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Artificial Salmon Spawning Marine Advisory
Bulletin No. 7

by: William W. Smoker, and Curtis L. Kerns

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OUT OF PRINT



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A Manual

By William W. Smoker
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Marine Advisory Bulletin No. 7
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ARTIFICIAL SALMON SPAWNING

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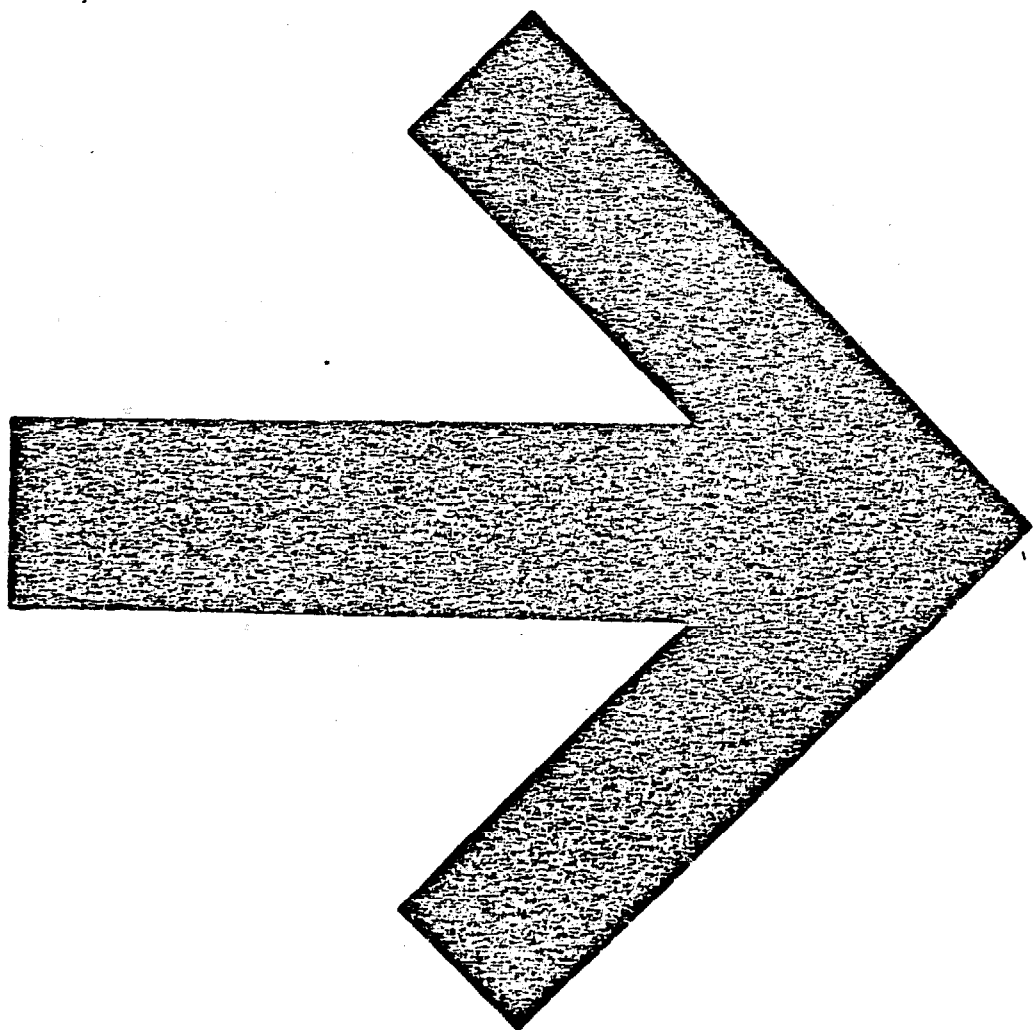


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Sketches by Ann C. Schell

INTRODUCTION

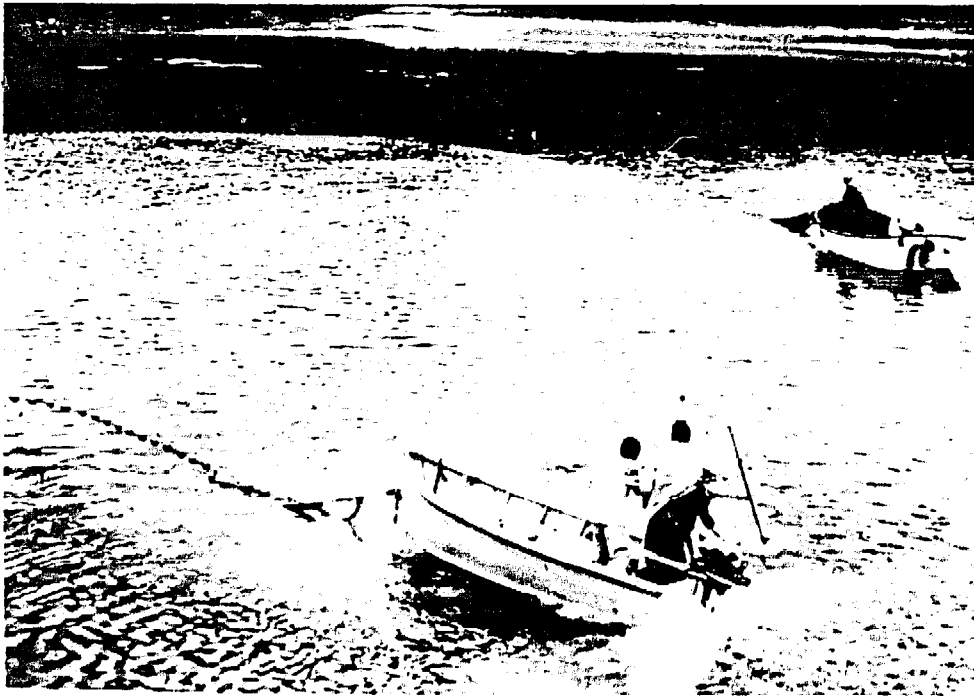
This manual is designed primarily for the aquaculturist who is just getting started, but it includes tips that should be helpful for veterans as well. The procedures described aren't necessarily the only correct ones. They may actually be more time-consuming than others. But they are procedures that are least likely to go wrong for the novice egg-taker. With time and experience, changes may be made to suit individual situations.

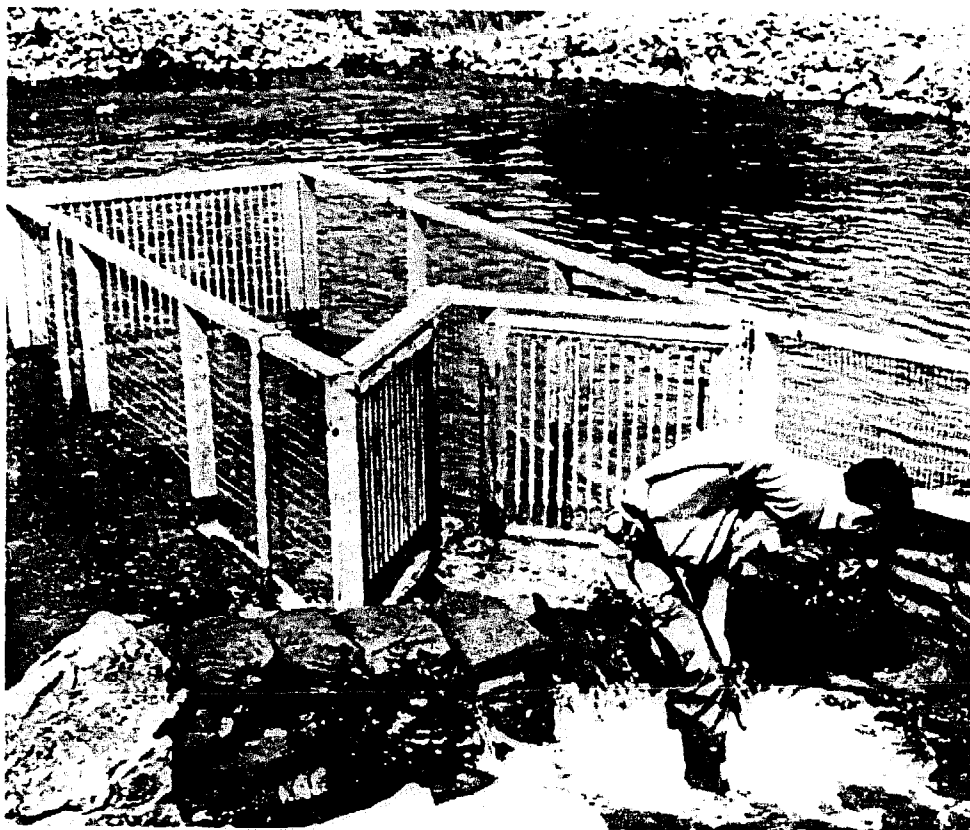
Even the "Rules of Thumb" presented here are not necessarily hard and fast rules. Not all have been scientifically tested. But where they have been used, incubators have been filled with live eggs. Much of this advice stems from experience gained from the first egg-take at the Prince William Sound Aquaculture Corporation (PWSAC) pink and chum salmon hatchery.

COLLECTING ADULTS

During your first years of operation, you will probably have to travel to a remote site to take your adult fish. In most cases, the easiest way to catch them will be with a seine. If you will be fishing at a creek mouth at high tide — the most likely situation — a small seine, such as a herring bait seine operated with a couple of skiffs, will be most effective. If you are given permission to take fish early enough in the run, you may be able to use a commercial seine and capture all the adults you need in a few sets.

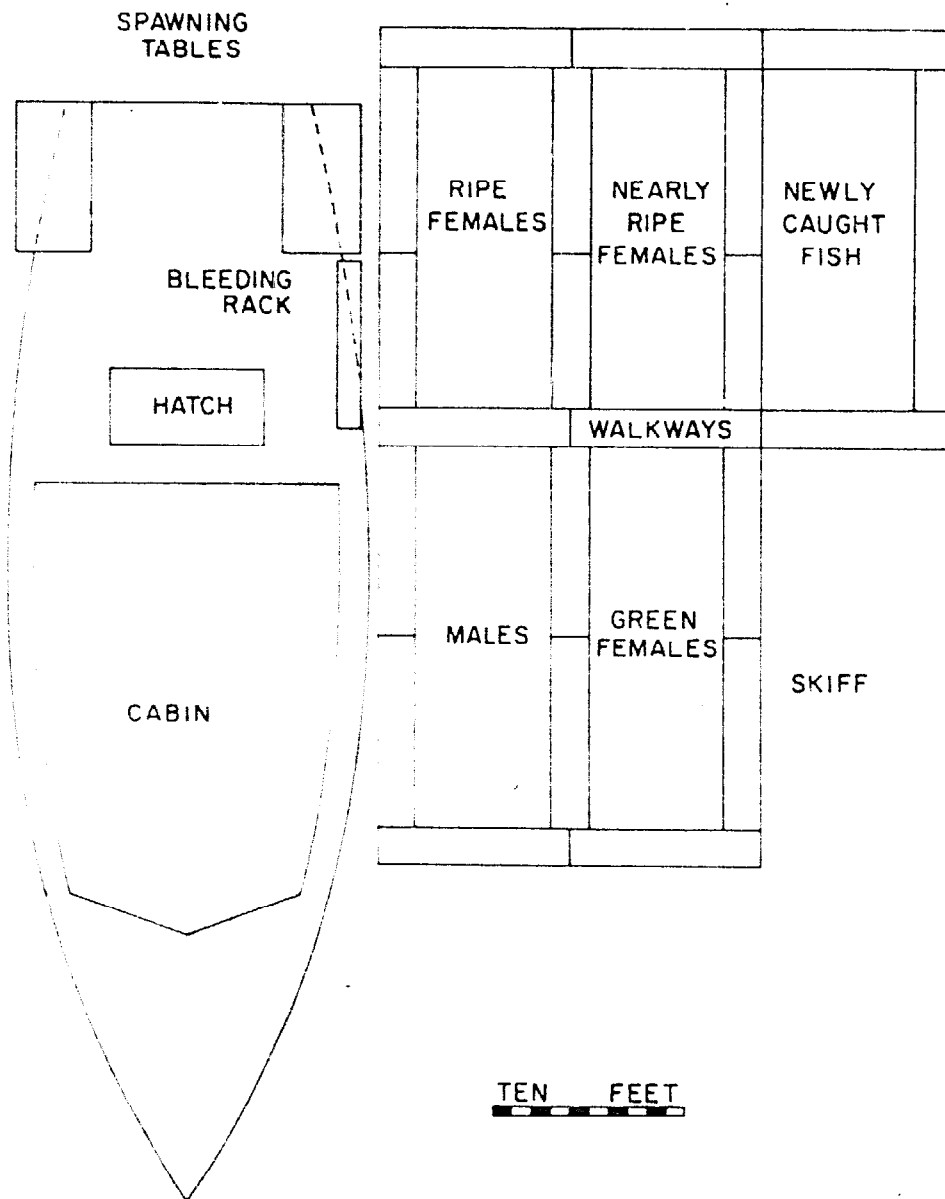
Try to avoid taking all your fish from just one portion of the run. Instead, take fish in a ratio that is proportional to the natural run: a few during the early portion of the run, most during the height of the run, and a few during the latter part of the run. The idea is to maintain genetic diversity. However, if you can take fish during only one portion of the run, the height of the run is probably the best time.





Once caught, the adults must be kept in holding pens until they are ripe. They are hardy and withstand a surprising amount of handling and crowding. However, keep in mind that they can suffocate if too many are jammed in a small space. Take the time to brail (hand net) them one at a time and do not throw them around carelessly. Eggs and milt can be damaged by rough handling. Do not hold females head down because the pressure of the egg skeins may be too much for their hearts.

If the donor stream is fairly close by, you may save time and effort by transporting the fish live to your hatchery site. Salmon will easily survive towing in a pen at speeds of 2 - 4 mph. If the towing forces the fish against the rear of the pen, you can decrease the water velocity either by slowing the boat down or closing off some of the openings in the front of the pen.



Arrangement of holding pens alongside the *Yankee Clipper*, as used during the Prince William Sound Aquaculture Corporation's remote site egg-take. Note spawning areas on the vessel's stern.

Rule of Thumb No. 1: *Take at least one male for every three females. This will help prevent inbreeding problems that might occur if few males are used – but it's easier than taking a male for each female.*

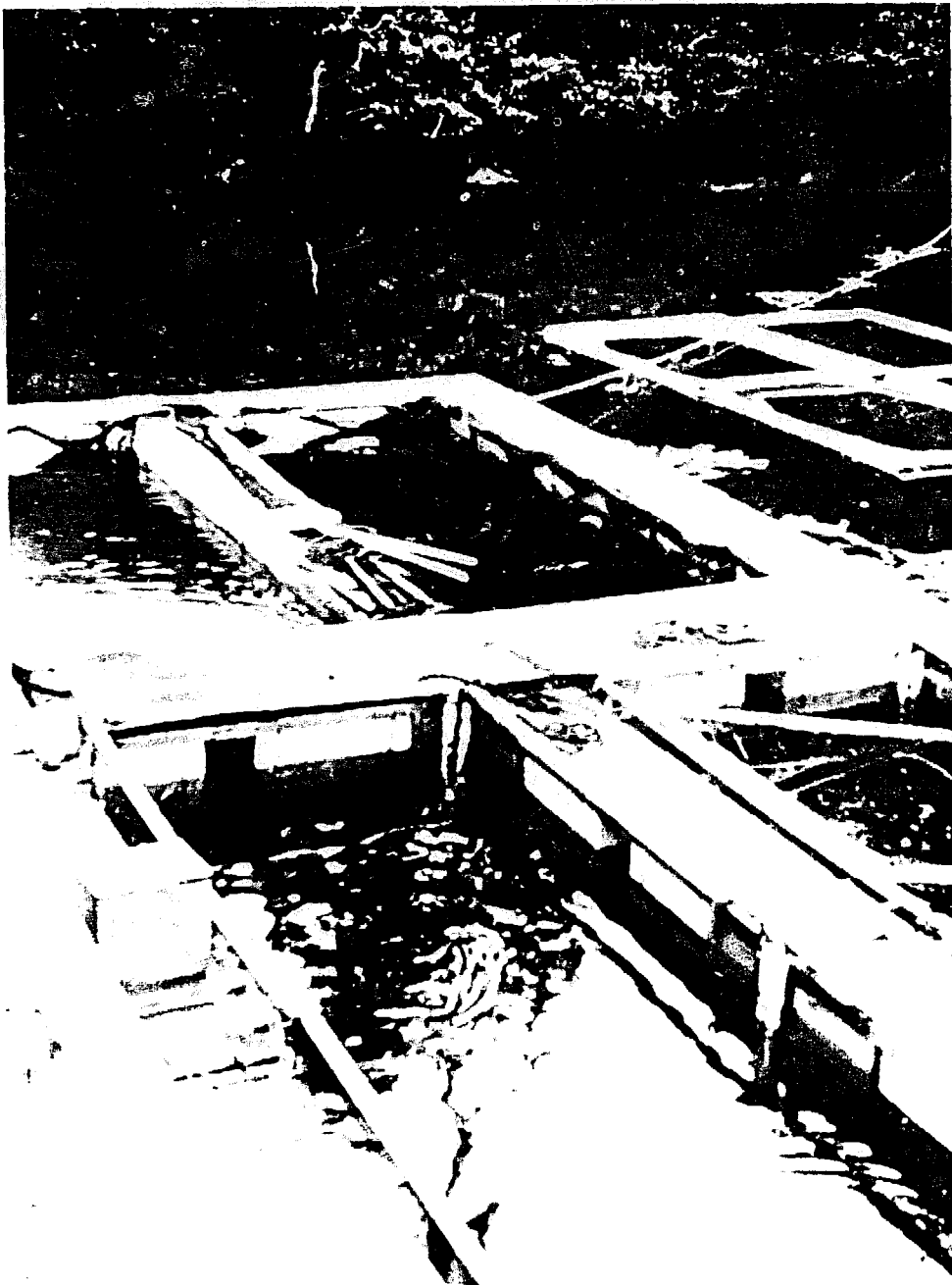
Rule of Thumb No. 2: *Resist the temptation to take only the largest, heaviest fish. The little ones are there for a good reason. For example, if you have three times as many males as are needed, take every third male you come across in the net, not just the big ones. Do the same for females if there are enough of them. And don't select for any one characteristic. (Animal geneticists commonly use as many as ten characteristics to form the base of a selection program. Salmonid genetics is not nearly well enough understood to design a selection program.) Remember, artificially spawned salmon must compete in the wild, unlike domesticated animals.*

HOLDING AND RIPENING ADULTS

At remote locations, you'll have to set up pens where the adult fish can mature. Probably the best type of holding pens are floating pens anchored offshore. Cages built in the spawning creek will work if you can find quiet water that is deep enough – but bears have little trouble opening most cages. Floating pens should be located where they are protected from heavy weather and where fresh water from the creek will flush through them. Fresh water is not always necessary, but it tends to hasten the ripening of your fish.

You will need at least three separate pens: one for males, one for females, and the third which you will keep empty to receive green females after they have been tested for ripeness.

The pen design developed by personnel at the Prince William Sound Aquaculture Corporation is a particularly good one. Rectangular 7 x 10-foot frames are made of 2-inch plastic water pipe. The bottoms, ends, and sides are formed by tautly laced panels of 3/4-inch herring seine. On the surface, the pens are surrounded by styrofoam float walkways.



Adults, particularly the males with their large teeth, are not as likely to become entangled in rigid pens as they are in a loose-bag sort of pen. For extended or close holding, use plastic covered wire to form the sides and bottom, if used, of the pen.

After a run has been established at your hatchery site, catching adults will be much easier because you will be able to build a trap in the stream. This trap may consist of a fence across the stream with an opening into a cage, or some other design that allows you to select adults periodically. Your holding pens can probably be dug out near the creek where you will have the advantage of fresh water and a gravel bottom — a more natural situation. Consequently, the adults will ripen faster.



Waterflows Necessary
Per 100 lbs. of Adult Fish

Gallons of Waterflow Per Minute		Temperature	Sea Level Dissolved Oxygen Saturation Value (mg/l)	
Optimum	Minimum	F	Fresh	Salt
1.0	0.5	35	13.6	11.5
1.25	0.7	40	12.6	10.7
1.8	0.9	45	11.7	10.0
2.6	1.3	50	10.9	9.4
3.2	1.6	55	10.2	8.9
3.8	1.9	60	9.7	8.4
4.5	2.25	65	9.1	7.9
5.2	2.6	70	8.7	7.6

If the oxygen level of the water is less than atmospheric saturation, multiply table water flow by $\frac{100}{\text{saturation}}$. For example if your water is 50° F and you measure 8.7 mg/l of oxygen in it, your water is 80% saturated (8.7 is 80 percent of 10.9, the value for fresh water at 50° F). Therefore your optimum flow rate is $2.6 \times \frac{100}{80}$ which is 3.3 gallons per minute. Fish should not be held for any more than an hour or so in densities of more than 2 fish per cubic foot of volume (e.g., a pen 5' x 10' x 5' deep will safely hold 500 fish).

Rule of Thumb No. 3: *For pens built ashore, allow waterflows per 100 pounds of fish based on the chart on the opposite page.*

SORTING AND TESTING

Sexing and Separating Adults

Mature males are much easier to identify than females. They have a pronounced hook at the end of the upper jaw and develop a hump or sail along the back. These spawning features are not so obvious in females. (See pages 10-11.) Sometimes, you will capture brightly colored fish which do not show these features. In that case, you will have to hold them in pens until they do.

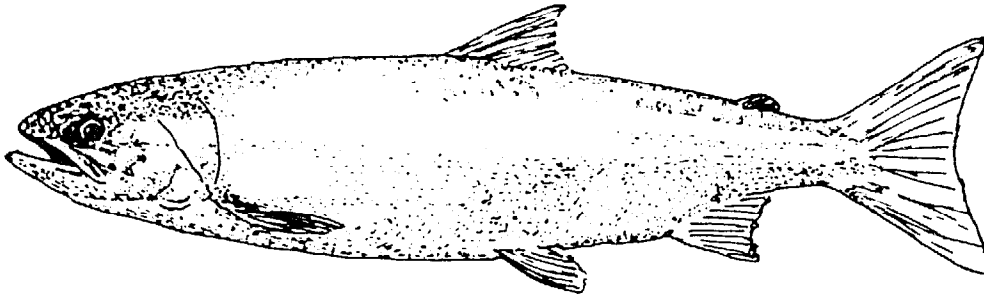
Males are separated from females for a number of reasons. For one thing, it conserves holding pen space since fewer males are taken than females. It also makes handling and processing the eggs and milt easier and more efficient. In addition, it lessens the chance of fish spawning prematurely in the holding pens (a hazard if the fish are held in pens with gravel bottoms).

Testing the Females for Ripeness

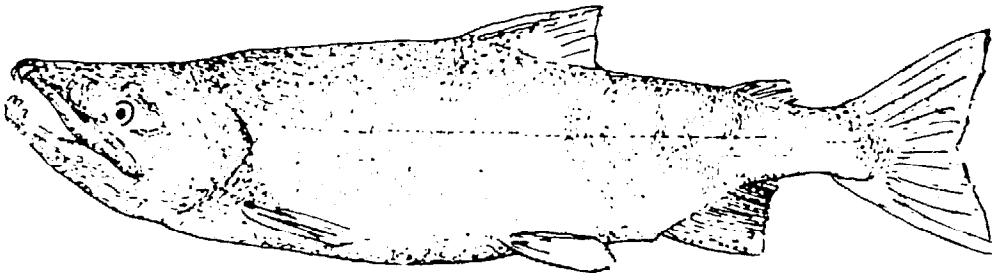
This procedure requires two people: one to brail the fish and the other to handle the fish. After the first person dips the female out of the pen, grasp her by the thin part of the tail with your left hand. A strong grip is needed — cotton gloves help. With your right hand under her belly, cradle the fish against your chest or stomach. Then, with your left hand, cock her tail up, and with your right hand apply a gentle pressure to her belly.

If the eggs fall readily, quickly cradle the fish belly up so as not to lose any more eggs than necessary. (If 50 to 100 eggs are lost from each female, 20 to 40 extra females will be required per million eggs taken.)

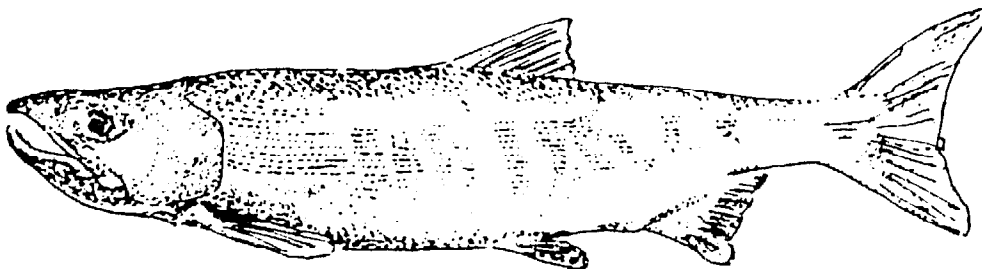
CHUM SALMON



Sea-run

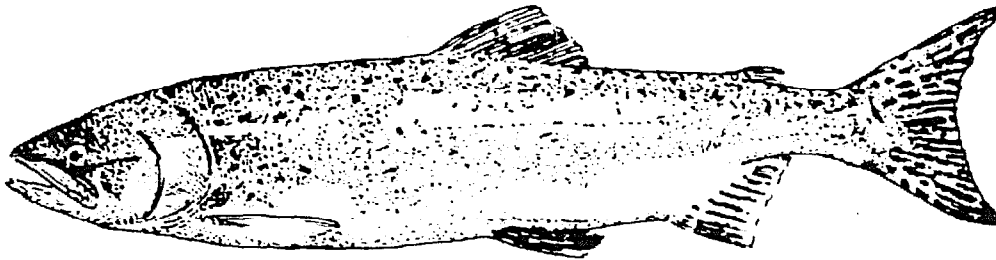


Spawning Male

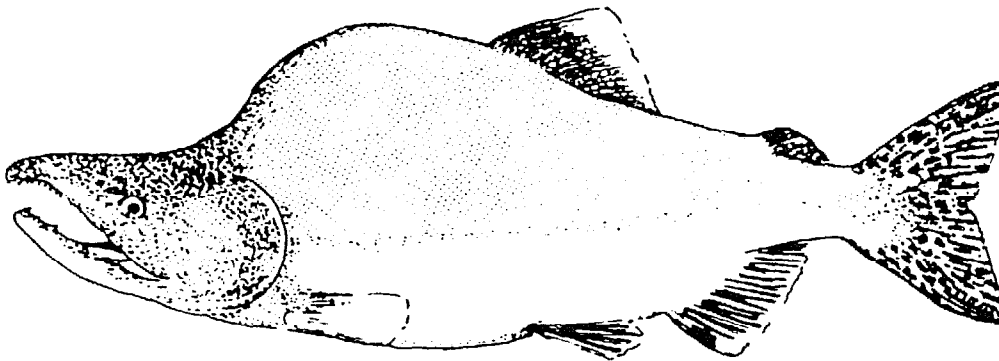


Spawning Female

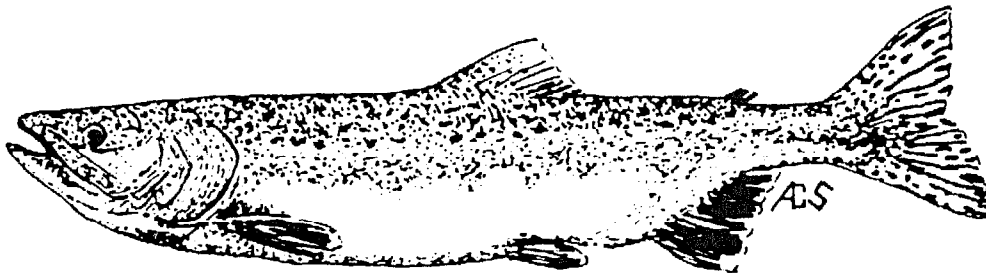
PINK SALMON



Fresh-run Female



Spawning Male



Spawning Female



Rule of Thumb No. 4: *The fish is ready to spawn if her belly muscles are soft and a few eggs are expelled from the vent. If you have to use more than a gentle pressure, the fish is not ripe and should be placed in the holding pen for green females.*

After you have collected a fairly large number of green females, keep a close watch on them – but don't overdo it. Check them every few days to observe their ripening process, and then check only 25 fish on any given day. In this way you will avoid unnecessary handling of fish and will save time and effort.

When many of the females are ripe, check them all and take eggs from the ripe ones. Once they are ripe they do not last long. In this situation it will help if you have several holding pens so that you can sort the "nearly ripe" from the "very green" females.

Rule of Thumb No. 5: Wait until 10 of the 25 females checked are ripe before you begin taking eggs from a large group of fish.

Testing Males for Ripeness

The fish is held in the same manner as the female. Strip the male by squeezing along his belly with the thumb and forefinger of your right hand, pushing towards the tail. If milt is produced readily, the fish is ripe.

Rule of Thumb No. 6: Always waste the first few eggs from the female and the first shot of milt from the male. They may contain urine, fecal material, blood and/or water.

TAKING EGGS

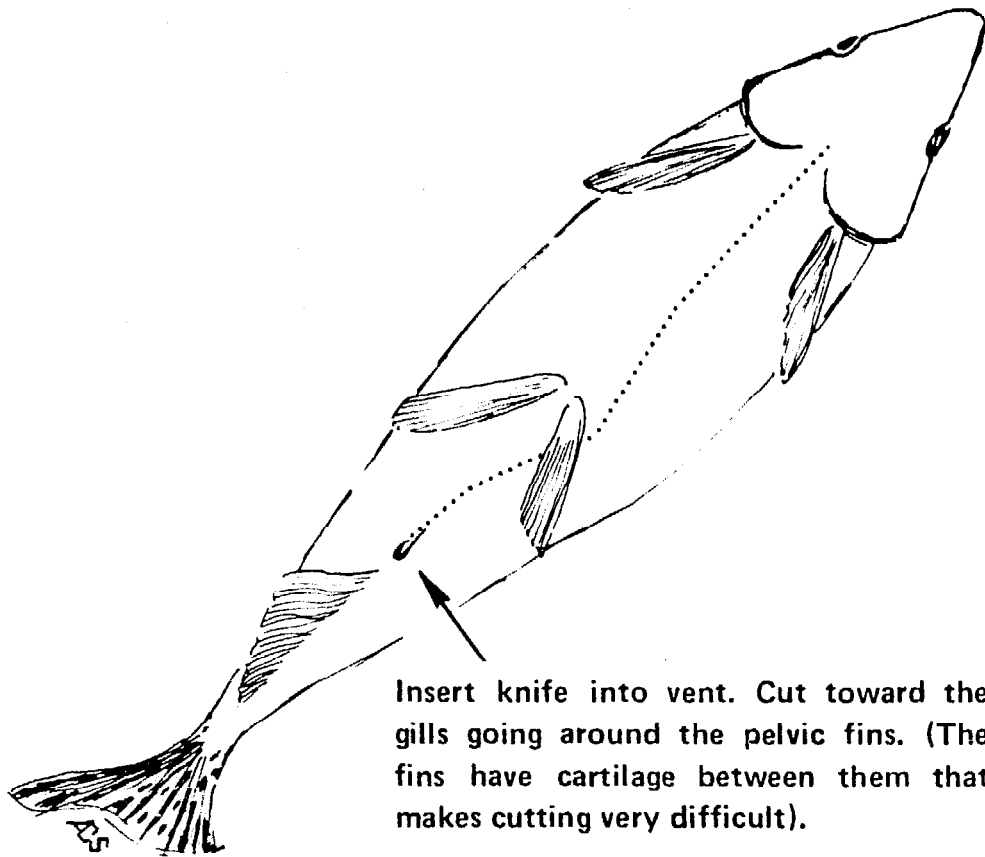
A ripe female is killed by a sharp blow with a club between and behind her eyes. She is then bled to prevent blood from contaminating her eggs when they are taken. To bleed, lay her on a shelf or board and cut her tail until your knife meets her backbone. The cut is usually made from the belly side, but it can be done from the back as well. The cut severs the large caudal artery and the blood will quickly drain.

Egg-taking should be done out of the weather. If you are on a float alongside the holding pens, put up a plastic tent for protection from both the sun and the rain. After the fish are killed but before they are stripped, they should not be left in the sun for more than a few minutes. This is true for both males and females. It is also essential that the eggs and milt be kept from any contact with water.

Rule of Thumb No. 7: *Don't let eggs, in or out of the female, get any warmer than 60° F. Keep the unspawned fish and spawned eggs and milt as cool as possible.*

Two spawntakers are required for the actual egg-taking. They stand facing each other on either side of a table or bench which holds the spawning basins. The first spawntaker, who should wear cotton gloves, grasps the female's head with the left hand, hooking the forefinger and middle finger under the fish's gill covers. With the right hand, the belly is wiped clean and the tail is grasped.





Insert knife into vent. Cut toward the gills going around the pelvic fins. (The fins have cartilage between them that makes cutting very difficult).

The fish is then lifted and held head up with the belly towards the basin and the anal fin (the one behind the vent opening on the belly side) draped over the rim of the basin. Using a splitting knife, the second spawntaker slits the belly from vent opening to throat. The pelvic fins (the pair of fins just in front of the vent) are cut around, not between.

If the fish is fully ripe her eggs will spill quickly into the basin. If she is just barely ripe, only a few eggs will fall. In this case, the second spawntaker holds the body cavity open with the left hand and runs the right forefinger along the body wall on each side, tearing away the membranes but being careful not to squeeze any eggs. This action opens up any pockets that might trap eggs. The fore end of the large skeins or sacs of eggs on either side is then grasped and gently shaken to loosen the eggs.

Rule of Thumb No. 8: *Any ripe eggs will fall into the basin. Eggs that do not readily fall away from the sac are green and will not fertilize.*

Rule of Thumb No. 9: *Blood, slime, and broken eggs interfere seriously with good fertilization and should be kept out of the basin as completely as possible.*



TAKING MILT

Take milt from males in the same way as they were tested. Males need not be killed, but it is usually convenient to do so. If you have a shortage of males, they may be kept alive and stripped several times. Allow enough time between spawnings to permit the milt to build up again — usually four to six hours.



Milt may be stripped directly onto the eggs in the spawning basins if your incubators are nearby. Eggs become very tender soon after fertilization, so if your incubators are at some distance it is better to transport eggs and milt separately. Strip the male into a plastic bag — a “whirl bag” or a “zip lock” or some sort of sandwich bag. Be careful not to get any moisture in the bag — don’t even blow into it to inflate it. *Milt is very sensitive to water and lives only a few seconds after contact with water.*

Put the milt from only one male in each bag. (Some weak males produce watery milt that could contaminate other milt.) Tie the bag shut so that some air is trapped inside to help keep it dry.

TRANSPORTATION AND FERTILIZATION

Eggs and milt can be safely transported in insulated shipping boxes packed with crushed ice. Gently pour the eggs from the spawning basins into heavy plastic bags — eggs from about six fish per six-gallon bag. Solid containers, such as a gallon-sized mustard or mayonnaise jar, may also be used and tend to protect the eggs from physical damage better than a flexible bag. Be careful not to introduce water into the containers. Tie the bags or close the containers tightly and pack them in the transportation box. Do not put ice right next to the milt or eggs as some freezing might occur. Cardboard (or moss) can be used to separate the ice from the eggs and milt.

Packed in this way, the eggs and milt will last a fairly long time — even until the next day. If your transportation breaks down or the weather blows up, you will have some time to spare.

Rule of Thumb No. 10: *If plastic bags are used, don’t stack the eggs any deeper than about ten inches in the transportation box.*

At the hatchery, take the eggs and milt out of the ice and allow them to come to room temperature. Pour the eggs from one bag into three or four basins. Open two bags of milt and pour about a half a cup of water into each. Then immediately pour some of the diluted milt from both bags into each basin of eggs. Two persons will be required for this operation because speed is essential. Once touched by water the milt will lose its potency in 15 seconds.

Quickly and gently swirl the basins to mix the eggs and milt. If there were eggs from six females in the transport bag, the inbreeding problems referred to in Rule No. 1 should be avoided. Furthermore, the eggs from each female will have had a chance at milt from two males, so that if one was sterile the other will have made up for it.

Rule of Thumb No. 11: *You may dry fertilize with eggs and milt that have been freshly removed from fish, but always add water (wet fertilize) to eggs and milt that have been removed earlier. Dry fertilization using eggs and milt from fish killed earlier will result in a much lower fertilization rate.*

If you are taking eggs where transportation is unnecessary, the males can simply be stripped into the spawning basins. This, of course, is the safest procedure. Line up six basins, each with the eggs from one female. Strip the milt from two males into each basin. Then gently swirl the basins to mix the eggs and milt.

The basins should be emptied into the incubators as quickly as possible. Hold the lip of the basin under the water surface and pour the eggs into a layer on the incubator screen.

During their first hour in the incubator the fertilized eggs are water-hardening — taking up water and swelling into a rigid shape. They are especially tender at this time.

After the water-hardening process is completed, you can check for dead eggs (they appear white) and remove them. For the next several hours the eggs will tolerate some gentle handling. But after that time they must be left in absolute quiet for several weeks until the pigment of the eyes is visible. Even strong vibrations through the hatchery floor can be harmful. Keep the eggs out of the light as much as possible. Provide a cover for the incubators.

A mortality rate of 2 or 3 percent is not unusual, but 20 to 30 percent indicates trouble somewhere along the line. If there is no obvious reason for poor fertilization, suspicion falls on the milt, and you should try using milt from more males. Review your procedures to ensure that all possible care is being taken to keep the eggs and milt clean, dry, and cool.

ADDITIONAL READING

- Wood, J. W. 1974. Diseases of Pacific Salmon, Their Prevention and Treatment. State of Washington, Department of Fisheries, Hatchery Division, 115 General Administration Building, Olympia, WA 98504. \$5.00.
- Leitritz, E., and R. C. Lewis, 1976. Trout and Salmon Culture. Fish Bulletin 164. State of California, Department of Fish & Game, Office of Procurement, Documents Section, P. O. Box 20191, Sacramento, CA 95820. \$3.00.
- McNeil, W. J., and J. E. Bailey, 1975. Salmon Rancher's Manual. NW Fisheries Center, Auke Bay Fisheries Laboratory, P. O. Box 155, Auke Bay, AK 99821. Free.