fish. The women made these gloves themselves. Fins were removed with a five-inch flat-jawed stainless steel clipper of a type known as nail-splitting forceps. A hand tally mounted on the trough beside each marker enabled her to keep count of the fish clipped. (See Figures 6, 7, 8, and 9.)

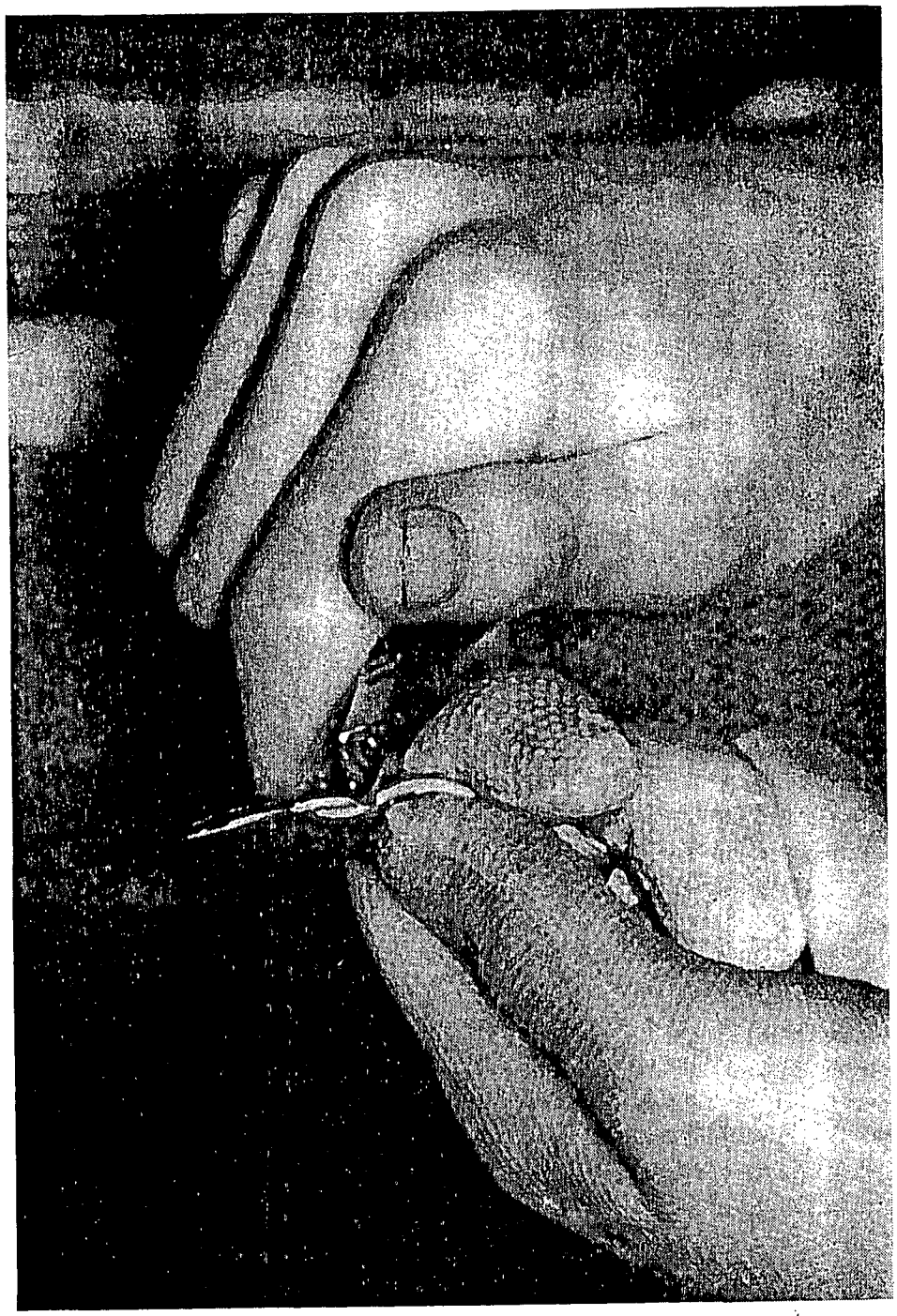

FIGURE 8. Clipping a ventral fin from a wild silver salmon fingerling. Note the bobbinet glove covering the thumb and two fingers of the marker. *Photograph by D. H. Fry, Jr.*

FIGURE 9. Clippe

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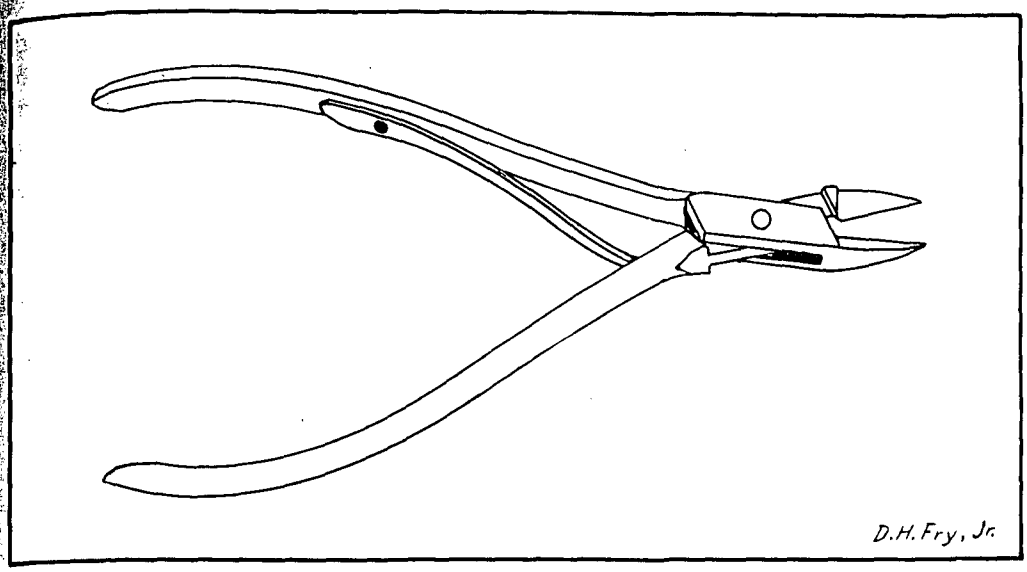

FIGURE 9. Clippers used for marking salmon. About two-thirds actual size. These tools are known to the surgical supply trade as nail-splitting forceps.

Numbers of Salmon Marked

During 1950 and 1951, California marked 860,917 salmon. Of these, 845,469 were released. Mortality from all causes after marking was 15,448 or about 1.8 percent. Of those marked and released, 444,026 were hatchery-raised king salmon and 235,248 were king salmon captured in the Sacramento River. In addition, 166,195 silver salmon captured in the streams of Humboldt and Del Norte Counties were marked and released. Table 1 gives a summary of the first two years of marking.

Hatchery-reared Salmon

The 235,466 hatchery-raised king salmon released in Battle Creek in the spring of 1950 were the progeny of the 1949 fall run, trapped and spawned artificially at Coleman Hatchery on Battle Creek. This group of fish was furnished for marking by the U. S. Fish and Wildlife Service. These hatchery-reared salmon were marked at Coleman Hatchery by the same crew and during the same period that salmon brought in from the Sacramento River were being marked. Hatchery fish were marked whenever all available wild salmon had been fin clipped. This procedure decreased the time spent at the hatchery by wild kings, but it increased the period of marking for hatchery fish. After marking, hatchery-reared fingerlings were held in outside ponds until they were released in a group on March 31st. They averaged 44 mm. in total length when marking started, but the mean had increased to 56 mm. by the time the last group was marked. Eighty percent of the fish were marked during the last 11 days. During this period, the mean increased from 52 mm. to 56 mm. total length. The mean of the entire group at time of marking was 53 mm. (slightly over two inches).

An additional 132,734 hatchery-raised king salmon were marked and released in the spring of 1950. These salmon were hatched from eggs spawned artificially at Sweasey Dam on Mad River in the fall of 1949 (1949 brood year). They were reared at Prairie Creek Hatchery where

TABLE 1

Marked Fingerling Salmon Released in 1950 and 1951

Year marked and released	Date of release	Species	Brood year	Origin of eggs or fish	Where marked	Where released	Fins removed	Mean length when marked	Number marked	Number released
1950	Feb. 17 to March 13	King (captured)	1949	Sacramento River at Red Bluff	Coleman Station	Sacramento River at Jelly's Ferry	Dorsal and left ventral	41 mm.	237,797	235,248
1950	March 31	King (hatchery)	1949	Battle Creek Coleman Station	Coleman Station	Battle Creek at Coleman Station	Dorsal and right ventral	53 mm.	238,021	235,466
1950	May 4 to May 18	King (hatchery)	1949	Mad River at Sweasey Dam	Prairie Creek Hatchery	Big River Mendocino County	Anal and left ventral	43 mm.	137,396	132,734
1951	July 19 to Aug. 2	King (hatchery)	1950	Mad River at Sweasey Dam	Prairie Creek Hatchery	Mad River at Sweasey Dam	Left ventral	66 mm.	79,341	75,826
1951	May 11 to July 21	Silver (captured)	1949	Del Norte and Humboldt Counties	Prairie Creek Hatchery	Del Norte and Humboldt Counties	Adipose and both ventrals	124 mm.	1,784	1,772
1951	May 14 to July 22	Silver (captured)	1950	Del Norte and Humboldt Counties	Prairie Creek Hatchery	Del Norte and Humboldt Counties	Adipose and right ventrals	52 mm.	166,578	164,423
									860,917	845,469

the marking was done. The fish were planted between May 4th and May 18th in Big River in Mendocino County where the Department of Fish and Game is attempting to establish a run of king salmon. The fish averaged 43 mm. in total length when marked (slightly under $1\frac{3}{4}$ inches).

For a marking experiment, it would have been far better to have planted the marked fish in Mad River since that stream produced the eggs. However, the department was already committed to stocking Big River and the egg take had been so poor that there were not enough fingerlings for both plants.

In the spring of 1951, a group of 75,826 hatchery-raised king salmon were marked at Prairie Creek Hatchery and placed in Mad River. Only the left ventral fin was excised on each of these fish. This work was done as one of a series of hatchery survival experiments being conducted by the Bureau of Fish Conservation. It was not part of the Pacific Marine Fisheries Commission experiment, but the actual marking was done by the same workers. These fish were the young from the 1950 fall run (1950 brood year) in Mad River, spawned artificially at Sweasey Dam. Marking was completed on June 19th; however, the fish were not released until the latter part of July and the early part of August. On June 15th, 300 of the marked salmon were measured, giving an average total length of 66 mm. and a range of 55 to 78 mm.

Marked Wild Salmon

Three groups of salmon captured in streams were marked and released in 1950 and 1951.

The 235,248 king salmon captured and released in the Sacramento River near Red Bluff in February and March of 1950 were the offspring of salmon which spawned in the fall of 1949. All or nearly all of them were fall-run fish. There is little possibility that many were the progeny of the 1949 spring run. The Sacramento spring run adults spawn earlier than fall-run fish and there are usually two peaks in the seaward migration of the young. The first and smaller peak is presumed to consist of spring-run fish. Fyke netting for young kings was not started until the middle of February, and undoubtedly all but the end of the spring run had passed Red Bluff. The small and remarkably uniform size of the salmon captured would strengthen the belief that the somewhat older spring-run fish were not present in any number. All salmon were hauled to Coleman Hatchery for marking, and were later released in the Sacramento River at Jelly's Ferry. Fingerlings from 14 different daily catches were measured in lots of 50 each, with each group varying only slightly from 41 mm. in average total length.

In 1951, two age groups of silver salmon were seined in the smaller coastal streams of Humboldt and Del Norte Counties. One hundred sixty-four thousand four hundred twenty-three silvers were the young of the 1950 brood year, and 1,772 were yearlings or the progeny of the 1949 brood year. All silvers were marked at Prairie Creek Hatchery and returned to the streams within three days. All marked silvers were placed in streams between Elk River, a tributary to Humboldt Bay, and Mill Creek, a tributary to Smith River. Table 2 shows the numbers of silvers seined from each stream, and marked fish returned. The majority of those streams from which salmon were seined and not returned, were streams which usually went dry during summer months. Others, such as

TABLE 2

Silver Salmon Seined and Released in the Streams of Humboldt and Del Norte Counties, May-July, 1951

Stream	County	Salmon taken from each stream		Marked salmon released in each stream	
		Yearlings (1949 brood yr.)	Fish of the yr. (1950 brood yr.)	Yearlings (1949 brood yr.)	Fish of the yr. (1950 brood yr.)
High Prairie Creek	Del Norte	166	3,371		3,813
Hunter Creek	Del Norte	35	500		
Jaqua Creek	Del Norte		25		
Jordan Creek	Del Norte		200		
McGarvey Creek	Del Norte	20	200		
Mill Creek	Del Norte	71	60,531	184	68,790
Turwar Creek	Del Norte	50	3,000		
Wilson Creek	Del Norte	833	10,531		
Boyes Creek	Humboldt		240		
Bull Creek	Humboldt		3,000		
Camp Bauer Creek	Humboldt		200		
Chadd Creek	Humboldt		500		
Cooper Mill Creek	Humboldt		216		
Cummings Creek	Humboldt	2	500		
Elk River	Humboldt		17,671	44	8,591
Fielder Creek	Humboldt		2,100		
Freshwater Creek	Humboldt	2	8,640	7	1,391
Grassy Creek	Humboldt	45	11,158		
Grizzly Creek	Humboldt		500		
Hely Creek	Humboldt		200		
Jacoby Creek	Humboldt	20	14,223		13,021
Jordan Creek	Humboldt		500		
Lindsey Creek	Humboldt	80	10,583		16,518
Little Lost Man Creek	Humboldt		189		
Little River	Humboldt		813	5	2,213
Lost Man Creek	Humboldt	20	1,500	258	9,253
May Creek	Humboldt		300		
Noisey Creek	Humboldt		500		
Palmer Creek	Humboldt		956		
Prairie Creek	Humboldt	430	6,931	1,232	30,786
Redwood Creek	Humboldt			42	10,049
Squaw Creek	Humboldt	10	6,800		
		1,784	166,578	1,772	164,423

TOTAL - PRAIRIE CR = '50 '50 = 9610

Bull Creek and Freshwater Creek, showed signs of pollution in sections below communities, and were not replanted except in localities remote from the polluted area. This accounts in part for a smaller number of salmon being returned to some streams than was taken out for marking. Little River and Redwood Creek are both excellent silver salmon streams but were not seined extensively because in the few places where they could be reached by road, the pools were so deep as to make netting impractical. However, these streams made good planting places and as such received more fish than were taken from them.

The relatively few yearling silvers fell into two size groups: The larger fish were captured in May close to the ocean. Apparently, they were about to enter salt water. An even 1,000 of these fish were marked, most of them from Wilson Creek. A sample of 25 of these fish had a range of 144 to 177 mm. with a mean of 149 mm. total length (5⅞ inches).

The smaller yearlings were taken throughout the seining operations, usually in an isolated section of a stream or in some other place from

which low flows had made it difficult or impossible for them to reach the ocean. Eighty-two were measured and they ranged from 90 to 132 mm. with a mean of 99 mm. A total of 772 of the smaller yearlings were marked.

The 1950 brood-year fish increased in size throughout the period of marking (May 14 to July 21, 1951). Early in June, 242 were measured and showed a range of 40 to 88 mm. (mean 52 mm. total length). By the end of the marking period, the fastest growing fish of the year were a few millimeters longer than some of the stunted yearlings which had been trapped in drying sections of the streams. There was no overlap between the two year classes in any one stream.

Mortality Due to Marking and Related Causes

During 1950-1951, the California Department of Fish and Game marked 860,917 salmon. Mortality from all causes after marking such as disease, direct effects of marking and handling, was 15,448 or 1.8 percent. During the period of marking, over 4,000 marked fish and unmarked controls were set aside in lots of 500. These groups were held from four days to two months. Observation of these groups showed that most of the mortality which could be attributed to handling and marking occurred during the first 24 to 36 hours after clipping. As a result of these observations, all wild fish were held at least 36 hours after marking. Hatchery fish were held much longer.

Speed and Accuracy of Marking—Fin Regeneration

Experience of many markers in many previous experiments has shown that if fins are not properly removed, they will grow back or regenerate. Two important factors are the size of the fish and the completeness of the excision. The smallest fish not only show the greatest tendencies toward fin regeneration, but they are also the most difficult to mark cleanly.

Marking must be done with great care in order to minimize regeneration, and care is the factor which should be stressed with the marking crew. Speed must also be considered—particularly when there are hundreds of thousands of fish to be marked.

Table 3 shows the different groups of salmon marked during 1950 and 1951, and the average time taken to mark each group. For the entire 860,917 salmon fin clipped, the average number marked by each marker for an eight-hour day was 1,577 or 197 for each hour.

The greatest speed in marking was displayed at Prairie Creek Hatchery where 79,341 fish were fin clipped at an average rate of 230 per hour for each marker. These fish were comparatively large and this was the only lot from which only a single fin was removed. A close second in speed of marking was the fin clipping at Coleman Hatchery in 1950 where two groups (wild kings plus hatchery kings) totaling 475,818 were marked at an average rate of 225 per hour by each marker. Two fins were removed from fish marked at Coleman Hatchery. Only one lot of fish showed possible ill effects from excessive speed in marking. The wild king salmon averaged only 41 mm. in length when marked, yet they were fin clipped at approximately the same rate as fish averaging 12 mm. longer. The

TABLE 3

Marked Salmon Sampling, for Correctness of Marks, at the Time of Marking

Year marked	Species	Brood year	Average total length	Fins removed	Where marked	Number marked	Number sampled	Number with all marks acceptable	Percentage with all marks acceptable	Average number marked per marker per hour
1950	King (captured)	1949	41 mm.	Dorsal and left ventral	Coleman Station	237,797	2,764	2,697	97.6	225
1950	King (hatchery)	1949	53 mm.	Dorsal and right ventral	Coleman Station	238,021	7,628	7,322	96.0	
1950	King (hatchery)	1949	43 mm.	Anal and left ventral	Prairie Creek Hatchery	137,396	11,457	10,718	93.5	170
1951	King (hatchery)	1950	66 mm.	Left ventral	Prairie Creek Hatchery	79,341	20,012	18,982	94.9	230
1951	Silver (captured-yearling)	1949	124 mm.	Adipose and both ventrals	Prairie Creek Hatchery	1,784	500	500	100.0	163
1951	Silver (captured-fish of the year)	1950	52 mm.	Adipose and right ventral	Prairie Creek Hatchery	166,578	10,133	10,103	99.7	

TABLE 4

Regeneration of Clipped Fins

TABLE 4

Regeneration of Clipped Fins

	Number sampled	Months after marking	Both fin marks recognizable	Ventral fin mark recognizable. Dorsal fin mark not recognizable	Dorsal fin mark recognizable. Ventral fin mark not recognizable	Neither fin mark recognizable
King salmon, 1949 brood year: Wild fish from Sacramento River, 41 mm. mean length when marked	352	11	65.4% (230)	29.8% (105)	1.9% (7)	2.8% (10)
King salmon, 1949 brood year: Hatchery fish (Coleman Hatchery), 50 mm. mean length when measured	398	11	96.0% (382)	1.0% (4)	0.5% (2)	2.5% (10)
			Both fin marks recognizable	Ventral fin mark recognizable. Adipose fin mark not recognizable	Adipose fin mark recognizable. Ventral fin mark not recognizable	Neither fin mark recognizable
Silver salmon, 1950 brood year: Wild fish from Del Norte and Humboldt Counties	278	4½	100.0% (278)	0% (0)	0% (0)	0% (0)

dorsal fins of these captured kings regenerated badly. This is discussed below.

Accuracy of marks rather than speed was emhpasized at all times. A system which served to stimulate proper marking was to display from time to time on a bulletin board the results obtained from the sampling of salmon taken from each marker. The number of marked fish sampled and the number which were acceptable were recorded opposite the name of each marker. No mention was made of the total number clipped by each individual. The effect was to have each woman striving to improve the quality of her work.

Inspecting for Correctness of Marks

Fifty-two thousand four hundred ninety-four marked salmon were sampled at the time of marking to find out what percentage of the fish were well enough fin clipped so that there would presumably be little or no regeneration. Table 3 gives the percentage of each group of fish that was judged to be properly clipped. The sampling was usually accomplished by examining an equal number of fish from every marker. In this manner, a check on each person marking fish was also obtained. Occasionally a scap net full of salmon was taken from a grouped lot of marked fish in a hatchery trough. Standards were set up for the sampling so that each person looking over fin-clipped fish would be judging the marks in the same manner. Frequent comparisons of interpretations as to the acceptability of marks were made by individual samplers to insure uniformity in the sampling techniques. Table 3 shows the different groups of fish with the results of sampling for correctness of marks at the time of marking. The percentage of acceptable marks seemed satisfactory but these salmon were so small that some idea of the actual

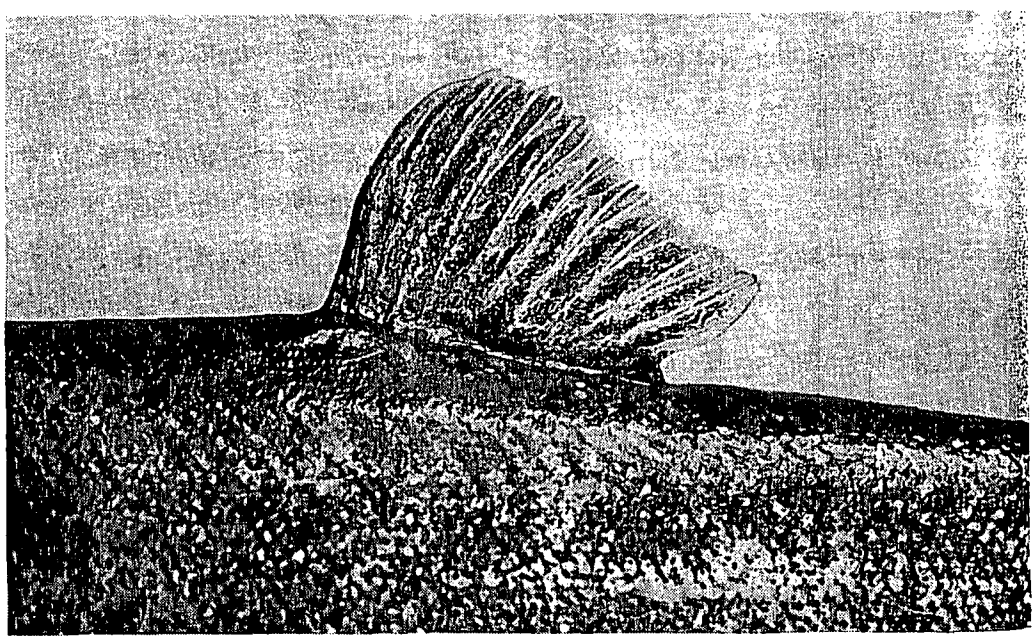

FIGURE 10. King salmon. An extreme example of dorsal fin regeneration. This fin is slightly smaller than a normal dorsal, looks and feels slightly misshapen, but could easily be missed by even a careful observer. *Photograph by D. H. Fry, Jr.*

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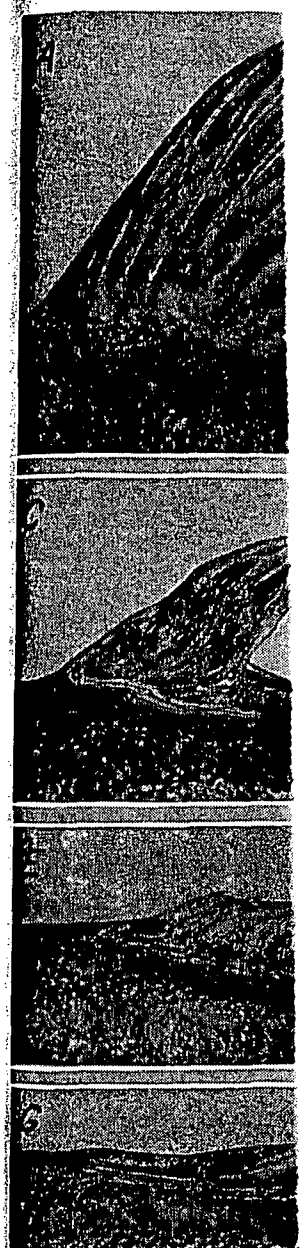

FIGURE 11. King salmon; n
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amount of fin regeneration was necessary in order to make a good estimate of the numbers of correctly marked fish released. Table 4 shows the three lots of marked fish set aside for this study and the results of sampling over a period of months. In each case, the number sampled from $4\frac{1}{2}$ to 11 months after marking was the total still living. The greatest fin regeneration was in the dorsal fins of the king salmon captured in the Sacramento River. Eleven months after marking, only two-thirds of the captured fish sampled had dorsal fin marks which were acceptable and

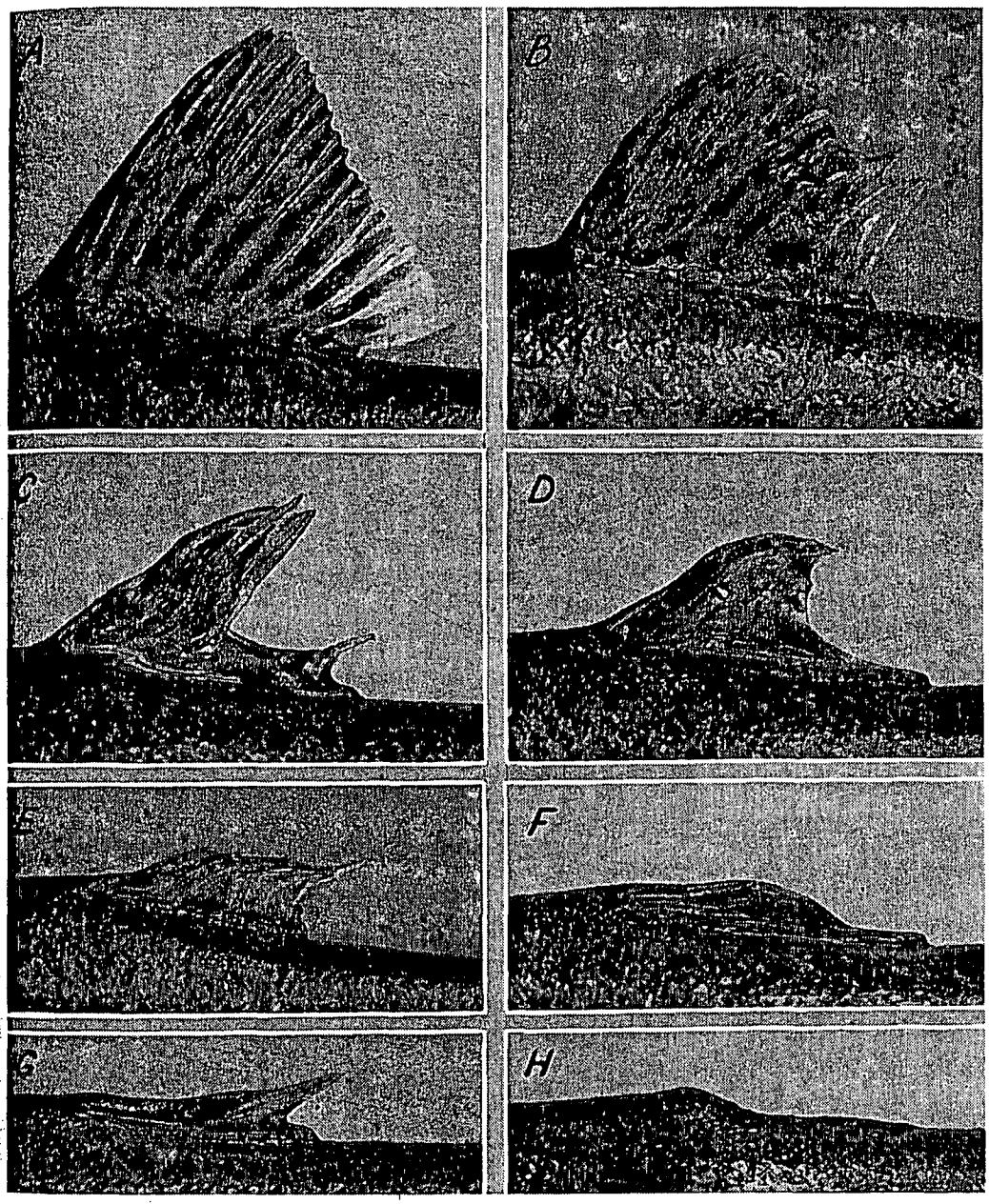
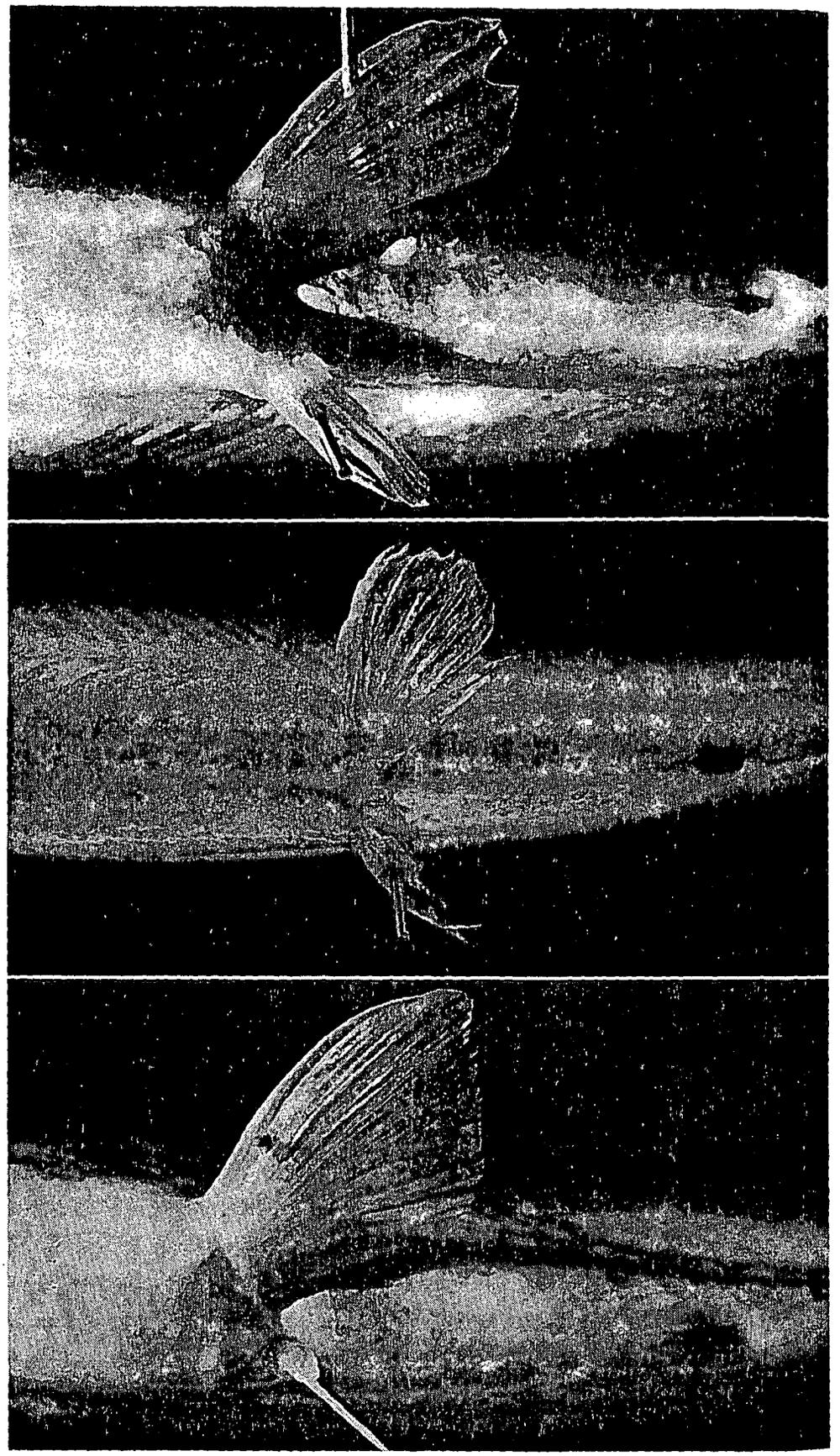


FIGURE 11. King salmon; normal and regenerated dorsal fins. These fish were held at the hatchery for about 10 months, and were about seven inches long when photographed at the end of that time. Most or all of the regeneration had taken place months previously. Trained observers will be inspecting the commercial salmon catch looking for marked fish. A—Normal fin. B—This is as extreme a case of regeneration as a careful observer could possibly detect. C-G—Varying degrees of regeneration. None are apt to pass unnoticed. H—No regeneration. *Photographs by D. H. Fry, Jr.*



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could be positively recognized (Table 4). The hatchery kings also displayed a considerable fin regeneration; however, the regrowth was so incomplete in most instances that it was easy to recognize the fins as having been clipped.

As the king salmon grew, the marks became easier to recognize, but when a sampler looked at a regenerated fin on a six-inch salmon, he realized only too well the futility of trying to guess whether or not another sampler would notice that fin, one, two or three years later while examining hundreds of unmarked fish. This problem applies only to such fins as are shown in Figure 10 and possibly 11B. There should be no trouble identifying the partially regenerated and badly deformed fins such as those shown in Figures 11C to 11G and in Figure 12.

When these marked fish mature, the Sacramento River should be a valuable source of specimens which will be a help in determining more quantitatively just how hard it is for a sampler to recognize fins which have grown back. Any marked 1949 brood-year salmon in the Sacramento will have had the dorsal and one ventral fin clipped, and thus will be positively identifiable if either mark is recognizable.

The problem is actually much less difficult than it would be if the dorsal fins alone were being marked. Each marked dorsal is accompanied by a marked ventral (right or left) and less than 5 percent of the ventral fins seemed apt to be unrecognizable.

It is not known why the regeneration of fins was greatest among wild kings; the only apparent difference between this and the other groups marked was the length of the fish. This may be the only factor of importance and it may not.

Fin regeneration was almost absent on the wild silvers. The small group sampled $4\frac{1}{2}$ months after marking had the most perfectly removed fins of any lot examined. A clipped adipose fin gave no indication of any regeneration, and the ventral fins at most displayed a ray or two of regrowth.

SUMMARY

In 1946, delegates from California, Oregon and Washington formed the Pacific Marine Fisheries Commission to better coordinate fisheries' research and management on the Pacific Coast.

One problem of the commission has been that of the ocean fishery for king and silver salmon (*Oncorhynchus tschawytscha* and *O. Kisutch*). Previous work on these two species has included a tagging program engaged in by the three member states and by Canada and Alaska.

California, Oregon and Washington are now engaged in a marking program intended to give quantitative information about the movements of salmon at sea.

It was planned to mark silver salmon in groups of at least 100,000 and king salmon in groups of 200,000 when possible.

California is the only state marking wild (captured) fish.

FIGURE 12. (OPPOSITE PAGE) King salmon; regeneration of ventral fins. The fins have been spread out as far as they would readily open, and pinned in place. Comparison of size and "spreadability" with that of a normal fin makes regenerated ventrals easy to detect. Data as in Figure 11. In each photograph the normal fin is above. TOP: The regenerated fin is somewhat the smaller and could not be spread open like the normal fin. MIDDLE: An even more club-like regenerated fin. BOTTOM: The regenerated fin is no more than a small lump. Completely removed fins were common. *Photographs by D. H. Fry, Jr.*

In 1950, California used 22 fyke nets to capture king salmon on the Sacramento River. A total of 235,248 wild fish and 235,466 hatchery fish from Coleman Fishery Station were released in this area. Another 132,734 hatchery king salmon from Prairie Creek Hatchery were released in Big River, Mendocino County.

In 1951, wild silver salmon were seined from the coastal streams of Del Norte and Humboldt Counties. A total of 164,423 fish of the year and 1,772 yearlings were marked and released.

Also in 1951, a group of 75,826 hatchery king salmon were marked at Prairie Creek Hatchery and released in Mad River. (This was not part of the Pacific Marine Fisheries Commission experiment.)

All marking of both wild and hatchery fish was done at two hatcheries —Coleman Fishery Station (federal) and Prairie Creek (state).

Women markers were used.

Mortality after marking was 1.8 percent. Most deaths occurred within 36 hours after marking.

The average rate was 197 salmon marked per marker per hour.

Samples of fish from three groups were held to check the extent of fin regeneration.

Dorsal fins of the wild Sacramento kings regenerated badly. About one-third of the fish had dorsals which might not be recognizable if the fish were retaken at sea. Ventral fins of these same fish showed much less regeneration (5 percent possibly unrecognizable). These wild fish were the smallest marked (mean total length 41 mm.). Hatchery kings from Coleman Station (Sacramento River System fish) showed much less regeneration and silver salmon showed almost none.

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