CALIFORNIA FISH AND GAME

VOLUME 43 OCTOBER, 1957 NUMBER 4

Published Quarterly by the
CALIFORNIA DEPARTMENT OF FISH AND GAME
SACRAMENTO

Fry, Donald H., Jr., and Eldon P. Hughes
1951. The California salmon troll fishery. Pac. Mar. Fish. Comm., Bull. 2, p. 7-42.
Gilbert, Charles H.
1913. The salmon of Swiftsure Bank. Brit. Columbia, Comm. Fish., Rept. for 1912, p. I 14-I 18.
Heg, Robert, and Jack Van Hyning
1951. Food of the chinook and silver salmon taken off the Oregon coast. Oregon Fish Comm. Res. Briefs, vol. 3, no. 2, p. 32-40.
Martin, A. C., R. H. Gensch, and C. P. Brown
1946. Alternative methods in upland gamebird food analysis. Jour. Wildl. Mangt., vol. 10, no. 1, p. 8-12.
Milne, D. J.
1955. Selectivity of trolling lures. Fish. Res. Bd. Canada, Pac. Coast Sta., Prog. Rept. 103, p. 3-5.
Pritchard, A. L., and Albert L. Tester
1944. Food of spring and coho salmon in British Columbia. Fish. Res. Bd. Canada, Bull., 65, 23 p.
Roedel, Phil M.
1953. Common ocean fishes of the California coast. Calif. Dept. Fish and Game, Fish Bull. 91, 184 p.
Senter, Vance E.
1940. Observations on the food of Pacific salmon. Pac. Fisherman, vol. 38, no. 4, p. 26.
Silliman, Ralph P.
1941. Fluctuations in the diet of the chinook and silver salmons (*Oncorhynchus tschawytscha* and *O. kisutch*) off Washington, as related to the troll catch of salmon. Copeia, no. 2, p. 80-87.
Snyder, J. O.
1924. Young salmon taken at sea. Calif. Fish and Game, vol. 10, no. 2, p. 62-64.
Whitney, J. Parker
1893. Salmon in salt water. Forest and Stream, vol. 41, no. 6, p. 120-121.

THE USE OF WIRE FYKE TRAPS TO ESTIMATE THE RUNS OF ADULT SALMON AND STEELHEAD IN THE SACRAMENTO RIVER[1]

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[1] Submitted for publication March, 1957. This was a cooperative project carried out with funds provided by the Marine Fisheries Branch and by Federal Aid in Wildlife Restoration Project California F-7-R, "Sacramento-San Joaquin River Salmon and Steelhead Study".

INTRODUCTION

One of the basic tools necessary for proper management of salmon and steelhead is a knowledge of the sizes of their annual spawning escapements or runs. Other information, including the time these runs enter different river systems, the spawning periods, and the areas in each stream utilized by the fish for spawning purposes is also essential to manage this resource effectively.

Such data are becoming increasingly valuable in planning for the safety and maintenance of salmon and steelhead runs, in view of the multitude of water development projects on our streams, both proposed and under construction.

Since 1939 the California Department of Fish and Game has made population estimates of fall-run king salmon (*Oncorhynchus tshawytscha*) in various Sacramento-San Joaquin Valley streams. Most of this work has been done by the Marine Fisheries Branch. Steelhead rainbow trout (*Salmo gairdneri gairdneri*) research in the Central Valley did not become a full time program until 1952 and has been conducted since then in the Sacramento River system by Dingell-Johnson Project F-7-R, "Sacramento-San Joaquin River Salmon and Steelhead Study", under the Inland Fisheries Branch.

Whenever possible, fish ladder counts have been used for salmon enumeration, but there are relatively few permanent weirs or dams in the Central Valley where complete, or even partial, counts can be made. Most of the diversion dams are upstream from the major spawning areas.

During the period from 1939 through 1942, when fish ladders were not available, the method used was to count salmon through an opening in a weir built across the stream. This method did not prove satisfactory, since the weirs washed out during high water.

In 1943, weir counts were abandoned by the Department, and a tag and recovery method was substituted. This method of population estimation requires only that a known number of salmon be tagged and allowed to proceed upstream to spawn and die. From the ratio of tagged to untagged carcasses on the spawning beds, it is possible to calculate the size of the spawning run.

The first method of capturing salmon for this tagging employed a temporary V-shaped webbing weir, which extended across the entire stream. The apex of the "V" was at the upstream end. An opening at the apex allowed the fish to enter a trap, where they remained until removed for tagging. This method proved satisfactory in use on the American and Stanislaus rivers.

In 1950 it was decided to do some experimental fishing in the Sacramento River to determine if it was practical to make a tag and recovery estimate of the fall salmon run. The Sacramento carries a considerable amount of traffic, including both commercial tugs and private vessels. It is also too large to permit use of a weir of the type just described. Obviously, another method of capturing fish had to be used. Gill nets were first selected, principally because we had had considerable experience in their use. The area fished was about one and one-half miles upstream from the mouth of the Feather River. Though showing promise, this method was abandoned as being impractical with the manpower available.

In 1951 the Department initiated the use of large wire-mesh traps. These cylindrical fish traps, 10 feet in diameter and 19½ feet long, were patterned after traps formerly used by commercial fishermen in the Sacramento River near Princeton Ferry. Such traps had been declared illegal for commercial fishing several years previously. After considerable searching, an abandoned trap was found in a heavily wooded area adjacent to the Sacramento River between Princeton Ferry and Colusa. Measurements were taken of the abandoned trap and six new ones were constructed during the summer of 1951. These traps were first fished in the Sacramento River in the fall of 1951. They were quite successful in taking salmon, and much to everybody's surprise they also took large numbers of steelhead. At that time very little was known about the migration of steelhead into the upper Sacramento River. It was decided to take advantage of this unexpected opportunity and tag all trapped steelhead. The procedure for determining the sizes of runs for both salmon and steelhead, with the tag recovery method, is essentially the same. The principal difference is that steelhead do not die after spawning, so the ratio of tagged to untagged steelhead is determined by examining live fish.

Starting with the summer of 1953, seven traps have been operated co-operatively in the Sacramento River by Dingell-Johnson Project F-7-R and Marine Fisheries Branch personnel. Salmon data have been analyzed by Marine Fisheries Branch personnel and the Dingell-Johnson personnel have concentrated on the steelhead data.

This report is a summary of the present methods used in constructing the fish traps, their operation in the Sacramento River, and a generalized treatise on the effectiveness of these traps in capturing king salmon, steelhead trout, silver salmon (*Oncorhynchus kisutch*), striped bass (*Roccus saxatilis*), American shad (*Alosa sapidissima*), and other species of fishes.

ACKNOWLEDGMENTS

Success of the trapping program on the Sacramento River has been due to the efforts of many persons in the Department of Fish and Game. In addition, land owners in the trapping area have been most generous in permitting unrestricted use of their land to operate the traps, and from time to time have helped to clear brush and trees from net fishing sites.

We are especially indebted to the late Mr. David J. Glenn of the Department of Fish and Game. Mr. Glenn's knowledge of the Sacramento River, and of commercial fishing and fishing gear, gained through many years of commercial fishing experience on the river, coupled with an inherent drive to experiment with new ideas, contributed perhaps the most to the successful development and operation of these traps.

To Mr. Taylor London, warden with the Department of Fish and Game, we also wish to express our gratitude. It was largely through his efforts that one of the old abandoned commercial fish traps was located.

To them and many others we wish to express our heartiest thanks.

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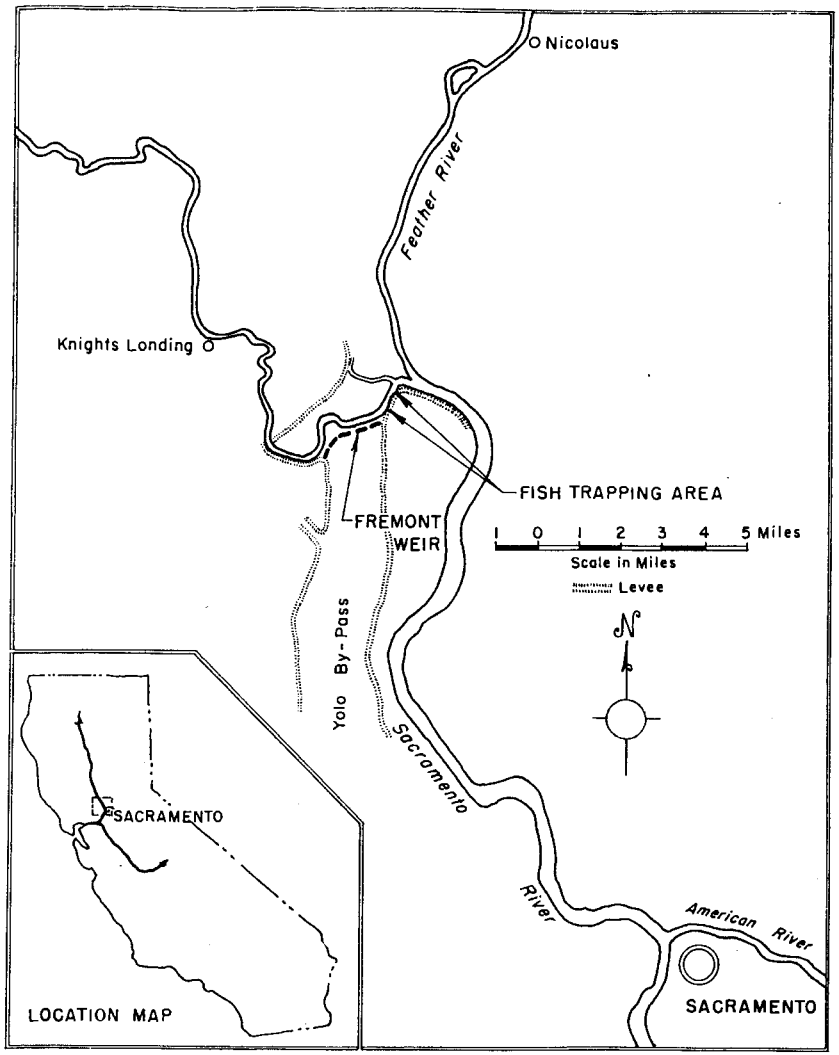

FIGURE 1. Map showing the trapping area and nearby points.

DESCRIPTION OF THE TRAPPING AREA

The trapping area starts at the downstream end of Fremont Weir and extends downstream along the right bank of the river for a distance of about one and one-half miles. The lower end is about one-half mile above the mouth of the Feather River. Fremont Weir is located 23 river miles upstream from the City of Sacramento. It is a flood control structure over which flood waters spill from the Sacramento River into the Yolo Bypass.

The Sacramento River near the trapping area is about 150 feet wide and of variable depth. In the main channel, depths of 30 and 40 feet are common. Along the steep dirt and sand banks characteristic of this section, water depths of 20 feet are common a few feet from shore, even during low summer and fall flows. The river drops one foot in elevation about every three miles. There are no gravel riffles. The first riffles of any consequence are found just above the City of Colusa, some 70 miles farther upstream. During summer and fall months the river flow in this area is usually between 5,000 and 10,000 cubic feet per second. Water velocities of 2 to 3 feet per second are encountered at the individual trapping sites, which are close to shore. Velocities in the center of the river are higher. Figure 2 shows a general view of the Sacramento River at the upper end of the trapping area.

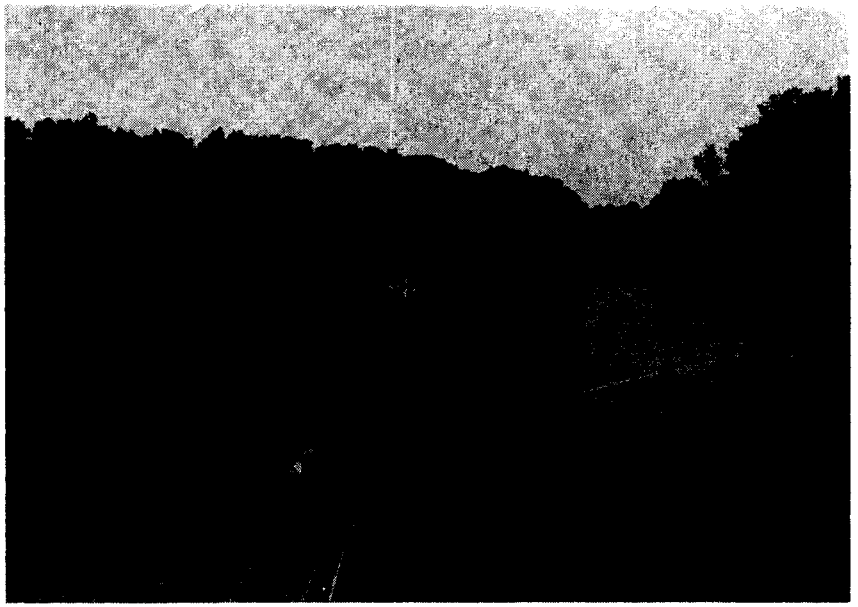

FIGURE 2. The Sacramento River at the upper end of the trapping area. *Photograph by John E. Riggs.*

During most of the year and especially during the period of steelhead and fall-run king salmon migration, the lower Sacramento River is heavily laden with silt, which gives a light brown color to the water. During summer and fall, normal turbidity is increased by returned irrigation water, principally from rice fields between Colusa and Knights Landing. During winter and spring, muddy water is caused not only by silt from the main channel, but also by debris washed into the river by rain-swollen tributaries. However, during a dry winter the Sacramento River is comparatively clear in its lower reaches.

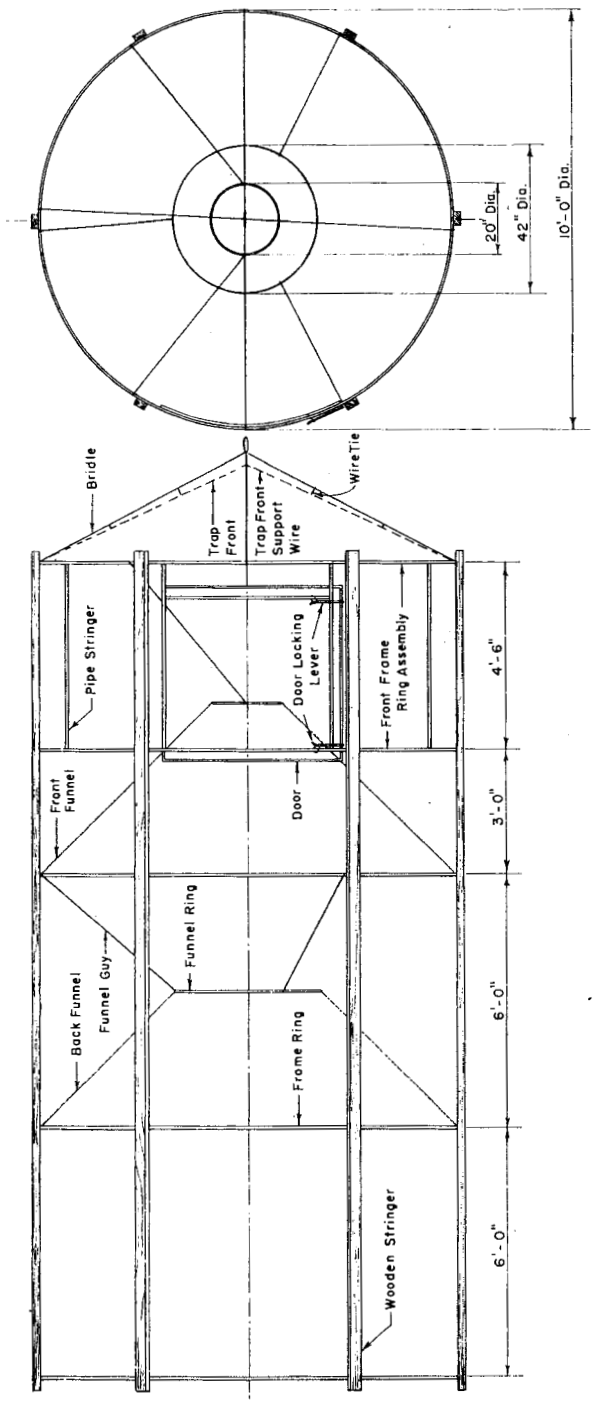

FIGURE 3. General diagram of wire fyke trap construction. The wire mesh covering is not shown.

CONSTRUCTION OF TRAP PARTS

General Description of Traps

The traps are essentially large cylinders, 10 feet in diameter and 19½ feet in length (Figure 3). They are open at one end and contain two funnels, which act as a one-way passage for fish into a pot or impounding area. The traps are always fished with the back or open end downstream.[2] The two funnels face the same way, with the small openings upstream, and a fish must swim through both to enter the pot. The funnels and the exterior of the trap are covered with wire mesh netting. Captured fish are removed with a dip net through a door which opens into the pot.

The trap frame consists of five rings made of three-quarter-inch pipe. The rings are held rigidly in place by six 2 by 4 inch wooden stringers which extend the length of the trap. Two different sizes of wire netting are employed in the trap construction. One-inch mesh, 18-gauge stucco wire is used to cover the pot of the trap, which includes the front funnel. The remainder of the trap, including the back funnel, is covered with 2 by 3 inch mesh, 15-gauge salmon trap wire. When the coarser mesh was used to cover the impounding area there were too many casualties due to gilling, particularly among the steelhead. All pipe, wire netting, and other wires used are galvanized.

A completed trap weighs between 500 and 600 pounds and contains approximately $100 worth of materials. With experienced personnel, it takes a two-man team about 16 hours to construct a trap, starting with prefabricated rings and the necessary materials and tools.

The Rings

The frame rings are 10 feet in diameter and approximately 31½ feet in circumference. A convenient method of construction is to use standard 21-foot lengths of pipe. Each ring then consists of one and one-half lengths of pipe welded together. As an alternative to welding, a short length of three-quarter-inch diameter iron rod, bent to the proper radius, may be inserted into the ends of the pipes and the joint then secured with two or more quarter-inch diameter rivets on each side of the joint. In event of damage to a trap, a riveted ring can more easily be taken apart and reshaped. The original frame rings were shaped with a pipe bending jig at the Department's Elk Grove Fish Screen Shop. Since that time all new rings have been constructed by a commercial firm.

The small funnel rings, which are attached to the small end of the funnels, are made of three-eighths-inch diameter pipe. They are bent by hand and checked against a pattern. The ring for the back funnel opening has a diameter of 42 inches, while the front funnel has a 20-inch diameter.

[2] Throughout this report, "upstream", "forward", and "front" mean toward, or nearest to, the closed end of the trap; and "downstream", "rear", and "back" mean toward, or nearest to, the open end.

Front Frame Ring Assembly

The two front frame rings are assembled as a unit by welding four pieces of three-quarter-inch pipe between them. Two of these 54-inch long pipe stringers are welded to the rings 48 inches apart, to form a 48-inch high door opening for removing fish. The other two pipe stringers are welded between the rings opposite the door opening, to provide additional support (Figure 4). The door opening is completed by welding a 48-inch long section of pipe between the two stringers, parallel to, and 10 inches from, the upstream frame ring. The latter section of pipe is bent to conform with the shape of the frame rings. This provides a door opening 44 inches wide and 48 inches high. By having the front edge of the door opening 10 inches back from the upstream ring, an area is provided for overlapping and securing the netting covering the end of the trap to that covering the sides.

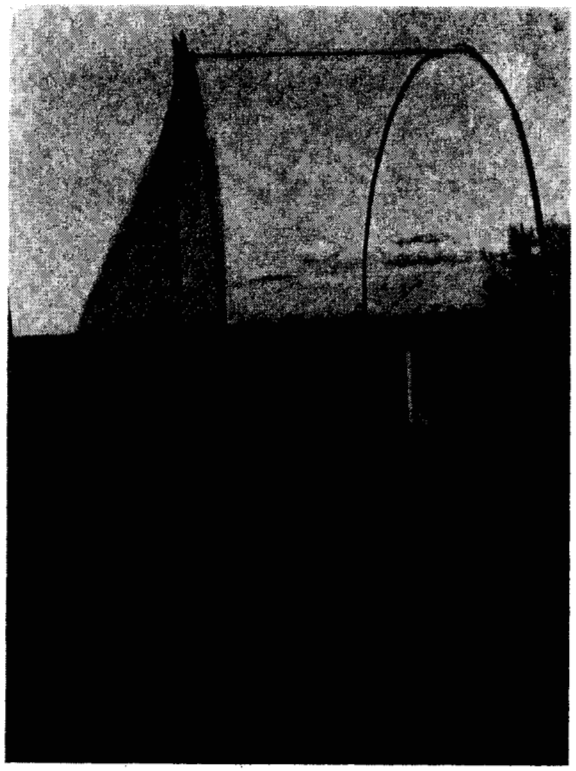

FIGURE 4. The front frame ring assembly with the wire mesh front in place, but not yet secured. *Photograph by Don A. LaFaunce.*

Pattern for Funnels and Trap Front

When cutting the wire netting to cover the funnels and front end of the trap, a great deal of time can be saved if a pattern is first marked on the ground or the floor. Satisfactory patterns for 10-foot diameter traps are shown in Figure 5. When used on a working surface the patterns are superimposed for convenience as shown in Figure 6.

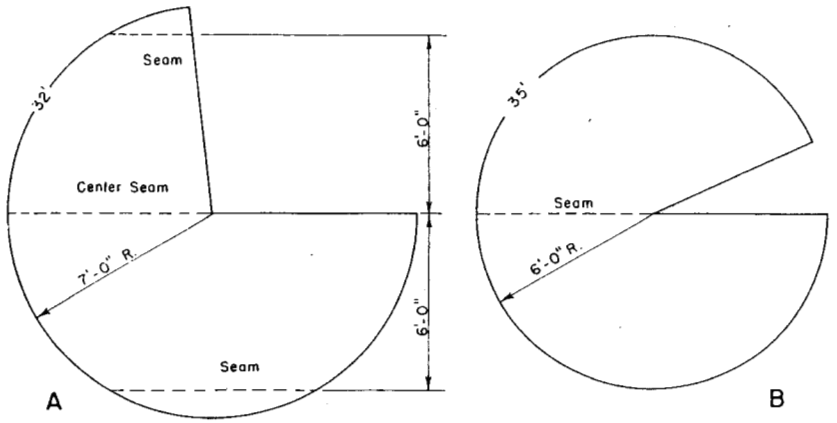

FIGURE 5. Pattern for funnels (A) and trap front (B).

The funnels are made as cones. The tip of the cone is cut off when the small funnel ring is attached. To lay out the funnel pattern, start at a focal point near the center of the pattern area and describe an arc, using a seven-foot radius. The radius of the pattern arc coincides with the length of the sides of the cone or funnel, assuming that the funnel is projected to an apex. The length of the arc described is 32 feet. The circumference of the trap frame ring to which the base of the funnel will be attached is 31½ feet. The additional six inches are to allow for overlapping the meshes at the center seam.

Next, draw radial lines between the focal point and the ends of the arc, completing the pattern. It was found to be more practical not to lay out, as part of the pattern, lines indicating material to be cut away from the apex of the cone, to install the small funnel rings. This material is cut away later, when the funnel rings are attached. For convenience, a center line may be drawn on the platform first. A center line is an aid in laying out the netting to cover the pattern. A common center line and focal point are also desirable when funnel patterns for more than one diameter of trap or funnel height are to be drawn on the same platform.

The trap front is a complete cone. A satisfactory pattern can be made using a 6-foot radius and a 35-foot arc. The base of a trap front cut on this pattern will fit snugly on a 10-foot diameter ring, five and one-half feet from the apex, measured along the sides of the funnel, and will also leave six inches of netting for overlapping the barrel of the trap. The trap front will have a height of about two feet, measured vertically from the base to the apex.

The Funnels

Material required for the front funnel is as follows:

1. one 10-foot diameter ring of ¾-inch pipe;
2. one 20-inch diameter ring of ⅜-inch pipe;
3. one-inch mesh, 18-gauge stucco netting (72 inches wide, if possible);
4. 16-gauge galvanized wire for lacing.

Material required for the back funnel is as follows:

1. one 10-foot ring of ¾-inch pipe;
2. one 42-inch ring of ⅜-inch pipe;
3. 6-foot wide 2-inch by 3-inch mesh, 15-gauge salmon trap netting;
4. 16-gauge galvanized wire for lacing.

To assemble a funnel, unroll the netting with one edge along the center line of the pattern. Weight it down with bricks, rocks, etc., and cut around the arc of the pattern. By cutting the netting an inch or two wider than the pattern a better fit can often be obtained on the frame ring, especially if the ring is not perfectly round. Roll more netting out on the other side of the center line, weight it down, and again cut around pattern. When the netting is cut, the pieces are laced together at the selvage edges with No. 16 galvanized wire. Figure 6 shows a funnel being cut and laced. The two netting edges formed by the radial pattern lines are not joined until after the material has been fitted on the frame ring. An additional small piece of netting is required at each side to cover the funnel pattern. Wherever possible, it is best to lace selvage edges together, since they are stronger than cut edges. Otherwise, it would be theoretically possible to construct the funnel out of three pieces instead of four, since the netting is six feet wide.

After the netting has been cut and laced, it is suspended by the apex, so that the base of the funnel is several inches off the platform. A 10-foot frame ring is then fitted to the inside of the base of the funnel, as shown in Figure 6B. The wire mesh is tied to the frame ring at about 30-inch intervals with temporary ties of No. 16 wire. Any irregularities in the funnel can then be corrected by slightly shifting the ring on the netting. The lapped portion of the center seam, formed by the two radial edges of the pattern, is secured by twisting the cut ends of the wires into the adjacent meshes. All of the wire ends must point toward the inside or center of the funnel, to eliminate any sharp projections in the pot of the trap, upon which the confined fish might cut themselves.

The small funnel ring is attached by setting the funnel on its base and putting the small ring over the apex, as shown in Figures 6C and 6D. A man can then crawl underneath the funnel, cut off the apex, allowing a sufficient overlap, bend the wire over the ring, and twist the cut edges through the adjacent mesh.

Figure 6 shows the construction of a front funnel made with 1½-inch mesh netting.[3] The same pattern and procedure are used for the back funnel, except that it is made with 2 by 3 inch mesh netting.

[3] These photographs were taken before the mesh size was changed to one-inch mesh. The same construction procedure is followed, however, regardless of mesh size.

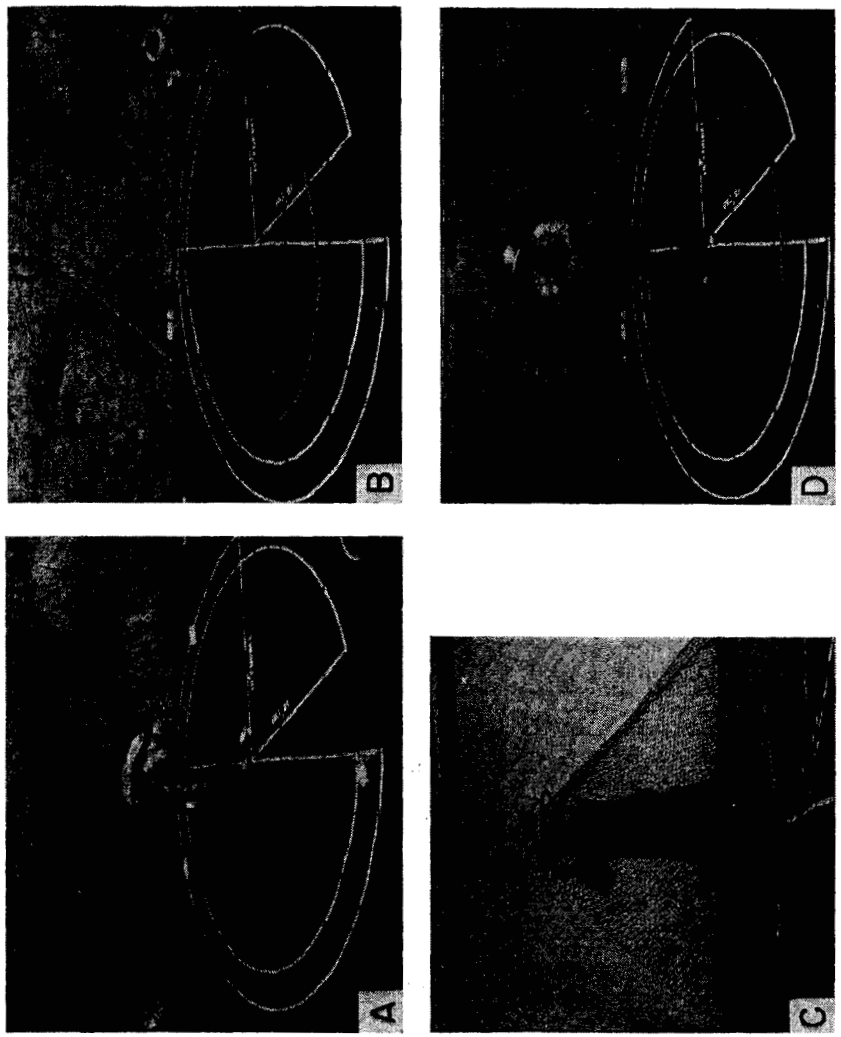

FIGURE 6. Assembling a funnel. A, cutting the netting using the painted pattern; B, the netting has been formed into a cone and the 10-foot frame ring is being installed; C, the frame ring has been installed and the small funnel ring is being fitted; D, the small ring is being laced into the funnel. *Photographs by John E. Riggs.*

Trap Front

The trap front forms the forward wall of the fish impounding area. In addition to the front frame ring assembly, a supply of one-inch mesh wire netting is required. It is constructed in the form of a cone, with the apex pointing upstream. This shape helps to shunt floating debris around the trap, and increases the volume of the impounding area.

Figure 5A shows a pattern for the trap front. The same general procedure is followed for cutting out and assembling the front as is used for the funnels. After the netting has been cut to fit the pattern and laced, it is suspended by the apex, and the frame ring assembly with the forward ring uppermost is slid beneath it. The two netting edges formed by the radial pattern lines are not joined until after the material has been fitted on the frame ring. The netting is then placed on the forward ring, leaving an overlap of six inches around the ring. The netting is then attached at about 30-inch intervals to the ring with temporary ties of No. 16 wire. After the netting has been attached and properly fitted to the ring, there will be an overlap of six inches at the center seam. The overlapping netting is then secured by twisting the cut ends into the adjacent meshes, the same as for the funnels. If the frame ring assembly is placed on edge after the wire mesh has been temporarily tied to the front ring, twisting the center seam wires becomes considerably easier. The ends of all wires should be left projecting toward the outside of the trap. Figure 4 shows a trap front and rings after the front has been completed.

Trap Assembly Jig

A great aid in the final assembly of each trap is a jig to hold the frame rings and funnels in place while the barrel is being covered with netting, and until the wooden stringers have been attached. The jig used included four lengths of one-inch diameter pipe, each 21 feet long. Three-eighths-inch diameter holes were drilled through the pipes at intervals representing the desired spacing of the trap frame rings. Holes for the frame ring next to the front end of the trap were omitted, since this ring was already part of a rigid assembly. The remainder of the jig consisted of 16 iron hook bolts. These bolts were made of three-eighths-inch material, with a bend at the end, to hook around the three-quarter-inch diameter frame rings (Figure 7). By holding the principal component parts of the trap frame rigid throughout the final assembly, the jig saved time and effort.

FINAL TRAP ASSEMBLY

One of the first steps in the final assembly of the trap is to attach the jig pipes to the frame rings. The front ring assembly, including the trap front netting, is placed on its side. The fifth or back frame ring is then placed against the front ring and each is marked identically at four equally spaced points around its circumference. The back ring is then laid aside temporarily. Next, the two funnels, including the frame rings, are nested against the rear ring of the front ring assembly and attached individually with temporary wire ties. The first of the jig pipes is inserted along the inside of these four rings and fastened with a hook bolt to the front ring, at one of the four marks.

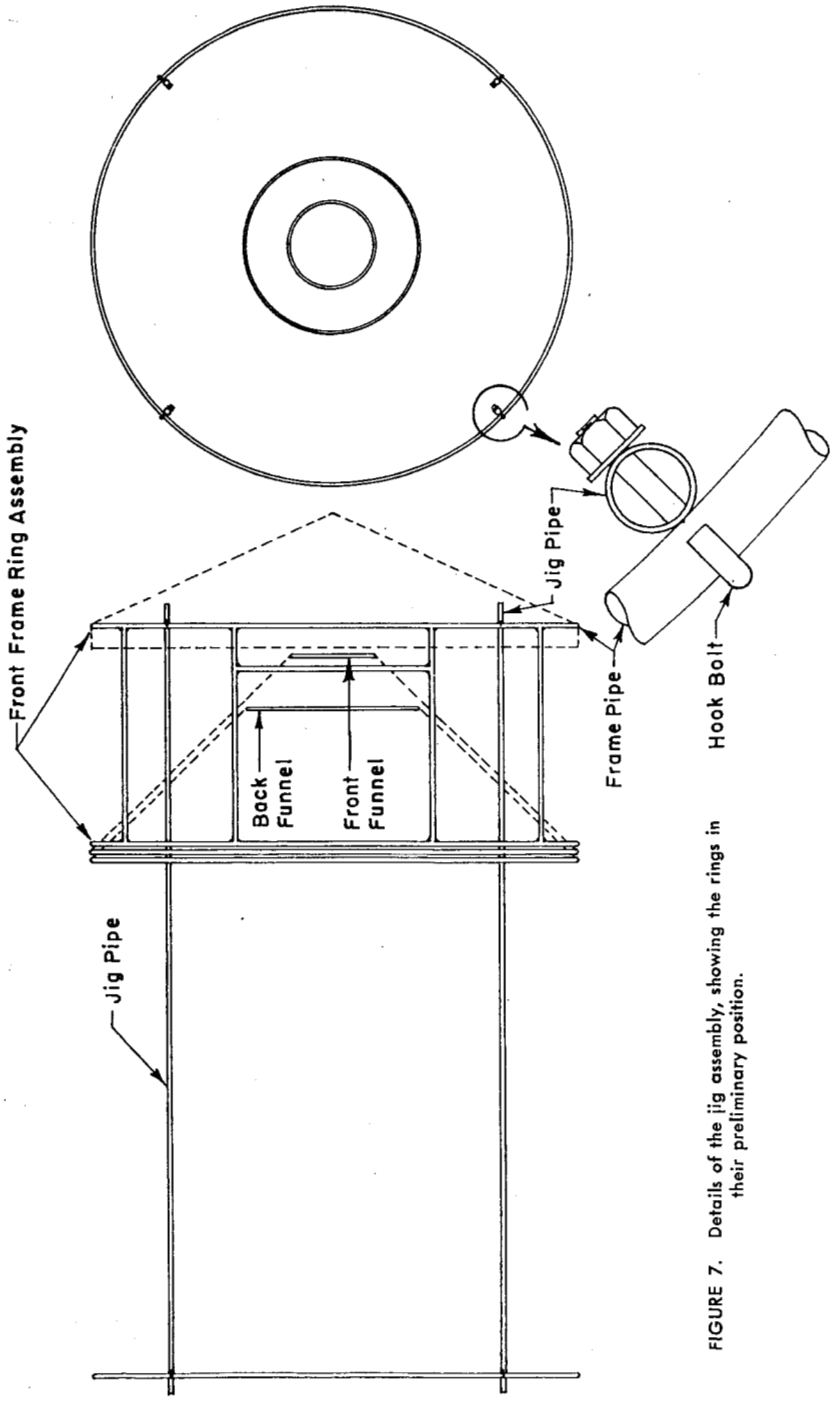

FIGURE 7. Details of the jig assembly, showing the rings in their preliminary position.

The back frame ring is then fastened to the other end of the jig pipe with a hook bolt, at one of the marks. A second jig pipe is now fastened to the opposite side of the frame rings, in the same manner. The entire assembly is then rolled one-quarter turn and the other two jig pipes are attached at the appropriate marks on the front and back rings. Figure 7 shows the assembly at this point. After all four pipes have been attached to the front and back frame rings, the temporary ties holding the funnels together are cut, and the funnels are shifted to their respective positions. They are then bolted in position to the jig pipes.

Two sizes of wire mesh netting cover the outside or barrel of the trap. Two strips of 2 by 3 inch mesh salmon trap wire, each six feet wide, encase the portion to the rear of the front funnel. The remaining section of the trap, the fish impounding area, is covered with a 6-foot and 1½-foot strip of 1-inch mesh stucco wire netting. The 1½-foot strip was made by splitting a 3-foot roll, since narrow rolls of stucco wire were not available. To prevent long sharp wires from protruding, all cuts should be made close to the twisted portions of the wire mesh. The two strips of netting are laced together before covering the trap. However, it is not advisable to lace the two different sizes of netting together, since this frequently causes buckling. Instead, they are laced simultaneously to the trap frame ring where they join. The barrel of the trap is covered by laying the laced strips side by side on the ground and then rolling the trap frame over them. As the frame rolls over the wire, the netting is laced firmly to the frame rings with No. 16 wire. Tying the netting to the rings with temporary ties of No. 16 wire, ahead of the lacing, often helps to space the netting. As the wire lacing attaches the netting covering the barrel of the trap to the frame rings, it also laces the funnel netting to the rings. The cut ends of the trap front netting overlap the barrel and are twisted into the meshes covering it as the trap covering and front are laced to the front frame ring.

An easy method of securing the wire mesh to the door opening is to trim the netting close along the *sides* of the door opening and then lace with No. 16 wire. When the netting is cut properly, there is in effect a selvage edge at every other mesh to lace through, since the twisted sides of each hexagonal mesh are parallel to the sides of the door opening. However, the netting at the *top* and *bottom* of the door opening should be cut long enough to wrap around the pipe stringers of the door opening, and the cut ends should be twisted into the adjacent meshes. All wire ends should be left on the outside of the trap. These cut ends should be kept as short as possible on the bottom of the door opening, so they will not foul the dip net while fish are being removed from the trap. The wire mesh is applied to the door frame itself in the same manner.

The Door

The door is hung on the inside of the trap from the top of the door opening frame, with hinges made of doubled strands of No. 16 wire. The door opening rope and the door locking levers complete the door assembly. See Figure 8 for details of locking levers. The door is opened inward by a rope running on the inside of the trap from the bottom of the door through a small pulley fastened to one of the

stringers above the door, thence to the outside of the trap. The door frame is made of three-eighths-inch pipe. It is 51 inches high and 50 inches wide. This allows the door to overlap the door opening by 3 inches at the sides and bottom. The door is bent to conform with the curvature of the door opening to assure a fish-tight fit when closed.

Attaching the Longitudinal Stringers

When all lacing is complete, the 2 by 4 inch stringers are fastened to the frame rings on the outside of the trap with No. 9 galvanized wire. One stringer is attached immediately above and another just below the door opening. The lower stringer should be at least two inches below the door opening to allow space for the door-locking levers. The remaining stringers are spaced equally around the trap. One-fourth-inch holes are drilled through the stringers to take the wire at the two end frame rings, so there will be no chance of slippage. The rest of the wire ties are wrapped around both pipe and board at each frame ring and twisted tight. The stringers are tied at all rings. The pipe jigs may now be removed. Next, the funnels are guyed to the frame rings with No. 9 wire. The front funnel guys should not interfere with fish removal or opening of the door.

The Bridle

The head cable bridle on the front of the trap is made with two pieces of quarter-inch cable. It is attached at four equally spaced points to the front frame ring and crossed in the center. The bridle

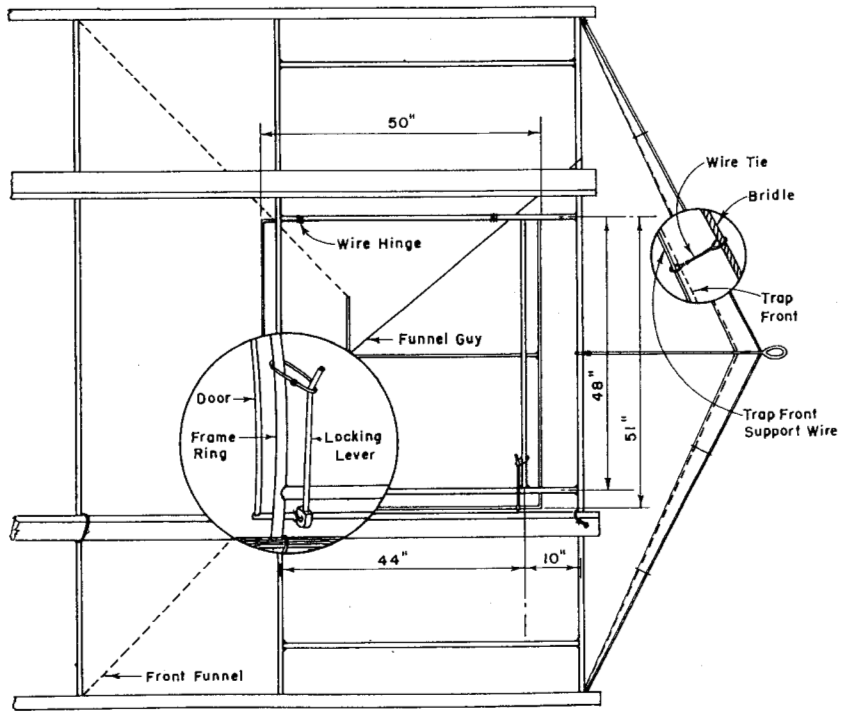

FIGURE 8. General diagram of the front of the trap, showing the door and bridle assembly.

cables are fastened together where they cross, with a three-eighths-inch cable clip. One of the cables is cut slightly longer than the other and a small loop is formed in it at the center, before the cable clip is attached. The head cable is later attached to this loop. The bridle cables are fastened to the frame ring with a half hitch and are secured by seizing with No. 16 wire or with a cable clip. On the Sacramento River, there was ordinarily no great strain on the bridle, so securing with cable clips was not necessary. The bridle should be made so that it clears the trap front by a few inches. To support the wire netting of the trap front, two pieces of No. 9 wire are fastened across the front of the trap on the inside of the wire mesh, directly opposite the bridle cables. These trap front supports are tied with short pieces of wire to the bridle at the center, and at one or two other points to each bridle cable. The ties should be long enough so that they will have a slight amount of slack when the bridle is fully extended (Figure 8). The head cable then pulls directly on the bridle and not on the wire netting. The purpose of the wire trap front supports is to keep the trap front netting from sagging, and to distribute any strain on the netting over a wide area and thus prevent breaking the mesh.

TRANSPORTING THE TRAPS

The traps are transported on a two-wheeled flat bed trailer, with an extended tongue (Figure 9A). Two lengths of 4 by 6 inch timber, each six feet long, are fastened crosswise to the ends of the trailer to support the traps. The trap is tied to the trailer with rope or wire. Figure 9B shows a trap loaded on the trailer.

When it is necessary to move a trap a short distance at the trapping site, a sled is used (Figure 9C). This sled consists of two lengths of 2 by 12 inch lumber for runners, each about 12 feet long. Three-inch angle iron was attached along the bottom and inside of the runners. The runners were spaced about four feet apart and held rigidly by sections of pipe welded between the pieces of angle iron. The trap is supported on the sled with two-by-fours attached across the top at each end of the wooden runners. A trap is easily rolled onto the sled because the sled is so low. The sled is pulled by a bridle made of quarter-inch wire rope. A heavy harness snap on the forward end of the bridle hooks the sled to the rear of an automobile. Traps have been easily moved as far as one mile with the sled. By using the sled rather than the more expensive trailer for these short hauls, it was permissible to leave the moving equipment at the fishing site permanently without fear of loss from vandalism.

On one occasion, it was necessary to move a trap by water. Four empty 50-gallon oil drums were attached to opposite sides of the trap, with two on either end. The four drums provided ample buoyance (Figure 9D). The trap was then towed with two outboard motor powered skiffs. One boat was powered by a 16-horsepower motor, the other by a 25-horsepower motor. This method is entirely satisfactory for moving a trap downstream, across the river, or a short distance upstream. Moving one upstream a long distance by this method would have been difficult.

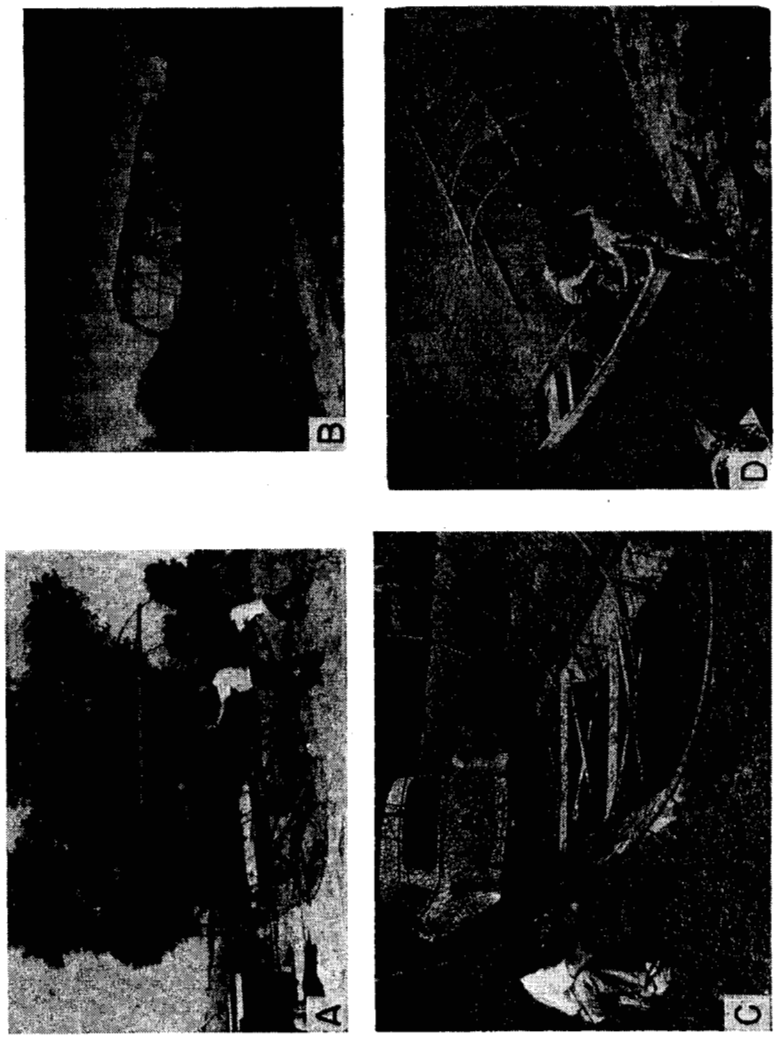

FIGURE 9. Transportation methods. A, rolling the trap onto the trailer; B, the trap in place on the trailer and ready to travel; C, the trap on the low sled; D, using empty oil drums as floats for water transportation. Photographs A and C by John E. Riggs; B, by Don A. LaFaunce; D, by Richard J. Hallock.

OPERATING THE TRAPS

Placing Traps in the River

To aid in rolling the traps up and down the bank they are attached to two strands of No. 9 galvanized wire, which are called runner wires. The runner wires are wrapped around the trap before placing it into operation. These wires are attached to the second and fourth frame rings and to a stringer at the point where the two cross. A man holds each wire tight to keep the slack out of it while the rest of the crew rolls the trap onto the wires, until the desired number of wraps is made. The number of wraps will vary, depending upon the depth of fishing anticipated and the height of the river bank. Three or four are ample on the Sacramento River. By having a man hold each of the runner wires taut while they are rolled onto the trap, practically all of the undesirable slack is eliminated. The direction of wrap must be such that the trap, when being rolled up the bank, is rolled onto the wire.

After the runner wires have been attached, the trap is set on the bank above the desired fishing spot, open end downstream. One end of the head cable is then attached to a solid object on the bank, such as a stump, tree, or post, about 100 to 150 feet upstream. The free ends of the runner wires, coming off the bottom of the trap, are then fastened to strong stakes or trees on the bank, opposite the trap ring where they are attached. One end of a quarter-inch wire rope known as the pull cable is attached to the center ring with a clove hitch and cable clips where a stringer crosses it. The free end of the pull cable is attached to an automobile (or windlass, or whatever device is to be used in pulling the trap up and down the bank). The slack is taken out of the pull cable with the automobile, which is then slowly backed towards the river. As the car backs, the trap is rolled over the bank, with the cable kept tight. As the trap rolls down the bank, it unrolls the runner wires and rolls up the pull cable. The car is continued to be backed slowly and the trap allowed to roll to the water's edge. The free end of the head cable is attached to the trap bridle, using cable clips. The length of the head cable is quite important. If it is too short, the trap will shift on the runner wires when being rolled up and down the bank. If the head cable is too long, the weight of the cable, plus the water resistance, will have a tendency to make the trap stand on end. A head cable of 100 to 150 feet worked satisfactorily on the Sacramento River. If it was desirable to fish the traps deeper, or farther out in the river, the head cable was lengthened.

Adjusting the Door

When a trap is first put in the water, and as the water level changes during the season, it is usually necessary to adjust the door position so that captured fish may be removed. The trap is adjusted so that when the door is opened about one and one-half feet of water remains in the trap for the fish to swim in. Figures 10A, 10B, and 10C show a trap in a raised position, ready for the removal of fish. Adjustment is made by rotating the trap in place until it is in the desired position.

FIGURE 10. The trap in use on the river. A, rolling the trap out of the water; B, removing the fish with a dip net; C, view from the river side, showing the position of the skiff when the trap is lifted—minor repairs and cleaning are carried on in this position; D, the skiff is tied alongside the trap while the fish are removed and tagged. *Photographs A, C, and D by Gene P. LaFaunce; B, by Richard J. Hallock.*

Such adjustments are made by taking up or letting out the runner wires. A convenient method is to use a large hook, such as a hay hook, attached to a rope. The trap is hooked at one end, lifted until there is enough slack in the runner wire, which is then let out or shortened by the appropriate amount, fastened, and the hook removed. The operation is then repeated at the other end of the trap. This job usually requires two men on the bank, assisted by a man in a boat. If, for example, the adjustment requires shifting the trap several feet or one-half turn, it is necessary to let out or haul in the pull cable accordingly, by moving the automobile.

Fishing Sites

The traps were usually fished with the tops between six inches and one foot under the water surface and as close to a steep bank as possible. They were most successful in capturing fish when fishing this top 10 feet of the river near the shore. Various positions farther out in the river were tried, but were definitely not as productive, particularly in capturing steelhead. Also, the increased water velocities encountered away from the bank proved unduly harmful to the captured fish. However, the farther away from a bank the traps were fished, the deeper they were in the water. No attempts were made to fish the traps at any distance from shore, at any depth other than at the bottom of the river.

The most desirable fishing sites for all species captured were on the deep side of the river, where the bank was almost vertical. The high vertical bank also allowed the traps to be fished through considerable fluctuation in water level. Particularly good fishing areas were those where the river first straightened out after making a sharp curve. Several excellent trap locations were also available along fairly straight stretches of river, but always on the swifter, deeper side. One fishing site along a particularly brushy shore line was exceptionally good for catching large numbers of steelhead, but not salmon. At the beginning of the trapping at Fremont Weir in 1951, the traps were shifted continuously until enough sites which consistently produced good catches were found. From year to year, the river channel has changed, necessitating a relocation of a few fishing sites. Often just a simple movement of a trap 10 feet upstream or downstream has increased the catches to the desired level.

Tug boats traveling between Sacramento and Colusa pass this section of the Sacramento River at all hours of the day and night. Five-gallon cans painted red were used as buoys to mark the traps for the benefit of boat traffic and sport fishermen along the bank.

Safety Cables

There was always the possibility that the automobile brakes might not hold, or that the pull cable might snap. A safety cable was devised to keep the trap from rolling onto the tagging skiff and the tagging personnel, if such an accident occurred.

One end of the safety cable is attached to the trap at the center frame ring in the same manner as the pull cable, and the other end is fastened to a strong tree or a post on the bank. It is tied so that when fully extended the trap will be fishing at the proper depth. This fastening is *not* undone during normal fishing operations. Sufficient surplus

cable is kept to allow the trap to shift in a vertical direction as the water level changes during the season.

The safety cable plays in and out, off the top of the trap, in the same manner as the pull cable. When the trap is rolled up the bank to remove fish, the safety cable is also hauled in to keep it from tangling with the pull cable. As soon as the trap is in position to remove the fish, the safety cable is pulled tight and tied securely to the tree, stump, or post.

After the fish have been removed and the trap has been cleaned and inspected for holes, and any necessary repairs have been made (cleaning leaves and debris off the traps is accomplished quite easily by slapping the wire webbing with a paddle or small wooden club), the skiff is moved away from the trap. The safety cable is untied and the automobile driver then backs up, lowering the trap by its own weight. The safety cable plays out on its own until it tightens and stops the trap at the desired depth. The pull cable then goes slack and the driver disconnects it from the auto and ties it to a tree or post.

Because of the high, steep banks along this section of the Sacramento River, it was usually impossible for the driver of the automobile pulling the trap or replacing it in the water to see the men in the tagging skiff or to hear their shouted instructions. A safe procedure was to have a man in the boat and a man standing on the bank, where he could see and direct both the skiff and the automobile.

Snatch Blocks

To facilitate rolling the traps in and out of the water, six-inch steel snatch blocks were used. These pulleys were carried from trap to trap during the day's tagging. The suspended snatch blocks prevented the pull cable from cutting into the bank, with a resulting friction that would wear the cable and hamper the trap movement. If the cable had cut into the bank the traps would often not roll into the water on their own accord. When trees were handy, the snatch block was suspended from one of them. If no trees were available, a strong post was set in the bank and the pulley secured to it. In some instances, a steel tripod was used in conjunction with a post, to keep the cable clear of the ground. The tripods were made of three-inch angle iron, with 5-foot long legs.

Fishing Operations

After a night's fishing, the trap should be rolled up the bank very slowly. If it is apparent that there is a large catch, overcrowding of the fish is avoided by stopping the trap while it is fairly deep in the water. Fish can then be dipped out and tagged until they are fairly well thinned out. The trap can then be rolled a little farther up the bank and the process repeated.

If the trap is rolled too far or too fast, there is likely to be a panic during which even medium-sized fish may injure themselves by swimming into the mesh at great speed. With the possible exception of shad, the only panicking of fish was that caused by raising the trap and the resulting confinement of the fish in shallow water. If the trap is moved slowly, the fish remain relatively quiet. It is usually good technique to remove the larger fish and any more active "trouble makers" as soon as possible.

SPECIES OF FISHES CAPTURED

Steelhead Trout

Adult steelhead migrate into the upper Sacramento River during most months of the year. The first migrants each season pass the trapping area in mid-June, and the run is continuous until the middle of the following March. Very few, if any, adult steelhead move from the Delta into the upper Sacramento River between the middle of March and the middle of June. The bulk of the run passes the trapping area between early August and late November. The peak of the run usually occurs near the end of September.

Sacramento River steelhead are generally smaller in size than those found in California's coastal streams, usually averaging between three and six pounds, with fish up to eight pounds being common. Steelhead over 13 pounds are rare in the Sacramento River.

The size of the steelhead run has varied between 15,000 and 31,500 during the past four years.

The seven traps fished at Fremont Weir were very effective in capturing large numbers of live adult steelhead. The percentage of the total run trapped has varied between 10 and 20 percent (Table 1). Trapped fish are in excellent condition, with very few visible marks or bruises which might indicate any attempt by the fish to swim against the wire webbing in an effort to escape. Steelhead were left in the traps for as long as three days and still remained in excellent condition. Marked fish were placed in the traps from time to time to find out if they were escaping once they had entered the trap. None of the marked fish ever escaped, although it was possible for them to swim downstream and out of the traps through the open funnels. Over 160 steelhead have been taken in a single trap with 24 hours of fishing. Steelhead entered the traps during daylight hours, as well as during hours of darkness. However, by far the greatest catches were made at night. During the peak of the run, fair numbers of fish entered the traps during the daytime.

The traps are somewhat selective with regard to sizes of steelhead captured, but not nearly to the degree that they are with king salmon. When the steelhead run consists of a large number of comparatively small individuals, a greater percentage of the total run is captured. It has also been demonstrated by the trapping that the average size of steelhead decreases at the peak of the run, with a preponderance of larger fish migrating upstream at the beginning and end of the season. An excellent cross section of the steelhead population, over 12.5 inches in length, has been trapped each year at Fremont Weir. Fish 12.5 inches in length represent the minimum size tagged, although the minimum size trapped is 11 inches. During the past two years, examination of steelhead upstream from Fremont Weir, at Coleman Fisheries Station holding ponds on Battle Creek, at Clough Dam Counting Station on Mill Creek, and while doing creel census work on the main stem of the Sacramento River, has revealed an almost identical percentage of tagged fish.

TABLE 1

Numbers of Adult Steelhead Trapped in the Sacramento River Near Fremont Weir, Seasons of 1953-54 Through 1956-57

Month	1953-54[1]			1954-55[2]			1955-56[3]			1956-57[4]		
	Number of trap hours	Number of steelhead trapped	Catch per one hundred trap hours	Number of trap hours	Number of steelhead trapped	Catch per one hundred trap hours	Number of trap hours	Number of steelhead trapped	Catch per one hundred trap hours	Number of trap hours	Number of steelhead trapped	Catch per one hundred trap hours
July	1,687	23	1.36	1,581	78	4.93	2,488	51	2.05	1,550	3	0.19
August	3,923	523	13.33	3,606	591	16.39	3,529	667	18.90	3,799	371	9.76
September	3,410	861	25.25	3,636	3,545	97.50	3,548	1,300	36.64	3,296	1,829	55.49
October	3,480	471	13.53	3,441	1,521	44.20	3,168	709	22.38	3,736	1,443	38.62
November	2,760	104	3.77	2,075	284	13.69	2,066	142	6.87	2,198	189	8.60
December	2,840	82	2.89	860	67	7.79	716	24	3.35	1,454	40	2.75
January	2,304	57	2.47									
February	812	8	0.99	189	17	8.99						
March	1,416	4	0.28									
April	648	0	0.00									
May	672	0	0.00									
June	1,008	3	0.30									
Totals	24,960	2,136		15,388	6,103		15,515	2,893		16,033	3,875	

[1] Estimated total run in the Sacramento River system above the mouth of the Feather River = 15,000.
[2] Estimated total run in the Sacramento River system above the mouth of the Feather River = 30,000.
[3] Estimated total run in the Sacramento River system above the mouth of the Feather River = 31,500.
[4] Estimated total run in the Sacramento River system above the mouth of the Feather River = 20,000.

King Salmon

Adult king salmon migrate into the upper Sacramento River system during all months of the year. Although there is a continuous movement of salmon past the Fremont Weir trapping site, there are three periods each year when the intensity of the migration is greatly increased. These peaks in the migration represent three distinct runs of winter, spring, and fall fish. Most of those moving upstream between the peaks are apparently either early or late segments of one of the three main runs.

The movement of winter and spring-run salmon is fairly continuous, but with considerable overlap, and it is difficult to distinguish clear-cut peaks in their migration past the trapping site. However, even though they move up the river at about the same time, these two groups of fish separate in the upper river in accordance with time and place of spawning.

Most of the winter-run fish spawn during May and June, in the upper portion of the main stem of the Sacramento River, between Anderson and Keswick Dam.

Spring-run fish spawn principally in late August and September. Spawning takes place primarily in the upper reaches of the Sacramento River above Red Bluff, and in the higher reaches of the larger tributaries such as Butte, Deer, Mill, and Battle creeks.

The fall run, which is larger in numbers than the other two combined, peaks at Fremont Weir near the last week of September. The bulk of these fish pass the trapping site between the middle of August and the early part of November. Most of the fall-run fish spawn between the middle of October and the latter part of December, with the greatest spawning activity taking place near the middle of November. Spawning takes place in the Sacramento River from a short distance below Chico to Keswick Dam, and in the lower reaches of practically all suitable tributary streams.

Based on tagging at Fremont Weir, salmon carcass counts in the upper river, and tag recovery data, the fall run of king salmon in the Sacramento River system, above its confluence with the Feather River, has varied between 123,463 and 446,000 fish during the period from 1953 through 1956. The traps as fished were effective in capturing large numbers of live adult king salmon. All salmon captured were in excellent condition insofar as damage caused by the traps was concerned, even when they were left in the traps as long as three days. Marked fish placed in the traps from time to time showed that these fish did not escape once they entered the trap. Kings were caught primarily at night, even during the height of the run.

However, the traps were not nearly so effective for king salmon as they were for steelhead trout. While the traps captured between 10 and 20 percent of the steelhead run each year, only 1 percent of the salmon run was captured using the same traps and with the same fishing effort (Table 2). The traps were considerably more size selective with salmon than with steelhead, and a preponderance of small fish was captured in the traps. This size selectivity was brought to light when measurements were made of salmon upstream from the trapping site, while doing carcass examination on the spawning beds, during spawning operations at Coleman Station, and while counting fish at Mill

TABLE 2

Numbers of Adult King Salmon Trapped in the Sacramento River Near Fremont Weir, Seasons of 1953-54 Through 1956-57

Month	1953-54[1]			1954-55[2]			1955-56[3]			1956-57[4]		
	Number of trap hours	Number of salmon trapped	Catch per one hundred trap hours	Number of trap hours	Number of salmon trapped	Catch per one hundred trap hours	Number of trap hours	Number of salmon trapped	Catch per one hundred trap hours	Number of trap hours	Number of salmon trapped	Catch per one hundred trap hours
July	1,687	95	5.63	1,581	203	12.84	2,488	356	14.31	1,550	30	1.94
August	3,923	713	18.17	3,606	636	17.64	3,529	1,038	29.41	3,799	226	5.95
September	3,410	1,885	55.28	3,636	1,122	30.86	3,548	1,638	46.17	3,296	518	15.72
October	3,480	1,087	31.24	3,441	1,012	29.41	3,168	603	19.03	3,736	449	12.02
November	2,760	244	8.84	2,075	315	15.18	2,066	182	8.81	2,196	126	5.82
December	2,840	85	2.99	860	69	8.02	716	30	4.19	1,454	32	2.20
January	2,304	11	0.48									
February	812	46	5.67	189	7	3.70						
March	1,416	183	12.92									
April	648	50	7.72									
May	672	40	5.95									
June	1,008	34	3.37									
Totals	24,960	4,473	----------	15,388	3,364	----------	15,515	3,847	----------	16,033	1,383	----------

[1] Estimated total fall run in the Sacramento River system above the mouth of the Feather River = 446,000.
[2] Estimated total fall run in the Sacramento River system above the mouth of the Feather River = 347,000.
[3] Estimated total fall run in the Sacramento River system above the mouth of the Feather River = 325,000.
[4] Estimated total fall run in the Sacramento River system above the mouth of the Feather River = 123,463.

Creek Counting Station. The measurements revealed that the average size of fish in the runs was much greater than the average size of fish captured in the traps. This size selectivity of fish for tagging purposes resulted in a poor sample of the run being tagged, and made a reliable estimate of the total population much more difficult. A poor random sample of the run by the traps was also indicated by a great variance in the tagged to untagged ratios of salmon observed in the main stem of the Sacramento River and in the various tributaries.

The trapping site was not ideally located for a population study of Sacramento River salmon which migrate above its confluence with the Feather River. The tagged fish, some of which were released only one-half mile above the mouth of the Feather River, often moved back down the Sacramento River and spawned in the Feather River and even in the American River, some 20 miles below.

Silver Salmon

In March, 1956, 43,025 yearling silver salmon were released in Mill Creek, one of the principal tributaries of the Sacramento River. These fish were introduced in an effort to establish a run of silvers in the Sacramento River system.

During the months of August, September, and October, 1956, a total of 437 of these silvers was captured in the traps. The run peaked in late August. All fish captured were small males, measuring between 13 and 20 inches. Prior to this time there was only one authentic record of a silver salmon being taken in the Sacramento-San Joaquin River system. Subsequent examination of silvers in the upper river, during 1956, showed that approximately 11 percent of the run had been tagged, or that the run totaled about 3,220 fish. This indicates that the traps are about as effective in capturing silvers of this size (13 to 20 inches) as they are in capturing steelhead.

Striped Bass

Each spring a spawning run of adult striped bass moves out of the Delta into the Sacramento River. A significant portion of this run passes Sacramento and turns off into the Feather River. The remainder migrates on up the Sacramento River and a few are caught by anglers each summer at least as far upstream as Cottonwood. The peak of this spring migration passes Fremont Weir in April and early May.

The traps were not fished during the period of striped bass migration, except during a year and one-half of continuous operation between July, 1953, and December, 1954. No reliable figures regarding the size of the adult striped bass runs past Fremont Weir are available, so it is difficult to estimate the real effectiveness of the traps in capturing this species. In other words, it is possible that a good portion of the fish which passed the trapping area was captured in 1954, while on the other hand the numbers caught might represent but a small segment of the run. A total of 723 adult striped bass was captured during the month of April, 1954, with only 648 hours of trap fishing, when not more than four traps were operated at one time. On April 21, 1954, a total of 300 striped bass was trapped in one night's fishing with but four traps in operation. A total of 108 striped bass was taken in 672 trap hours of fishing in May, 1954 (Table 3).

TABLE 3

Numbers of Striped Bass Trapped in the Sacramento River Near Fremont Weir, July, 1953, Through June, 1954

Month	Number of trap hours	Number of striped bass trapped	Catch per one hundred trap hours
July	1,687	16	0.95
August	3,923	7	0.18
September	3,410	4	0.12
October	3,480	4	0.11
November	2,760	0	0.00
December	2,840	0	0.00
January	2,304	2	0.09
February	812	0	0.00
March	1,416	2	0.14
April	648	723	111.57
May	672	108	16.07
June	1,008	103	10.22
Totals	24,960	969	----

Striped bass captured in the traps are in excellent shape, and they take the confinement quite well. Bass up to an estimated 35 to 40 pounds have been taken in the traps. The bass appear to enter the traps primarily during hours of darkness. However, the traps were not emptied enough in the daytime, during the period of striped bass migration, to be certain.

Shad

The traps were exceptionally effective in capturing large numbers of adult shad during their annual spring migration up the Sacramento River. The peak of this spawning run passes the trapping area in May. Shad were the only fish captured which could not live for any length of time in the traps. The traps were emptied each morning after 24 hours of fishing and practically all of the shad trapped with this method of operation were dead. The shad were not damaged externally to any extent by the traps, and usually the only visible mark on dead fish was a slight redness about the mouth and head. It appeared as though the shad had either pointed their noses into one of the wire meshes and swam, without gilling themselves, until dead, or had made a series of rushes against the wire webbing, eventually inflicting fatal injuries.

Live shad could probably be obtained with these traps if they were emptied often enough, for example, on an hourly basis. It also appears possible that if the impounding area of the trap had been constructed with a smaller mesh and perhaps in the shape of a sphere, in which shad could not find a corner into which to poke their noses, they might swim around in a continuous circle without injuring themselves. This was not tried. Instead, the trapping operation was curtailed during the height of the shad run, to prevent a possible large loss.

Shad were caught principally during hours of darkness but during the peak of the run good numbers were also taken in the daytime.

Other Fishes Captured

Several other species of fishes were captured from time to time in the traps. Among those appearing most frequently were the catfishes,

primarily white catfish (*Ictalurus catus*), channel catfish (*Ictalurus punctatus*), and occasionally brown bullhead (*Ameiurus nebulosus*). Catfish were numerous at times in the trapping area, and large catches were made with commercial-type catfish nets of smaller meshed cotton webbing. The large traps set for steelhead and salmon were surprisingly ineffective in capturing catfish.

Largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) were often captured, particularly in the spring and fall months, but never in any quantity. Only one sturgeon has been captured in the traps to date. This was a 460-pound white sturgeon (*Acipenser transmontanus*) measuring over nine feet in length, captured during the fall of 1955. The sturgeon population of this section of the Sacramento River is unknown, and thus the effectiveness of the traps for this fish remains a mystery. However, it is doubtful that the traps are very effective in capturing sturgeon.

Three species of Pacific salmon, other than kings and silvers, have also been taken in the traps. Between 1951 and 1956, a total of 31 chum salmon (*Oncorhynchus keta*), 10 pink salmon (*O. gorbuscha*), and 3 sockeye salmon (*O. nerka*) was captured. These fish were probably strays, since only a few are observed each year in the Sacramento River system.

Miscellaneous fishes appearing in the traps include western suckers (*Catostomus occidentalis*), splittail (*Pogonichthys macrolepidotus*), hardhead (*Mylopharodon conocephalus*), greaser blackfish (*Orthodon microlepidotus*), Sacramento squawfish (*Ptychocheilus grandis*), carp (*Cyprinus carpio*), black crappie (*Pomoxis nigromaculatus*), brown trout (*Salmo trutta*), bluegill (*Lepomis macrochirus*), tule perch (*Hysterocarpus traski*), and Pacific lamprey (*Entosphenus tridentatus*). None of these species was ever numerous in the catches.

SUMMARY

This article describes the construction and use of large cylindrical fish traps and their effectiveness in capturing king salmon, steelhead trout, silver salmon, striped bass, American shad, and other species of fishes in the Sacramento River.

The traps are 10 feet in diameter and 19½ feet long, open at one end, and contain two funnels which act as a one-way pass into a pot or impounding area.

Detailed material lists and construction directions are given, together with fishing and transportation methods.

The traps are fished in the Sacramento River along steep dirt banks where the water is commonly 20 feet deep a few feet from shore. The flow is usually between 5,000 and 10,000 cubic feet per second, with velocities of 2 to 3 feet per second near the shore.

Seven of these traps fished at Fremont Weir captured from 10 to 20 percent of the total run of steelhead. One percent of the king salmon run and, in 1956, approximately 11 percent of the silver salmon run was captured. These three species were in good condition, with no evident injuries. Considerable mortality was experienced by the American shad.

FISHES COLLECTED IN THE TROPICAL EASTERN PACIFIC, 1954[1]

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INTRODUCTION

This paper is concerned with marine fishes of Central and South America and the Galapagos Islands collected incidental to tuna tagging operations conducted from the tuna clipper M. V. MAYFLOWER during the period February 13 to June 9, 1954 (California Department of Fish and Game, Cruise Report C-2-54). In all, some 5,000 specimens were preserved frozen or in formalin and brought to the California State Fisheries Laboratory for identification and dispositon. From these, 62 families containing 137 species in 115 genera have been identified.

The present collection supplements that made from the tuna clipper M. V. INTREPID during 1952 and 1953 (Clemens, 1955) and should aid materially in achieving a better understanding of the habits of these tropical species, as well as of their geographical distributions.

METHODS OF CAPTURE

Several methods of capture were employed to sample a variety of habitats. These methods were:

I. Hook and Line.

A. Trolling With Feathered Jigs and Plastic Squids.

Trolling, while cruising between different fishing areas and bait grounds, resulted in the capture of several specimens found relatively near the surface of the water. It was by this method that barracuda, *Sphyraena idiastes*, station 17; a rainbow runner, *Elagatis bipinnulatus*, station 17; and bullet mackerel, *Auxis thazard*, station 11, were taken at the Galapagos Islands. In addition, a dolphinfish, *Coryphaena hippurus*, station 54, was caught off Colombia and a bonito, *Sarda velox*, station 44, off Panama by trolling.

B. Bottom Fishing With Handlines.

Handlines were employed to good advantage when the vessel was anchored or drifting in water less than 400 feet deep. The use of various sized hooks baited with live or cut bait resulted in the capture of many species dwelling at or near the bottom. At station 47 off Colombia three species were caught with a handline in 300 feet of water. Of these, only one, a snapper, *Lutjanus peru*, was previously known to science. A second, a scorpaenid, has since been named *Pontinus clemensi* (Fitch, 1955), while the third, a serranid, *Epinephelus*, is being studied by Dr. Boyd W. Walker, University of California, Los Angeles. The remoras have also been included in this category, though for the most part they were removed from sharks caught on handlines. One exception, however, was a *Phtheirichthys lineatus*, station 22, captured off Panama. This fish was taken under the night light in a dip net—no sharks were noted in the vicinity.

C. Rod and Reel.

A good deal of rod and reel fishing was carried out whenever the opportunity arose and several of the more "gamy" species found in relatively

[1] Submitted for publication April, 1957.