THE ARTIFICIAL PROPAGATION OF SALMON ON THE PACIFIC COAST OF THE UNITED STATES.

WITH

NOTES ON THE NATURAL HISTORY OF THE QUINNAT SALMON.

By LIVINGSTON STONE, A. M.

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A BRIEF HISTORY OF THE SALMON-BREEDING WORK OF THE UNITED STATES FISH COMMISSION ON THE PACIFIC COAST, WITH ESPECIAL REFERENCE TO OPERATIONS AT BAIRD STATION, CALIFORNIA.

In 1864 the New Hampshire legislature had the intelligence and foresight to appoint a fish commission—the pioneer fish commission of the United States—at the suggestion of Hon. Henry A. Bellows, of Concord. Two years after, in 1866, the commission sent Dr. W. W. Fletcher to New Brunswick to procure salmon eggs for Merrimac River. This was the first effort ever made in America in the direction of salmon breeding. Only two or three hundred fry were actually known to have resulted from this expedition, but it was a beginning—a small beginning, it is true, but one which opened up a field of operations that has since been enlarged beyond the most sanguine expectations.

In 1867 Dr. Fletcher went again to New Brunswick, under the auspices of the New Hampshire Commission, and brought back 70,000 salmon eggs, of which about 10,000 were successfully hatched.

The next year, 1868, the writer, in connection with Mr. Joseph Goodfellow, of New Brunswick, put up a large salmon-hatching plant on Mirimichi River, and began the first systematic operations on this side of the Atlantic for taking and hatching salmon eggs. The neighboring residents,[1] however, very naturally jealous of the attempts of a foreigner to carry off their "salmon seed," as they expressed it (although by explicit stipulations half of the eggs were to remain in New Brunswick), threw so many obstacles in the way that it was only by persistent effort, in the face of most discouraging opposition, that any salmon eggs at all were secured, the whole output of the season amounting to only 443,900 eggs, and the next year the local public sentiment was so hostile that this hatchery, constructed on a large scale and almost ideal in its natural adaptability to its purpose, had to be abandoned altogether.

Very little was done in 1869 and 1870 in getting salmon eggs for the United States, except by purchase from the Canadian government, the price paid at that time being the preposterous sum of $40 in gold per 1,000, or nearly $45 in the then depreciated currency of the United States.

In 1871[2] Mr. Charles G. Atkins, of Maine, began operations in salmon breeding on the Penobscot, and obtained 72,300 eggs, at a cost of $18.09 per 1,000.

[1] See *Domesticated Trout*, page 315.

[2] Mr. Atkins has continued successfully to take salmon (*Salmo salar*) eggs on the Penobscot up to the present time (1896).

In the summer of 1872, at a meeting of members of the Fish-Culturists' Association and State fish commissioners, called, I think, by Prof. Spencer F. Baird, the United States Fish Commissioner, the subject of obtaining salmon eggs on a large scale was discussed, the writer advocating the plan of operating on the Pacific Coast,[1] where millions of eggs could be taken at the cost of a few hundred thousand obtained on the Atlantic Coast. One of the results of this meeting was that the writer was commissioned by Professor Baird to go to the Pacific Coast in search of salmon eggs. Professor Baird's instructions were contained in the following letter:

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Eastport, Maine, July 6, 1872.

DEAR SIR: An appropriation of $15,000 was made by Congress, at its last session, to be expended under the direction of the United States Commissioner of Fish and Fisheries, for introducing salmon, shad, and other useful food-fishes into new and suitable waters of the United States. At the recommendation of members of the Fish-Culturists' Association and certain State fish commissioners, I hereby appoint you a deputy commissioner, to proceed without delay to the Pacific Coast, in connection with this object. Your compensation in full for your services will be $250 a month, your pay commencing when you start for the West.

The sum of $750 will be allowed you for expenses of traveling and of investigation for the fiscal year, and a further allowance of $1,250 for the same period will be made for the cost of erecting and maintaining a hatching establishment, and for other necessary expenses connected with the packing and transportation of the eggs, etc.—$5,000 in all.

You will proceed to California at the earliest possible moment, and on arriving there put yourself in communication with the commissioners of the State of California and endeavor to obtain their assistance in your mission. If you can make arrangements to obtain, at reasonable cost, all the eggs that you desire in California, without proceeding farther north, you are hereby authorized to do so, but otherwise you will extend your journey to the Columbia River and adjacent waters, and if the season is not too far advanced you will proceed at once to make arrangements for obtaining a supply of salmon eggs; previously, however, by examination and counsel with those who are familiar with the subject, fixing upon the species best adapted for the purposes in question.

The general treatment of the whole subject must be left largely to your discretion, bearing in mind that the object is to lay the foundation of an arrangement, on a large scale, for obtaining eggs of the best varieties of *Salmonidæ* and other food-fishes of the western coast.

Very truly yours,

SPENCER F. BAIRD,
Commissioner.

LIVINGSTON STONE, ESQ.,
Charlestown, New Hampshire.

Perhaps I can not better give an account of what immediately followed than by quoting from my first report to Professor Baird, dated December 9, 1872:[2]

In pursuance of your instructions, received in July last, to proceed without delay to the Pacific Coast and make arrangements for obtaining a supply of salmon eggs, I left Boston on the 1st day of August for San Francisco, with this object. As I was directed in subsequent letters to obtain, if possible, the eggs of the Sacramento River salmon, I set myself at work at once to ascertain the time and place of the spawning of these fish, but, singular as it seems, I could find no one in San Francisco who was able to say either where or when the salmon of the Sacramento spawned.

Fortunately, a short time after, I was introduced, through the kindness of Hon. B. B. Redding, a member of the board of California commissioners of fisheries, to Mr. Montague, the chief engineer

[1] It may be well to mention here that the subject of this paper, viz, the quinnat salmon, must not be confounded with the other salmon of the Pacific Coast. The Atlantic has but one kind of salmon (*Salmo salar*), but the Pacific has five species, as follows: The quinnat salmon (*Oncorhynchus tschawytscha*), the blueback salmon (*O. nerka*), the silver salmon (*O. kisutch*), the dog salmon (*O. keta*), and the humpback salmon (*O. gorbuscha*). In addition to these the steelhead (*Salmo gairdneri*) is commonly known as a salmon, though really a trout. Although these salmon in some general features resemble the quinnat, they are very different from that fish in many matters of detail.

[2] United States Fish Commissioner's Report, 1872-73, page 168.

of the Pacific Railroad, who showed me the Pacific Railroad surveys of the upper waters of the Sacramento, and pointed out a place on the map, near the junction of McCloud and Pitt rivers, where he assured me he had seen Indians spearing salmon in the fall on their spawning-beds. This point is 185 miles north of Sacramento City. Following this clue I proceeded to Red Bluff, the northernmost railway station of the California and Oregon Railroad, situated 50 miles from McCloud River. From inquiries made there I became so well convinced that the salmon were then spawning on McCloud River, that as soon as supplies and men could be got ready I took the California and Oregon stage for Pitt River ferry, a mile from the mouth of the McCloud. We arrived here at daylight on the 30th of August. Leaving the stage at this point we followed up the west bank of Pitt River on foot to the mouth of the McCloud, and continued thence up McCloud River.

At a distance of about 2 miles above the mouth of the river we came upon several camps of Indians with hundreds of freshly caught salmon drying on the bushes. Salmon could also be seen in the river in such numbers that we counted 60 in one spot as we stood at the water's edge. It was evident that this was the place to get the breeding fish, and the next thing was to find water to mature the eggs for shipment. This was not so easy a task as finding the salmon, but we at last discovered a spring stream flowing 1,000 gallons an hour, which I decided to use, this season at least, and on the morning of September 1, 1872, the hatching works of the first salmon-breeding station of the United States were located on this stream.

The location is about 2 miles up McCloud River, on its western bank. It is 323 miles from San Francisco, via Pacific Railroad; 453 miles from Portland, Oreg., and is on the California stage road, which, at the time of our arrival, connected with the railroad at Red Bluff. The spawn found in the salmon that the Indians were spearing on our arrival indicated that there was no time to spare in getting ready for the hatching work. We were 25 miles from the nearest town or village, 50 miles from a railway station, over 50 miles from an available sawmill, and in the Sierra Nevada Mountains, where the mule teams barely made 20 miles a day with supplies; but we went to work, and in 15 days we had a house built, filtering-tanks, hatching-apparatus, and flume in perfect running order, and on the 16th of September we were catching and corralling salmon. There were but three of us, and every day for a week the mercury ran from 105° to 112° F. in the shade. But although we worked so expeditiously through the broiling sun of those days, we were too late. The first few hauls of the net showed that the salmon had spawned. In fact, the salmon begin to spawn in McCloud River some time in August and are through spawning, or nearly through, by the 20th of September.

We caught plenty of salmon in the seine, but only rarely a female with ova. By hard fishing and hauling the seine every night, and sometimes all night, we succeeded in catching 26 salmon, including both sexes, in spawning condition, by the 28th of September. On the night of the 28th, at midnight, as the returns did not seem to warrant the expense of handling the seine, I stopped fishing. Of the 26 breeding salmon caught, 12 were females, and yielded 50,000 eggs. Of this number, 20,000 were destroyed by the terrible heat of the last of September, the mercury on some days reaching as high as 112° in the shade. The remaining 30,000 did well in spite of many dangers from sediment and from a fungoid growth which seemed to penetrate the brook water on hot days, and which rendered constant vigilance necessary; and on the 12th day of October the most advanced eggs showed eye-spots. By Friday, October 18, all the eggs were ready to pack for shipment, but, owing to miscarriage of a letter, the moss, which was to be delivered on the previous Tuesday, did not arrive until the evening of the following Tuesday. On the next day, October 23, the eggs were packed and shipped to Sacramento, where I placed them in charge of Wells, Fargo & Co., by whom they were forwarded east on the 25th of October, 1872.

These were the first live salmon eggs that crossed the continent from the Pacific to the Atlantic.

Here let me quote again from the same report:[1]

The conditions of hatching salmon eggs in California are wholly different from those which present themselves in similar work in the East.

At the East you have to guard against cold, in California you have to guard against heat; at the East you can usually find a good spring in a favorable locality; here it is out of the question; at the East a brook will usually answer the purposes of hatching water in the absence of a spring; in California the brooks as a rule are wholly unsuitable for hatching; at the East the eggs are hatching

[1] United States Fish Commissioner's Report, 1872–73, pages 171–173.

in the winter; in California the salmon spawn in the summer; and finally, most of the hatching work is done in California before the Atlantic fish begin to spawn.

I tried three ways of capturing the parent salmon; first, by the Indian trap; second, by a stake net and pound; third, by a sweep seine. The Indian trap consists of a fence of stakes or bushes built out into the river at a fall or rapid in the form of a letter V, having the angle downstream, and a basket trap at the angle. This method proved perfectly worthless, as of course it must, for catching healthy fish, as this contrivance catches only the exhausted fish that are going down the river and none of the good fish that are coming up.

The second method of using a stake net did not work, on account of the volume and force of the river current. I set the stake net so as to just reverse the form of the Indian trap; that is, so that it formed the letter V with the angle upstream, and a trap or pound in the angle. As it happened, it was too late for such a net to be effective, because the salmon were all going down at that time, and none, or at most a very few, were coming up; but even if the salmon had been coming up, this contrivance would not have answered here as a permanency, because the velocity and volume of water in the McCloud are such as would ultimately tear any such net away in any place where it could otherwise be set to advantage.

The third method, of sweeping with a seine, worked to perfection. In some of the holes, and especially in one large hole near which it is proposed to place the hatching works next year, any number of parent salmon can be caught in the proper season. The only objection to hauling a seine in these places is that as the boat taking out the seine turns to come ashore again it is drawn near the brink of the rapids, over which it would be dangerous to go in the night. This is an objection, however, which skill and nerve can always overcome.

On the darkest nights the scene on the river bank was exceedingly wild and picturesque. Behind us was the tall, dark shadow of Persephone Mountain, and before us at our feet ran the gleaming rapid current of the McCloud, while the camp fire threw an unsteady light upon the forest, mountain, and river, suddenly cut off by the dense darkness beyond. The flaming pitch-pine torches stuck into the sandy beach at intervals of 20 feet to guide the boatmen, the dusky forms of a half-dozen Indians coiled around the fire, or stoically watching the fishing, the net, the fishing boat, and the struggling fish added to the effect, and made a picture which, especially when the woods were set on fire to attract the salmon, was one of surpassing interest. It was quite impressive, in the midst of these surroundings, to reflect that we were beyond the white man's boundary, in the home of the Indian, where the bear, the panther, the deer, and the Indian had lived for centuries undisturbed.

As will be seen by the foregoing, Baird station of the United States Fish Commission was founded in August, 1872. It was known as McCloud River station until 1878, when the writer, having succeeded in getting a post-office established on the river, named the post-office "Baird," after the distinguished first Fish Commissioner of the United States, Hon. Spencer F. Baird, since which time the station has been called Baird station.

The first plant on McCloud River was a very modest affair. It consisted of a rough-board, one-room cabin, 10 by 14 feet, and 24 hatching-troughs in the open air, each covered, of course, but with no roof over them. The results of the first year were modest enough, too. The whole net product of the season's operations was only 30,000 salmon eggs, costing over $100 per 1,000, and when these were shipped across the continent to their destination in New Jersey 24,000 were lost in transit, leaving only 6,000 good eggs to be hatched and planted in the tributaries of the Atlantic. Nevertheless, two important facts were established by the experiment, compared with the value of which the cost of the enterprise was trifling. The experiment established the fact that salmon eggs could be obtained in future from the Pacific Coast, and probably in large quantities, and also the fact, most important of all at that time, that salmon eggs could be shipped alive across the continent. The last fact was the more valuable, because up to that time salmon eggs had never been subjected to a long journey by rail, and serious doubts had been often expressed by experts as to the possibility of getting salmon eggs alive from the Pacific to the Atlantic.

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Previous to this year the Pacific Coast, as a source of supply in procuring salmon eggs, was an untried field. No one knew anything definite about it. Everything was conjectural. The sending off, also, of the delicate embryos packed in wooden boxes, to run the gauntlet of the vague and innumerable dangers of a journey across the continent, seemed like sailing out into an undiscovered sea; but now that the season was over the untried field had become familiar ground, and a path over the unknown sea had been found. In the number of eggs procured the results of the first year were small, but in the practical demonstration of what it was possible to accomplish on the Pacific Coast, the results of the first year's operations on the McCloud equal or surpass those of any subsequent season.

It may also be mentioned here that a valuable mass of information concerning the natural history of the salmon of the Sacramento was obtained this year, and 270 valuable specimens of the fauna of California, chiefly fishes, of course, were collected and forwarded to the Smithsonian Institution.

The next year (1873), wishing to follow up the lead now clearly brought to view, Professor Baird dispatched the writer a second time to California, with instructions to procure as many salmon eggs as possible.

Here I will quote from my reports:

Having secured supplies and men for the season's campaign, I left this (San Francisco) city again for McCloud River on the 5th of August, arriving at camp the next morning at daylight.

The year before, the idea of using McCloud River water not having suggested itself, I had been obliged to locate the camp and hatching works at a considerable distance from the river in order to obtain brook water for maturing the eggs. The inconvenience of this arrangement, which placed the fishing-grounds and hatching-works a mile apart, is apparent. In fact, the constant necessity for crossing and carrying materials from one point to the other, frequently in a temperature of 100° F. in the shade, became so intolerable before the season was over, with its consequent labor, risk, and loss of time, that I resolved, if possible, the next season to bring the camp, hatching-works, fishing-grounds, and stage communication together at one place. This I was fortunately enabled to do by using the river water for hatching at a point where the California and Oregon stage road touches the west bank of the McCloud. The first plan for conveying the water supply from a higher part of the river to the hatching works was not successful, on account of there not being sufficient fall for a satisfactory hatching apparatus, and for other reasons. This plan was therefore abandoned and the attempt was made to raise water from the river by a wheel placed in the current. This method worked to our entire satisfaction.

Having moved the station to the bank of McCloud River, we began fishing in midsummer, thinking that the salmon could be caught and safely confined until the coming of the spawning season rendered them ready for use. In this we met with a great and complete disappointment.

The confinement of the parent salmon in suitable inclosures, though it seems so simple a matter, was a very trying and difficult problem to solve, and gave us no end of trouble. To show the character of this difficulty, I will give my experience in the order in which it came. We began building our inclosures by staking down a small circular fence of stakes in a shallow place in the river near the shore. The stakes were driven down one by one, very firmly, and then firmly bound together and held in their place by withes. The main objection at first to this was that it was on too small a scale. We then built other inclosures on the same plan, but larger and deeper. This, however, gave the fish more scope for jumping, and, although the top of the stakes was several feet above the surface of the water in the inclosure, the salmon easily jumped over them and escaped into the river. We then put a covering, or roof, over the corral on a level with the top of the fence. The salmon now, although they could not escape by jumping out, were no less persistent in their attempts to do so, and literally wore and lashed themselves to death in their frantic and ceaseless efforts to escape. I then built a large, covered, wooden box, 16 feet long and about 4 feet deep and 5 feet broad, with wide seams between the boards to let the water through, and anchored it in the current. As the box, when soaked, sank nearly its depth in the water, the salmon had no chance to jump and lash themselves as in the staked inclosure, and we flattered ourselves we had found the solution of this troublesome problem

of providing a suitable place of confinement; but what was our surprise and disappointment when, on examining the box a few days later, we found the salmon all dead. The close confinement had really prevented them from injuring themselves as before by jumping, but at the same time had acted so unfavorably in other ways as to cause their death.

The prospect now looked very discouraging. We could catch salmon enough for our purpose, but we could not keep them alive. They were, in fact, dying as fast as we caught them. It now occurred to us that an open pond, supplied by a good stream of river water, would obviate the difficulties presented, as the fish, having nothing but dry land to jump onto, would give up jumping and remain quiet. I accordingly put on a force of Indians at once, and in a few days had a pond of considerable size ready, and supplied by a stream of water taken from the flume which conveyed the river water from the wheel to the hatching-house. A large number of salmon were then put in here, and we felt decidedly encouraged. But now a new difficulty presented itself, viz, the fish would not ripen in the pond. Whether it was that the roiling of the pond by their movements when frightened prevented the eggs and milt from maturing, or whether the friction produced by their incessant jumping in the river is one of the necessary conditions of their ripening, I do not know, but it is certain that neither eggs nor milt matured in the pond, and I think we did not take a single ripe egg or any first-rate milt from one of the fish there confined. My next move was to build a close board floor over the staked inclosures in the river, almost touching the surface of the water. This prevented the fish from wearing themselves out by jumping and did not seem to interfere with their ripening, but it did not keep them wholly from dying. At last I became convinced, and am still of the opinion, that the Sacramento spawning salmon can not be kept alive in any inclosure on a small scale. There seemed now to be but one alternative left, and that was to let those die that were confined, and to keep on fishing and select such fish as we could use as we went along. This we did, and fortunately there were so many fish running in the river that we were able, even after this, to obtain enough to furnish the requisite supply of eggs.

Two million salmon eggs were taken this season on the McCloud, most of which were shipped across the continent. It was not a large number, but, as in 1872, it demonstrated two important facts: one was the certainty that large numbers of eggs could be obtained here, the other that a large percentage of the eggs could be shipped across the continent alive and in good condition. Previous to the operations of this year it was not known positively that great quantities of salmon eggs could be procured on this coast, nor was it by any means thoroughly established that most of the eggs could make the journey across the continent safely. When this season was over, however, it was known that an immense number of salmon eggs could be obtained on this coast, and also that a great majority of them could be sent alive to the Atlantic.

I will now quote from the report of the United States Fish Commissioner for 1873–74, relative to some of the difficulties encountered and the means employed:

In the season of 1872 I used water for hatching from a spring brook which emptied into the McCloud a short distance above the site of our present camp, and which had its source about a mile to the west of the river. This brook gave us no end of trouble, on account of its unsuitableness to its purpose. Its average flow in the morning was a little over 1,000 gallons an hour, but at night, after a very hot day, it would shrink to 250 gallons. It would also heat up some days to a very dangerous temperature; then, again, the hogs, which here run in the woods in a semi-wild state, would wallow in it and make it so roily that all attempts to filter it clean were fruitless; and last, but not least, there was present in the water all the time a vegetable growth, resembling our eastern *Conferva*, yet somewhat dissimilar to it, that no device of ours could cleanse the water of. It seemed to be ubiquitous, and gave a great deal of trouble.

These combined disadvantages of the water supply of 1872 decided me to abandon it this season and to look elsewhere for water. But here a new difficulty arose. There was no other spring or brook of any magnitude within several miles. To go that distance to locate would either destroy our stage communication or take us away from the river. There was but one alternative left, and that was to take the water supply from the McCloud. To accomplish this, a ditch was commenced about 50

rods above the new hatching-house site and was continued for 200 feet, when it was abandoned, the obstacles in the way of its successful prosecution making it practically useless.

We were now left without any water supply whatever. There were salmon in abundance at our very feet, but no water to hatch the eggs with. In this emergency the idea of raising water from the river itself by a wheel was suggested and immediately put into practice. From this time till it was finished, the wheel was the central object of interest at the camp. So much depended upon it and its successful working, and the project was so novel and unprecedented, that the progress of the work on it was watched with the greatest solicitude, and at last, when it was completed and actually revolved and lifted its 6,000 gallons of water an hour higher than our heads and poured it down the flume into the hatching-troughs, our relief and enthusiasm were unbounded. I celebrated the occasion by raising at sunset a large American flag over the camp.

The next year, 1874, the problems of procuring the salmon eggs and sending them to the Atlantic having been solved, the question on hand was how to obtain as many eggs as the conditions rendered possible. The solution of this question was very nearly reached this year, 5,000,000 eggs being secured.

The principal events of this year at the station were the introduction throughout the whole hatching-house of the deep trays with the Williamson troughs, and the building of a salmon-proof rack entirely across McCloud River, just opposite the station, in order to hold the breeding salmon in the vicinity of the seining-ground by preventing them from going any farther up the river, their instinct, of course, keeping them from going down the river. Both these devices worked admirably.

I will quote from the Commissioner's report for 1872–73:

The deep trays answered their purpose to perfection. The water, entering from the bottom and finding its exit from above the eggs, necessarily permeated all of them continually. It also kept the eggs suspended to a certain degree in the water, so that the underlying tiers were partly relieved of the weight of those above them. At first we placed the eggs in these trays 8 layers deep, but as the season progressed the deep trays worked so well that the layers were increased to 12, and, so far as could be learned, without detriment to the eggs.

I am free to say that this combination of deep wire-netting trays with the Williamson plan of hatching-troughs is the best apparatus for maturing salmon eggs that I have yet seen. It is simple, compact, and effective. By means of it we hatched 18,000 eggs to the superficial foot of hatching-troughs without the least difficulty; so that in one length of our hatching-troughs of 80 feet we matured 1,500,000 salmon eggs.

The rack just mentioned made the best kind of inclosure for the breeding salmon, enabling us to dispense with all the pens and pounds, etc., which caused so much trouble and disappointment the previous year.

The report continues:

When the salmon had made an unsuccessful assault upon the dam, they fell back into the hole at the foot of the rapids, which formed the lower fishing-ground. Here they were practically in as secure confinement as if they had been caught and placed in a pound, for the dam prevented them from going upstream, and their irrepressible instinct to ascend the river prevented them from going down. Every foot of this hole was swept by the seine. No better corral or inclosure for confining the fish could be constructed. Here they had their natural habitat and surroundings, the whole volume of McCloud River for a water-supply, and nothing whatever to prevent them from keeping healthy and in first-rate condition. It was the best possible kind of a pound for them. Last year they lashed themselves to pieces trying to escape from their artificial pens. This year they kept as fresh and well as could be wished. They accumulated in this hole by thousands. When any were wanted, it was only necessary to extend the net around them and haul them in. Once or twice no less than 15,000 pounds of salmon must have been inclosed in the net. They formed a solid mass, reaching several yards from the shore, and filling the net 2 or 3 feet deep. If I should say 20,000 pounds, I do not think it would be exaggerating.

This year the station graduated from its experimental stage, and from this time forward was recognized as a permanent station of the Fish Commission.

The next year, 1875, and the subsequent years previous to 1883, the main features of the work of the station having been settled, operations were conducted on the same lines as in 1874, the chief desiderata now being to increase the efficiency of the station and to reduce the pro rata expense of procuring and distributing the eggs.

The story of the happenings at the station consequently now become less interesting, but a few important events may be worth mentioning.

The prominent feature of the season of 1875 was the abundance of spawning salmon in the McCloud. They were so thick in the river in July that we counted a hundred salmon jumping out of the water in the space of a minute, making 6,000 to be actually seen in the air in an hour. Nearly 9,000,000 eggs were taken, and there were more to be had for the taking. The following statistics may be interesting:

There were in bulk almost 100 bushels of salmon eggs. To mature these eggs 1,200,000,000 foot-pounds of water were pumped from the river by the wheel-pump. It took 160 bushels of moss from Mount Shasta and over 800 yards of mosquito-bar to hatch the eggs. When packed, they filled 158 boxes 2 feet square by 6 inches deep. It took 79 crates, containing 2 boxes each, to hold the eggs. The whole lot of eggs sent east weighed, when packed, 20,000 pounds, and the express charges paid Wells, Fargo & Co. were about $3,000.

It was in this year (December 9, 1875) that 280 acres of land on the McCloud, including the station of the United States Fish Commission, were set aside by President Grant as a government reservation.

The first consignment of salmon eggs was sent across the equator to Australia and New Zealand this year. This was a very trying trip for salmon eggs, which can not survive a temperature of over 70° or 75° F., and which would hatch out in 10 days' journey at 60° F. The journey to Australia, however, was very successful, and, consent having been obtained to place the eggs in the ship's ice room during the voyage from San Francisco to Auckland, the eggs arrived in Australia in fine order.

Some salmon eggs were hatched at the station this year and the young fish planted in tributaries of the Sacramento.

Among the events of 1876 at the station, the building of the hatching-house should be mentioned, because previous to this year the hatching-troughs had all been under a huge tent. This year the tent was dispensed with, and a large and very substantial hatching-house was erected. Much progress had been made also in spawning the salmon and in packing the eggs for shipment, as is shown by the facts that 1,000,000 salmon eggs were taken in a single day, September 4, and that we succeeded in packing, for a long journey, 400,000 eggs in 1½ hours.

As an illustration of the effect upon the salmon-ova market of the operations of the United States Fish Commission in taking salmon eggs, I will mention the striking fact that "five years ago the United States paid the Canadians $40 per 1,000, in gold, for salmon eggs, and now the United States Fish Commission is sending salmon eggs from California to the British Colonies of the Pacific for 50 cents per 1,000, being a reduction of price in the ratio of 80 to 1."[1]

In 1876 the practice was inaugurated of shipping the eggs for eastern consignees all together in a private ice car as far as Chicago, and distributing them from there to their various destinations by express.

[1] United States Fish Commissioner's Report 1875-76, page 943.

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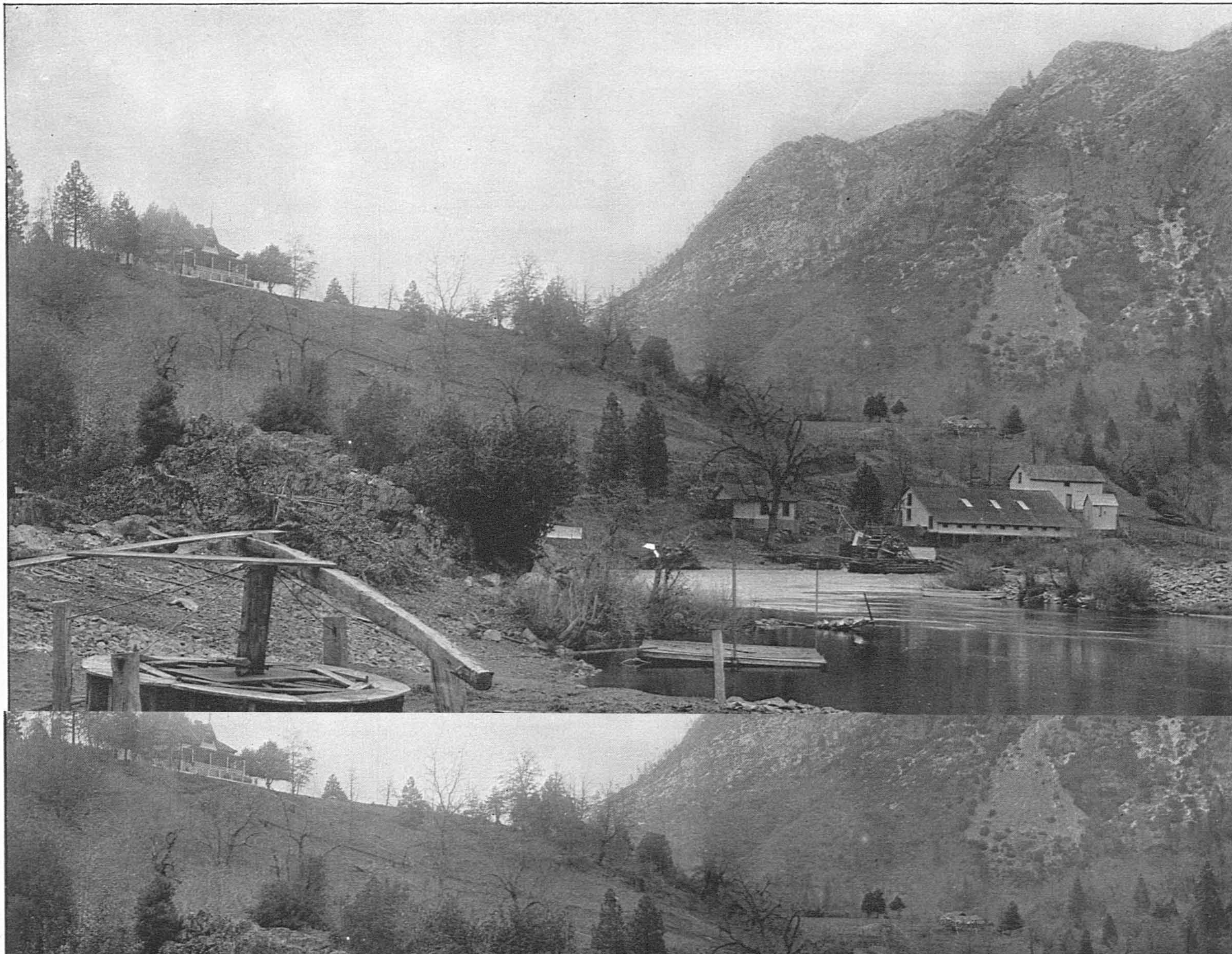

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Prof. Baird, in his report to Congress, speaks as follows in regard to this method:

After careful consideration, Mr. Stone advised that all the eastern shipments of eggs in 1876 should be made in bulk as far as Chicago, and that a special car should be secured and properly fitted up, in which the eggs should be placed and transferred on an express train in the care of proper messengers. This experiment was carried out and proved an entire success, 18 consignees in 13 States receiving their supplies in even better condition than usual and at less expense.

The foreign demand for ova had increased to such an extent by 1877 that during that year salmon eggs were sent from the McCloud to Prussia, Germany, the Netherlands, England, France, Canada, Australia, and New Zealand. The experience acquired in packing and shipping the eggs enabled us this year to get them to their destinations with very slight loss in transit.

The *Lyttleton Times*, Christ Church, New Zealand, of November 14, 1877, says:

The *splendid condition* in which the Wellington consignment of American salmon ova has arrived reflects great credit on those in America who had charge of the collecting and packing, which in several respects is an improvement on the English method.

The War Department furnished the station a military guard this year, which proved to be a very valuable acquisition.

The hatching of a large portion of the salmon eggs for the State of California continued during this year and subsequent years until 1884. The year 1878 was the year of the immense gathering of salmon in the McCloud. Regarding this extraordinary appearance, my report for 1878 reads:

I have never seen anything like it anywhere, not even on the tributaries of the Columbia. On the afternoon of the 15th of August there was a space in the river below the rack about 50 feet wide and 80 feet long, where, if a person could have balanced himself, he could actually have walked anywhere on the backs of the salmon, they were so thick. I have often heard travelers make this remark about salmon in small streams, so I know that it is not an uncommon thing in streams below a certain size, but to see salmon so thick as this in a river of so great volume as the McCloud must, I think, be a rare sight. About this time I kept a patrol on the bridge every moment, night and day, and this precaution, though an expensive one, was well rewarded, for this vast number of salmon continually striking the bridge with sledge-hammer blows were sure, in the course of time, to displace something and effect a passage through to the upper side, and when one did succeed in getting through, the others would follow with surprising rapidity, one after another, like a flock of sheep going through a break in a fence. This swarm of salmon just alluded to remained at the bridge and kept up the attack at one point or another for three days, and then fell back to the pools below, where, with occasional renewals of their attacks, they remained until they were caught in the seine.

The spawning season began the 20th of August, with the taking of 30,000 eggs from 7 fish. Every haul of the net brought an enormous quantity of salmon. Without our trying to capture many, the net would frequently bring in a thousand at a haul. We found very few ripe fish, however, until the 28th of August, when the spawning season set in in good earnest, and from this date to the last day of taking eggs the yield was very large and remarkably regular.

This leads me to say that the most extraordinary feature about the fishing season this year was that the salmon in the river did not seem to be diminished by our constant seining. We made enormous hauls with the net every day, spawned a large number of salmon, and gave a large number to the Indians for their winter supply, but always the next day the spawning salmon seemed to be as thick as ever. This abundance of salmon was a daily surprise to everyone. Every day we were regularly, though agreeably, disappointed. It was three weeks before we made any impression on the spawners in the river. At last, about the 15th of September, the females with spawn began to fall off a little, but only a little. We had enough eggs by this time, however, and stopped fishing on the 18th of September, not because of any scarcity of salmon, but because we did not want any more eggs. We had in the hatching-house, on the evening of that day, 12,246,000 salmon eggs, according to our record count, though without doubt 14,000,000 in reality, as our method of counting purposely left a large outside margin for emergencies. Had we continued to fish and take eggs till the close of the fishing season we could probably have taken 18,000,000 eggs, and perhaps more.

One of the ways employed for increasing the catch of breeders is so peculiar that perhaps a description of it may not be out of place here:

As may be readily supposed, the constant drawing of the net over the seining-hole had the effect of frightening the salmon off the ground. Of course it was necessary to get them back again before they spawned, as otherwise we should have lost the eggs. This year I accomplished it in this way: I had several Indians go up to the bridge armed with long poles. At a given signal three Indians jumped into the foaming rapids below the bridge, and by splashing the water with their arms and limbs and making as much of a disturbance in the water as possible, did everything they could to frighten the salmon out of the rapids. On reaching the deep holes, where the fish lay collected by hundreds and perhaps thousands, the Indians dove down in the very midst of the swarms of salmon, and, stirring them up with their long poles, succeeded in driving them out.

On these occasions the hauling of the seine was quite an exciting event. The Indian swimmers, their dark heads just showing above the white foam, screaming and shouting in the icy waters and brandishing their long poles, came down the rapids at great speed, disappearing entirely now and then as they dove down into a deep hole. As soon as they approached within about 4 rods of the fishing skiff, the boat shot out from the shore, the second boatman braced himself and his oars for a quick pull down along the bank, the man at the stern of the first boat began paying out the seine, the fishermen on the beach gathered at their respective ropes, the men on shore began throwing rocks in the rapids, and in a few moments the net was drawn to the beach with an enormous mass of struggling, writhing salmon, often weighing in the aggregate not less than 4 or 5 tons. Then the fishermen sprang into the water and examined the fish, taking the ripe ones to the corral and throwing the unripe ones back into the river until the net was emptied. Then all was quiet again and the men proceeded to take the eggs from the ripe salmon which they had captured.

This year, in packing eggs, we averaged 500,000 an hour:

Had not the character of the packing, as shown by the way in which the boxes were finally opened, been made the subject of unusual commendation from the parties who were engaged in unpacking the eggs at their destination, I should hardly venture to say how rapidly they were packed, lest it might be thought to imply undue haste or want of care. I will, however, under the circumstances, state that the eggs were actually packed at the rate of 500,000 an hour, and I will add my own testimony also, that I never saw eggs packed with more care, fidelity, and pains, the rapidity with which the work was dispatched being wholly the result of experience and skill and the enthusiasm with which everyone employed did the part of the work which fell to his share.—(United States Fish Commissioner's Report, 1878, page 762.)

We had an Indian scare this year and the War Department sent us rifles and ammunition. It was extremely unpleasant for a few weeks at the station, but it resulted in no actual injury. It will be remembered, perhaps, that during the previous year a gigantic plan had been arranged for the universal uprising of all the Indian tribes between the Missouri on the east and the Cascade Range and the Sierra Nevadas on the west. This came very near being successful, and if it had not been broken up, as it was, by the vigilance and activity of the United States troops it would have resulted in widespread calamity in the sparsely settled regions of the West. Fortunately, General Howard gave it a deathblow in the capture of Chief Joseph and his band near the Missouri, but the infection spread as far west as McCloud River, and for a few weeks rendered life there anything but agreeable.

In 1879 the experiment was tried of putting two sacks across the McCloud, one above the seining-ground, wholly closed to the salmon, of course, and one below the seining-ground, partly open at the bottom. It was thought in this way that more breeding salmon would remain on the seining-ground, but it was not a success and the results did not warrant a renewal of the experiment. We had a military guard at the station this year, and the presence of soldiers was found very useful, but they were not needed this season for protection from the Indians, who had become quiet again

and had almost dropped entirely their hostile demonstrations of the previous year. No trouble will ever be experienced here again from the Indians as a body. The gradual disappearance of the natives has contributed to this result, and railroads and white settlements have done the rest.

It was during this year that the McCloud River trout-breeding station was established in connection with the salmon station at Baird, from which station have emanated almost all the rainbow trout (*S. irideus*) which have now become so generally distributed over this country and Europe. The other trout of the McCloud River are the Dolly Varden (*Salvelinus malma*) and a new species, the no-shee, first described by Dr. Jordan as follows:

Description of the no-shee trout (Salmo gairdneri stonei), a new subspecies of trout from McCloud River.

Salmo gairdneri stonei subsp. nov.

Allied to the form called *Salmo irideus*, but distinguished by its small scales, the number of scales in a transverse series being about 155, 82 before dorsal, where they are small and imbedded, 25 above lateral line. Teeth fewer and smaller than in var. *irideus*, those on the vomer in a single zigzag series. Axillary scale of ventral small. Pectoral $1\frac{1}{3}$ in head. Eye large, $4\frac{1}{2}$ in head. Maxillary two-tenths. Upper part plain greenish. Spots small and sparse on dorsal, adipose fin, and caudal; a few spots only on posterior part of the body. A faint red lateral band; cheeks and opercles with red; no red between branches of lower jaw. Depth 4 in length. Anal rays 11. Described from a specimen 14 inches in length, collected by Livingston Stone, in McCloud River, at Baird, Cal.

This form is well known to the Indians and to the fishermen on the Upper Sacramento. According to Mr. Stone, the Indian fishermen say that it is abundant in the McCloud River, about 8 miles above Baird. They are larger in size than the ordinary *irideus*, one having been taken weighing 12 pounds. Named for Livingston Stone, director of the United States fish-hatchery at Baird.

Nothing of special interest occurred in 1880, but the next year, 1881, was made memorable by the extraordinary rise in McCloud River, which carried away almost the entire station in one night:

The month of January was attended by a rainfall wholly unprecedented[1] in northern California since its settlement by white men. Forty-seven inches of water fell in Shasta during this month, and in the mountains where the fishery is situated the fall must have been much greater. On the 27th of January the McCloud had risen $12\frac{1}{2}$ feet, but the water had been higher than that in previous years, and still no one supposed that the buildings were in danger. Again the river fell, but this time the fall was succeeded by the greatest rise of water ever known in this river before, either by white men or Indians now living. During the first days of February the rain poured down in torrents. It is said by those who saw it that it did not fall as rain usually falls, but it fell as if thousands of tons of water were dropped in a body from the sky at once. Mr. J. B. Campbell relates that near his house, in a canyon which is dry in summer, the water in not many minutes became 30 feet deep, and the violence of the current was so great that trees 100 feet long were swept down, trunk, branches, and all, into the river. On the 2d of February McCloud River began to rise at the rate of a foot an hour. By 9 o'clock in the evening it was $16\frac{3}{4}$ feet above its ordinary level. The water was soon a foot above the danger mark, and the buildings began to rock and totter as if nearly ready to fall. There was now no hope of saving them or anything in them. At 2.30 a. m. February 3 they toppled over with a great crash, and were seized by the resistless current and hurried down the river.

When the day dawned nothing was to be seen of the main structures which composed the United States salmon-breeding station on the McCloud River. The mess-house, where the workmen had eaten and slept for nine successive seasons, and which contained the original cabin, 12 by 14 feet, where the pioneers of the United States Fish Commission on this coast lived during the first season of 1872; the hatching-house, which, with the tents which had preceded it, had turned out 70,000,000 salmon eggs, the distribution of which had reached from New Zealand to St. Petersburg; the large dwelling-house,

[1] Rainfall at Shasta: January, 1881, 47 inches; February, 1881, 17.5 inches; total for the season, 109.7 inches.

to which improvements and conveniences had been added each year for five years—these were all gone, every vestige of them, and nothing was to be seen in the direction where they stood except the wreck of the faithful wheel which through summer's sun and winter's rain had poured 100,000,000 gallons of water over the salmon eggs in the hatchery, and which now lay dismantled and ruined upon the flatboats which had supported it, and which were kept from escaping by two wire cables made fast to the river bank. The river continued to rise the next forenoon until it reached a maximum height of 26⅞ feet above its summer level. This, of course, is not a very extraordinary rise for a slow river; but when it is remembered that the McCloud is at low water a succession of cascades and rapids, having an average fall of 40 feet to the mile, it will be seen at once what a vast volume of water must have been poured into this rapid river in a very short time, and with what velocity it must have come, to have raised the river 26 feet when its natural fall was sweeping it out of the canyon so swiftly. Those who saw this mighty volume of water at its highest point, rushing through its mountain canyon with such speed, say that it was appalling, while the roar of the torrent was so deafening that persons standing side by side on the bank could not hear each other when talking in an ordinary tone of voice.

It must be over two centuries since McCloud River rose, if ever, as high as it did last winter. There is very good evidence of this on the very spot where the fishery was located, for just behind the mess house, and exactly under where the fishery flag floats with a good south breeze, is an Indian graveyard, where the venerable chiefs of the McCloud have been taken for burial for at least two hundred years, and there is no knowing how much longer. One-third of this graveyard was swept away by the high water last winter, and the ground below was strewn with dead men's bones. Now, the fact that the Indians have been in the habit of burying their dead in this spot for two centuries proves that the river has never risen to the height of last winter's rise within that time, for nothing could induce the Indians to bury their fathers where they thought there was the least danger of the sacred bones being disturbed by the floods.

When the waters subsided it became apparent what a clean sweep the river had made. Here and there the stumps of a few posts, broken off and worn down nearly to the ground by driftwood rubbing over them, formed the only vestiges whatever to indicate that anything had ever existed there where the station stood but the clean rocky bar that the falling water had left.

The writer, at the direction of Professor Baird, proceeded immediately to rebuild the station, under a special appropriation made by Congress for that purpose. The entire cost of the new station, including the expense of taking the season's salmon eggs (7,500,000), was $15,000.

The only accident that ever occurred to the current wheel during the egg-taking season happened this year, but it was properly repaired, and owing to the really magnificent help of the Indians, who worked incessantly for seventeen hours, no losses occurred to the eggs. The breeding salmon appeared in the river in great numbers, making it necessary to take eggs during only about half the season.

Nothing of special interest happened in 1882, but in 1883 great dismay was caused by the nonappearance of the salmon in the upper tributaries of the Sacramento. The Southern Pacific Railroad Company had begun building its line from Redding north toward Oregon, and during the summer had reached the mouth of Pitt River, about 8 miles below Baird station. It is said to be the custom of this company to employ a great deal of gunpowder and dynamite for making excavations, and they had used these explosives to such an extent at and below the mouth of Pitt River that the breeding salmon coming up the river to spawn either could not get by where the blasting was going on or were killed outright by it. At all events, salmon were very scarce in the McCloud, and less than a million eggs were secured this season, and these only with great difficulty.

Owing to the destruction of the salmon by the railroad workers,[1] Professor Baird

[1] We were told that there were 6,000 workmen, white men and Chinamen, employed in the vicinity of Pitt River in building the road.

discontinued operations at the salmon-breeding station on McCloud River in 1884, and they were not renewed till 1888, when the writer was made field superintendent of the Pacific Coast, and instructed by Hon. Marshall McDonald, then United States Commissioner of Fish and Fisheries, to push vigorously the salmon-breeding work on this coast. The writer reopened Baird station in the spring of 1888, and leaving Mr. George B. Williams, jr., in charge as temporary superintendent, proceeded to Oregon to carry out the instructions of the Commissioner to secure for the United States the salmon-breeding station on Clackamas River, Oregon. This station, which the writer built for the Oregon and Washington Fish Propagating Company (cannery owners on the Columbia) in 1877, was still owned by them, but had been leased to the State of Oregon. The company at first wanted $10,000 for the station, but after several weeks of consulting and negotiating they consented to deed the place to the United States for nothing, and the Oregon commissioners gave up their lease on the reimbursement to them by the United States of the actual cost of improvements they had just made. The transfer was practically made July 1, 1888, on which day the splendid salmon-breeding plant on Clackamas River became a station of the United States Fish Commission.

Upon the writer's recommendation Mr. Williams was confirmed as permanent superintendent of Baird station, and held that position from 1888 to July, 1892. During this time an average of 3,000,000 salmon eggs was taken annually and various improvements made to the station, including the construction of a "winter-quarters building," which has always been used since for the superintendent's residence.

In August, 1892, on the resignation of Mr. Williams, the writer resumed charge of Baird station. Not much was accomplished that year, but the next year, 1893, nearly 8,000,000 eggs were taken. The next year, 1894, owing to very unexpected high water in October the number of salmon eggs collected dropped to about 4,500,000, but the next year, 1895, the number rose again to nearly 10,000,000, breaking the record of this station for every previous year except the extraordinary season of 1878, above mentioned.

Of these last few years, the work having fallen into specified grooves, there is very little to relate, one season being very much like another. One thing, however, which promises to be very useful to the station in the future, as well as a saving of expense, deserves mention, and that is the construction of a ditch for bringing the water supply by gravity to the hatching-house during the fall run of salmon.

It is dangerous to use the current wheel in the fall, and it is expensive to run the engine. The ditch does away with both, and as it requires no watching in good weather it saves the expense of a night watchman. The ditch takes the water from Wiley Creek at a point about 1¼ miles from the hatching-house, and up to this time has worked admirably, which is all the more encouraging because an irrigating ditch grows safer and more reliable every year it is used.

It should be mentioned here that, while at first, from 1872–1883, inclusive, Baird station was operated chiefly for other waters of the United States, now it is almost wholly operated for the benefit of the Pacific Coast, as the distribution this year, 1895–96, will show.

Perhaps this account of Baird station ought not to be concluded without a brief reference to a station of the California State Fish Commission, which may possibly pass very soon into the charge of the United States. This station is situated on a

small tributary of the Sacramento called Battle Creek, and is about 7 miles from the town of Anderson, in Shasta County, though it is itself just over the Tehama County line. This Battle Creek is the most extraordinary and prolific place for collecting quinnat-salmon eggs yet known, though the eggs are limited to the fall run of salmon, as none worth mentioning of the summer run of fish ascend Battle Creek. The first salmon make their appearance early in the fall, and before November and during that month they are found in almost incredible numbers in the wide lagoon extending about 2½ miles up the creek from its mouth. I am well aware that fish-culturists' predictions are generally overdrawn and consequently disappointing in the end, but it seems to me safe to say that 20,000,000 salmon eggs can be taken on Battle Creek in six weeks of a favorable year; 10,000,000 eggs were actually taken there in three weeks last year, and the California Fish Commission only stopped then because their hatching-house was filled. Battle Creek will not produce eggs of the summer-run salmon, but it will yield an almost unlimited number of fall-run eggs, until unfavorable conditions prevent the breeding salmon from ascending the stream.

To return to the Clackamas station, in Oregon, I will say that unfavorable conditions have already set in there and seriously interfered with the operations of the station. When it first passed into the hands of the United States Fish Commission it yielded 5,000,000 salmon eggs a year, but it was too near civilization to prosper long as a salmon-breeding station, and gradually mills and dams, timber cutting on the upper waters of the Clackamas, and logging in the river, together with other adverse influences, so crippled its efficiency that it was given up this year as a collecting-point for salmon eggs, but several million eggs have been sent there from Baird station and Battle Creek, so that a very respectable number of salmon eggs will doubtless be hatched for the benefit of Columbia River this season.

I may add here that several attempts have been made to discover and establish salmon-breeding points in the basin of the Columbia, but none has been found sufficiently productive to warrant their continuance. Some effort also has been made to secure quinnat-salmon eggs from the smaller California streams flowing into the Pacific Ocean, but no great success has been attained there yet, although many quinnat and steelhead eggs have been secured and favorable results obtained, notably at Fort Gaston station and its branches, in acclimatizing several species of the *Salmonidæ* not indigenous to this coast.

The question now naturally arises, What are the results of all this great labor and expenditure extended over so many years? Allow me to reply as follows:

When the work of the United States Fish Commission in salmon breeding was begun on the Pacific Coast, it was supposed that that coast had enough salmon to spare, and it was the intention of the Commission to increase the salmon on the Atlantic Coast by restocking its depleted salmon rivers. The highest hopes were entertained of doing this. After it had become an accomplished fact that millions of salmon eggs had been procured on this coast, and that they had been safely transported across the continent to the Atlantic rivers, I doubt if there was one person who had heard about it in America, whether interested in fish-culture or not, who did not believe that salmon were going to become abundant again in the Atlantic rivers on account of the introduction of the Pacific Coast fish; and not only this, but many persons believed that several southern rivers that had never had salmon in them before, would now become prolific salmon streams, when they were well stocked with

this new California salmon that abounded in warm latitudes on the Pacific Coast. That this did not prove to be the result was a stupendous surprise and disappointment. The eggs hatched out beautifully. The young fry, when deposited in the fresh-water streams seemed to thrive equally well. They grew rapidly and when the proper time came were observed to go down in vast numbers to the sea. What afterwards became of them will probably remain forever an unfathomable mystery. Except in very rare isolated instances, these millions of young salmon were never seen again. What became of them? Where did they go? Are any of them still alive anywhere in the boundless ocean? Or are they all dead? And if they are dead, what killed them? Much as this information has been desired, there lives no one who can answer these questions. Some have thought that they wandered off to the far North, and so became lost to the civilized world. Others thought that they strayed out into the ocean and were devoured by marine animals and larger fish. Professor Baird once jokingly remarked to the writer that he thought they had found an underground passage beneath the continent, and had returned by it to the Pacific. One thing is certain, and that is that these millions of salmon have disappeared as completely from the Atlantic Ocean[1] and its tributaries as if they had all been devoured years ago by the monsters of the deep.

Referring to this unaccountable and disheartening fact, Hon. Marshall McDonald, United States Fish Commissioner, said, in his report for 1888—

> These[2] experiments [stocking Atlantic rivers with California salmon] were undertaken on a scale unprecedented in the history of fish-culture. Millions of eggs were transferred to the eastern stations, hatched out, and the fry planted in nearly every one of the larger rivers south of the Hudson. In no single case did the experiment prove satisfactory, and the Commissioner was forced reluctantly to abandon an experiment which, reasoning from *a priori* considerations, gave fair promises of success, and which, had it succeeded, would have given us a new and valuable fishery in the Atlantic rivers.

This, however, is only one side of the case. As soon as the requisite space of time had elapsed after the United States Fish Commission began to return young salmon fry to the Sacramento, the fishes of that river showed a great increase. New canneries sprang up every succeeding year. The market for fresh and salted salmon in San Francisco felt the effects of the salmon-breeding work on the McCloud.

The following interesting statement appears in the United States Fish Commissioner's Report for 1882, page 840:

> One of the last official acts of the late Hon. B. B. Redding, as California fish commissioner, before he died, was to write a letter to Professor Baird in regard to this station, in which he stated that several hundred thousand dollars had been invested in canneries on the Sacramento River, and that this capital and these men would be ultimately thrown out of employment if the salmon hatching at this station should be given up. He also stated that the hatching of salmon here had increased the annual salmon catch on the Sacramento 5,000,000 pounds a year, and that the canneries on the river were dependent upon the salmon hatching of this station for their maintenance.

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[1] *Per contra* of the above: I have been recently informed that eggs are now being taken in France from quinnat-salmon breeders that were raised from eggs originally sent from Baird station. The *Pittsburg Dispatch*, January 13, 1896, makes the following statement:

"*California salmon in France.*—French newspapers a few weeks ago contained the announcement that a magnificent California salmon (*S. quinnat*), measuring 3½ feet in length, had just been taken in a pond in Landernau, Brittany, having been bred by the mayor of that town from spawn procured from the Trocadero aquarium. The flesh is described as most delicious; its color is not mentioned. This was followed by the capture of several smaller specimens. It has also been stated that a fish of the same species, weighing over 12 pounds, was caught last April at the city of Montereau. The editor rejoices that this matchless breed of salmon has now been acclimated and probably will soon abound in France."

[2] United States Fish Commissioner's Report, page XXXV, for 1888.

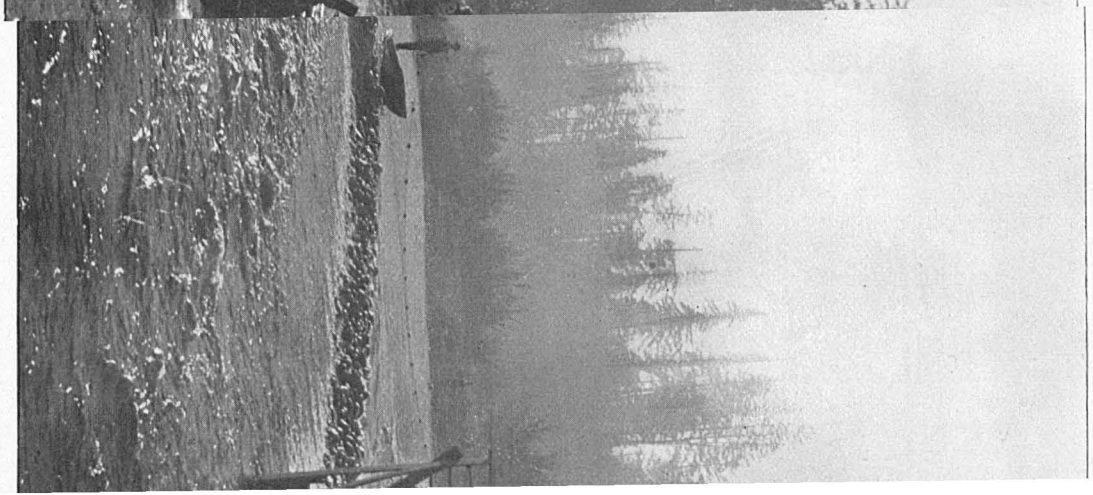
It thus appears that although nature has evidently designed that the quinnat-salmon shall not take up its abode on the American shores of the Atlantic, the breeding of this fish seems to serve a legitimate and very valuable purpose in keeping up the supply of its species in its native waters of the Pacific Slope; especially in view of the enormous drafts made upon these fish by the canneries and by the yearly increasing consumption of fresh and salted salmon.

The prospect for the immediate future at Baird station is very promising. To begin with, it has a valuable and very efficient plant in the way of buildings, apparatus, etc. At the upper or northern end of the station there is a large fenced corral or pasture for horses and cattle, and inclosed in this corral is a convenient stable and storehouse. Just below there is the hatching-house, with a capacity of 10,000,000 or 12,000,000 salmon eggs. Then comes the engine house, with a good steam engine and pump. A few rods below are the foreman's residence and the comfortable and commodious mess house, and nearly adjoining a store and post-office and the residence of the postmaster. Other smaller structures near the seining-ground complete the list of buildings at the station, with the exception of the superintendent's residence on a hill 100 feet above, which overlooks all or nearly all the other buildings; and last, but not least, a ditch 1½ miles long brings water from a neighboring creek into the hatching-house. The station has still, as it always had, the hearty good-will and cooperation of the California State Fish Commission, which alone is a most valuable aid to its efficiency.

Salmon are now very abundant in the Sacramento and McCloud, and are on the increase. The situation of the station and its adaptability to its purpose are almost ideal. McCloud River, on the banks of which it stands, is not only cold, clear, and very inviting to the salmon, but it is almost the only cold tributary of the Sacramento that has not been roiled by gold mining, in consequence of which the salmon come into the McCloud to breed in the summer, not only from choice, but also from necessity. The geological formation of the land about the river is not favorable for gold, which probably insures its safety indefinitely from gold miners.

It is also an Indian country. There is not a white family on the McCloud from its mouth almost to Mount Shasta, except those who live at the station and at the old trout-pond station of the Fish Commission. Furthermore, most of the land in the McCloud Canyon is unproductive, which is another protection against the advent of white men, and as long as white men keep away from the river the salmon in it will retain their primeval habits and abundance. The station also is situated in a United States reservation, which secures it from intrusion by land-jumpers or evil-minded people who might interfere with the salmon and salmon fishing. And, what I must not forget to add, it is located just at the junction of McCloud River and the California and Oregon stage road, which places the station, though in one of the wildest parts of California, in immediate touch with the civilized world. All these advantages make this station an ideal place for its purpose, and bespeak for it, for many years to come, an efficient and useful career. And it can be further said of this station, with justifiable pride, that after a quarter of a century's service it still remains the only station in the United States that can produce every year a satisfactory quota of eggs of the summer run of quinnat salmon.

DRIVING SALMON INTO THE TRAP, CLACKAMAS STATION, OREGON.



DRIVING SALMON INTO THE TRA

METHODS EMPLOYED BY THE UNITED STATES FISH COMMISSION ON THE PACIFIC COAST FOR CAPTURING BREEDING SALMON, TAKING AND SHIPPING THE EGGS, ETC., WITH SPECIAL REFERENCE TO BAIRD STATION, CALIFORNIA.

CAPTURING THE BREEDING SALMON.

The first Pacific Coast salmon captured in the United States for breeding purposes were caught in an Indian "basket trap," on McCloud River, in 1872. The reason that they were taken in this way was because there had been no time for making preparations for catching the salmon in any other way, the writer, who had been commissioned by Professor Baird, United States Commissioner of Fish and Fisheries, to procure eggs of these salmon, having arrived on the McCloud just in the midst of the spawning season. Professor Baird's report for that year reads as follows:

> The propriety was strongly urged at the Boston meeting of sending some experienced fish-culturist to the west coast for the purpose of securing a large amount of spawn of the California salmon. At the suggestion of the meeting, Mr. Livingston Stone was engaged to undertake this work, and proceeded to California as soon as he could arrange his affairs for the purpose. The experiment was, of course, uncertain, in the entire absence of any reliable information bearing upon the natural history of the species. It was not even known at what period they spawned, although Mr. Stone was assured by professed experts, on his arrival in California, that this occurs late in the month of September.
>
> After much fruitless inquiry, Mr. Stone at last learned, chiefly through Mr. B. B. Redding, fish commissioner of California, and through the chief engineer of the Central Pacific Railroad, that the Indians speared salmon on McCloud River, a stream of the Sierra Nevada, emptying into Pitt River 320 miles nearly due north of San Francisco. Proceeding to this station, in company with Mr. John G. Woodbury, of the Acclimatization Society, Mr. Stone immediately set to work in erecting the necessary hatching establishment, although, on account of the distance from any settlement and the absence of special facilities, he found the undertaking both difficult and expensive. The efforts of Mr. Stone and his party were prosecuted unintermittingly, day and night, for a sufficient length of time to prove that the season had almost entirely passed and that but few spawning fish remained.

The basket trap above mentioned consists of a partial obstruction across the river, made of wickerwork, in form having a general resemblance to the letter V, with the angle downstream. At the apex of the angle is a wicker basket, from which, if the fish fall into it, they can not escape. It should be mentioned here that after the breeding salmon ascend the river to spawn, they fall back after spawning, and gradually float, tail first, down the river, though occasionally they fall back in this way before spawning. These traps are put across the river by the Indians in order to capture the salmon, without, of course, any regard to the eggs they may contain. Fortunately, after the arrival of the writer on the McCloud, a few salmon that had not spawned fell into these traps, and for a slight money consideration given to the Indians the fish were obtained and their eggs secured for maturing.

As soon as circumstances rendered it practicable, a seine was procured and seining was begun in regular form in McCloud River; and from that time till now this method of seining with a sweep seine has been the best and the only successful method of capturing the parent salmon in the McCloud. Several experiments, however, have been tried, which may be worth mentioning, perhaps, simply to show that they are not satisfactory.

One of these experiments was made at Baird station by using fyke nets, set in McCloud River. In a small stream without too strong a current this method might be employed advantageously, but in the rapid current of the McCloud, which, though not a wide stream, carries a large volume of water, the fyke-net experiment proved a complete failure.

One or more large wooden traps have almost every year been built into the rack which extends across the river, and at times, especially during a rain storm accompanied by a marked rise in the river, large numbers of salmon are taken, but at other times only a few, and at all times only a small percentage of spawners are captured in the trap. The trap is quite a valuable auxiliary to the seine, but it would be a poor dependence if relied upon exclusively, because, although it will secure a great many unripe fish, the ripe ones, which are the ones that are wanted, finding an obstruction in their way, settle back to the spawning-grounds below and remain there.

Large dip nets have been occasionally used at the Clackamas station, in Oregon, the fishermen standing on the rack at night and dipping below it. Toward the end of the season this method secures a considerable number of spawners, but it involves labor and expense, and after all it is an open question whether most of the spawners taken with the dip nets would not have been captured in the regular course of fishing

The following plan deserves a brief description, as it is, I think, unique among methods employed by fish-culturists for capturing salmon:

There not being any entirely satisfactory seining-grounds at the Clackamas station, and the river just below the rack being shallow, we resorted to the Indian method of fishing. The aversion of the salmon to heading downstream is well known, but when they are very much frightened (stampeded) they will turn around and rush downstream at their utmost speed. The Indians take advantage of this and build a dam of rock or wickerwork, or anything that will present an obstruction to the frightened fish. This dam is shaped like the letter V, with the angle downstream, and at the angle, of course, is a large trap, which they can easily enter but can not escape from. This method of capturing the breeding salmon was the principal one employed at the Clackamas, and it worked very satisfactorily.

At Baird station, before it became customary to put a rack every year across the river, the seine fishing was exclusively done after dark, and was usually kept up all night. Since the rack has been used the seine has been hauled more or less in the daytime, with perfectly satisfactory results. We generally begin fishing now about 4.30 a. m., and keep it up as long as the fishing warrants it. We begin again about 5 o'clock in the afternoon and continue as we do in the morning.

The seines used at Baird station are from 120 to 170 feet long, made of about 28-thread twine, with a 4-inch mesh and a 20-foot bag, tapering down to about 6 feet at the ends. The seines have to be double-leaded, on account of the powerful current of the McCloud.

METHODS OF SPAWNING THE SALMON.

All methods of spawning salmon are in general the same, as of course they must necessarily be. There are, however, some slight differences in details, chiefly in holding the parent fish and in the manner of impregnating the eggs.

Where there is plenty of help and the salmon of medium size, the most expeditious way of holding the fish seems to be for the man who spawns the female salmon to hold

the head of the salmon in one hand and to press the spawn out with the other, another person being employed meantime in holding the tail of the fish to keep it still. This is the method uniformly adopted at Baird station. On the Columbia, however, where the salmon are larger and more unmanageable, the "straight-jacket," as it is called, is used. This is a sort of trough, made the average length of the salmon and hollowed out to fit in general the shape of the fish. Across the lower end of the trough is a permanent cleat, and at the upper end a strap with a buckle. The fish, when manipulated, is slid into the trough, the tail going down below the cleat, where it is securely held, and the head being immediately buckled in at the upper end with the strap. The fish is now securely held, and is unable either to get away or do any damage by its flounderings, and the eggs can be pressed out at leisure. The straight-jacket is almost indispensable with very large salmon, and a great convenience when the operators are short-handed. This is the method that has been generally employed at Clackamas station.

There is one more method of holding the fish that ought to be mentioned, which can be adopted with medium-sized salmon, and which might be called the one-man method. By this method, the operator holds the head of the salmon tightly between his knees, and, keeping the tail of the fish still with one hand, he presses out the ova with the other. This is a good way where there are only one or two men to attend to the spawning.

IMPREGNATING THE EGGS.

As in holding the spawning salmon, so in impregnating the eggs, all methods employed by enlightened fish-culturists are, in their general features, the same, the main points to be secured in all cases being identical, viz, to keep the eggs perfectly dry till the milt is applied, and to use the utmost dispatch in causing the spermatozoa of the milt to mingle with the eggs after the eggs are expressed from the fish.

The eggs, when they first leave the fish, have such an active absorbing power that they will very rapidly absorb any liquid that they come in contact with, and if taken in water will absorb the water so quickly that most of them become filled with water before the spermatozoa reach them, or rather before they reach the micropyle. But while it is a singular fact that the spermatozoa of the milt will die in water in two to three minutes, a little water is necessary to stimulate them into efficient activity. Consequently, while the eggs should be taken perfectly dry, a little water should be added to the milt, but the instant this is done the slightly diluted milt should be poured on the eggs. If the eggs are taken in one pan and the milt in another, simultaneously, and mixed together the instant they are ready, a very high rate of impregnation may be secured.

In actual practice at this station, one pan only has been generally used, and a very good impregnation has been secured in that way, but with only one pan the manipulations must be made quickly, and the rule must be observed to take the eggs dry and to introduce the diluted milt almost simultaneously with the taking of the eggs.

To obtain a high rate of impregnation, these points must be secured:

(1) The eggs must be taken dry.

(2) The milt must be taken simultaneously with the eggs.

(3) The milt must be diluted with a little water.

(4) The eggs and milt mixed together instantly after the diluting of the milt.

After the eggs have been impregnated, it is the custom to pour more water in the pan in a few minutes, and then leave the eggs perfectly quiet until they separate, which in the water of McCloud River in September (52° to 53° F.) usually takes about an hour. It should be added that the pans of impregnated eggs are placed in a trough filled with river water to keep them from becoming too warm. After the eggs separate they are carefully washed from all particles of effete milt, and then carried in buckets to the hatching-house. Here they are measured and placed in the hatching-trays.

HATCHING THE EGGS.

At Baird station the Williamson troughs with deep trays have been used for hatching the eggs. This plan has been found to be, in the writer's judgment, the best thing yet devised for maturing salmon eggs on a large scale. The trays used are really wire-netting baskets, about 12 inches wide by 24 inches long, and deep enough to bring the top of the trays an inch or two above the water, which is 5 or 6 inches deep in the Williamson troughs in which they were placed. Into these trays we pour 2 gallons of salmon eggs at a time. This makes the eggs 12 or 15 tiers deep, and yet they suffer no injury whatever from being so piled up, one explanation of this being that the water all the time forcing its way up through the eggs loosens them so that they do not feel the weight of those above them, while at the same time it reaches every egg and furnishes a fresh supply of air to them all.

The advantages of this method are:

(1) The top of the tray or basket is out of the water and always entirely dry; consequently in handling them the hands are always dry.

(2) By tilting one end of the tray or basket up and down a little, or by lifting the whole basket and settling it gently back again in its place, the white eggs will be forced to the top. Consequently no feather is required in picking over the eggs, and thus the injuries very often inflicted with the feather are obviated.

(3) The top of the basket being above the water, the eggs can never run over the top nor escape in any way, which is a great advantage over the shallow trays.

(4) The whole thing is so simple that nothing simpler that answers the purpose can be conceived. There is no complication of parts. There is nothing, in fact, to look after or move but the basket itself.

(5) Finally, it economizes space. Fifty thousand eggs can be kept on a superficial area of 2 square feet. Two troughs 20 feet long and 1 foot wide will, by this method, carry 1,000,000 salmon eggs.

The space in this trough, as in other hatching-troughs, is divided into compartments a trifle longer than the trays that are used to contain the eggs. The peculiar feature of the trough is that at the lower end of each compartment a cleat or partition, extending entirely across the trough, reaches from the bottom almost to the top, and another similar partition at the upper end of the compartment reaches from the top almost to the bottom of the trough. The water is consequently forced to flow under the upper partition and over the lower partition, and in order to do this it must necessarily ascend through the trays of eggs.

Two results are secured by this method:

(1) The trays may be made several inches deep and may be filled at least half full of eggs.

(2) A good but gentle circulation is continually maintained through the eggs.

An unusual advantage is gained in consequence, viz, ten times as many eggs can be hatched in the same space and with the same supply of water as by the old methods.

My report for 1874–75 speaks as follows of these hatching-troughs:

Too much can not be said in praise of these hatching-trays. With them it is only necessary, in picking out the white eggs, to raise the tray a little ways out of the water and gently immerse it again. The upward pressure of the water throws the dead eggs to the surface, where they can be picked out without even the touch of a feather. With these trays the hands are never wet, the trays are never changed from their places, the eggs never flow over the top, and the feather becomes unnecessary. In addition to these advantages, all sediment accumulating about the eggs can be easily run off by gently moving the tray up and down a few times in the water.—(United States Fish Commissioner's Report, 1874–75, page 447.)

In 1876, after a year's experience with these hatching-troughs, my report alludes to them again as follows:

The hatching apparatus is the same used last year, namely, the Williamson troughs, with the deep wire baskets described in last year's report. I ought to add here that the wire baskets gave the same satisfaction that they did the year before. *They are unquestionably the best thing known for maturing salmon eggs on a large scale.* Of the utmost simplicity in construction, they are more easily handled and will hatch more eggs with *less cost, less loss, less room,* and *less labor* than any other hatching apparatus in use.—(United States Fish Commissioner's Report, 1875–76, page 939.)

For some unaccountable reason this method of hatching the eggs of the *Salmonidæ*, which is now almost universally in use in the hatcheries of European countries, is seldom employed in this country, except on the Pacific Coast. The writer confidently recommends it, however, as the best method in existence. At the hatching-house at Baird,[1] the trays are 22 inches long, 12 inches wide, and 6 inches deep, the trough compartments in which they are placed being just enough longer to enable the trays to be raised and lowered, and to be also tilted slightly, without too much friction against the partitions and sides of the trough.

The troughs themselves are all 16 feet long and have a fall of 1½ inches to each. They are covered with canvas covers made sunlight proof by having been saturated with asphaltum varnish. I need hardly add that the trays and also the interior of the troughs are thickly coated with asphaltum.

The water supply for the first hatching apparatus (1872) was obtained from a small brook. After that, until 1890, it was obtained directly from McCloud River by a current wheel placed in the river near the hatching-house. The last automatic current wheel used was about 100 feet in circumference.

For the last few years the wheel has been made much smaller and has been used to produce power to work a centrifugal pump that pumps the water from the river up into the hatching-house. The writer, however, strongly recommends, on account of its perfect simplicity, the large wheel formerly used, that lifted the water automatically in buckets to the necessary height. In the wheel and pump combination there are numerous belts and pulleys and minor wheels and other machinery that are continually getting out of order, and consequently causing expense of time and money, besides creating various frictions which require continual watching. But with the automatic wheel there are no belts, no pulleys, no subsidiary wheels, nothing to wear out or get out of order, nothing to watch, and only one thing to cause friction, viz, the

[1] At Sisson station and Battle Creek station of the California Fish Commission the troughs are 16 or 18 inches wide, which I consider a better width than 12 inches, and would cordially recommend it.

revolving axle of the wheel, the bearings of which do not need to be oiled oftener than once a day.

For the first fifteen years of operations at this station after 1873 the current wheel was relied upon exclusively to furnish the water supply for the hatching-house. A steam engine and miner's pump were then introduced as a reserve agency to furnish water in the event of any accident to the wheel, and in 1895 a ditch was built to take water from Wiley Creek to the hatching-house by force of gravitation. The ditch is nearly 1¼ miles long, and furnishes an excellent water supply during the rainy season, when the river is too high to manipulate the wheel.

At the Clackamas station, in Oregon, the water supply was first obtained from the Clackamas River by a current wheel operating a Chinese pump, which lifted the water 27 feet into a flume running to the hatching-house. Subsequently water was taken from a point on Clear Creek, about a quarter of a mile distant, but owing to the nature of the bed of the creek no dam could be made to stay there, and now the water supply is pumped up from the Clackamas by a steam pump.

At Fort Gaston station, in Humboldt County, Cal., as also at the branch station at Redwood near by, the water supply for the hatching-house is taken from spring-fed streams in the neighboring hills.

To return again to Baird station, I will say that after the salmon are measured out and placed in hatching-trays very little is done to them except a slight picking over and rinsing off of sediment until the "delicate stage" is reached, which is just as the spinal column is forming. Then they are left alone until the distinct line of the backbone, becoming visible in the embryo, indicates that the delicate stage is passed. Then the white eggs are carefully picked out, and after a little, when the appearance of the choroid pigment (eye-spots) shows that the eggs can stand comparatively rough usage, they are "dippered," or the water otherwise actively agitated in order to kill off all the empty eggs. When these are removed the eggs are ready to be packed for shipment or to be hatched, as the case may be.

If the eggs are to be hatched, wire trays are used with every other strand lengthwise of the bottom of the tray removed, which enables the newly-hatched fish, as fast as they emerge from the eggs, to slip down into the trough below, where they can be kept, if desired, or whence they can be easily removed, if necessary.

PACKING THE EGGS.

The packing of eggs for shipment from this station over long distances has always been the same. The packing boxes are made of half-inch pine, 2 feet square and 1 foot deep. At the bottom of the box is placed a thick layer of moss, then comes one thickness of mosquito bar, then a layer of eggs, then mosquito bar again, then other successive layers of moss, netting, eggs, netting, and so on to the middle of the box. Here a firm wooden partition is fastened in, and the packing renewed above the partition in the same manner as below. The cover is then screwed on the top and another box packed. When two boxes are ready, they are placed in wooden crates, made large enough to allow a space of 3 inches on all sides of the boxes. This space is filled with hay to protect the eggs against changes of temperature. The cover being put on the crate and the marking done, the eggs are ready to ship.

I should have added that in the middle of the crate an open space is left about 4 inches in depth between the two boxes of eggs for ice. As soon as the crates arrive

at the railway station, this space is filled with ice and the top of the crate is also covered with ice.

The following letters show how the eggs, packed as above described, survived their overland journey in 1878:

MOUNT CARROLL, ILL., *October 16, 1878.*

DEAR SIR: The two crates of California salmon eggs, of which you notified me from California, reached me on the 14th instant. They are *in fine condition, only about 3 per cent* being found faulty.

Very truly, yours,

SAMUEL PRESTON.

LIVINGSTON STONE, Esq.

GLOUCESTER, MASS., *October 18, 1878.*

MY DEAR SIR: My man writes me of the safe arrival of the salmon eggs *in good condition.* Out of the lot of 250,000 he picked out 6,000 bad eggs, 2.4 per cent.

Yours, very respectfully,

FRANK N. CLARK.

LIVINGSTON STONE.

ST. PAUL, MINN., *October 28, 1878.*

DEAR SIR: The California salmon eggs from the McCloud River came to us on the evening of the 14th, and I am glad to say that they open up in better order than any we have ever received before. The packing and carriage were a complete success, and up to this time *the loss has not been over 5 per cent.*

Very respectfully, R. O. SWEENY.

Hon. S. F. BAIRD, *United States Fish Commissioner.*

TRENTON, N. J., *October 14, 1878.*

DEAR SIR: In accordance with your request of September 23, you are informed that the shipment of salmon eggs for the State of New Jersey, and others (total, 475,000), was received in due time, and that the condition of the eggs on arrival *was most excellent.*

Very respectfully,

E. J. ANDERSON,
Commissioner of Fisheries of New Jersey.

LIVINGSTON STONE, Esq.

ELGIN, ILL., *October 12, 1878.*

DEAR SIR: The California salmon eggs came *in excellent shape.*

W. A. PRATT.

LIVINGSTON STONE.

COUNCIL BLUFFS, IOWA, *October 17, 1878.*

DEAR SIR: The 50,000 California salmon eggs shipped me per express were duly received on the 14th instant, and in unpacking the same I find them *in excellent condition.*

Yours, respectfully, WM. A. MYNSTER.

LIVINGSTON STONE.

All the salmon eggs forwarded from this station were sent by express (the express messengers being instructed to keep the crates plentifully re-iced in transit), until 1876, when an ice car was used for transporting the eggs from Redding to Chicago, whence they were distributed to their eastern destinations. The ice car, which to start with was only a common box-freight car, was sent by the railroad company to Redding, the nearest railway point from Baird, with a ton or so of ice. The crates of salmon eggs in the meantime were forwarded by wagon from Baird. They were then packed into the car and the car sent down to Sacramento and filled up with ice; on the same day it left for Chicago on the regular passenger train of the Central Pacific.

The method of packing with moss, as above described, has always been employed at this station for shipping eggs over long distances, but for short distances the Annin packing box is used. This box is too well known to need description. I will only say that in my experience it has always answered its purpose admirably. We have frequently even found a few eggs alive in the return boxes, that had been overlooked in unpacking and which had remained in the box two or three weeks.

The following excellent tabulated statement,[1] prepared by Mr. Smiley, may not be out of place here.

Table showing the success in transporting and hatching 31,193,000 salmon eggs.

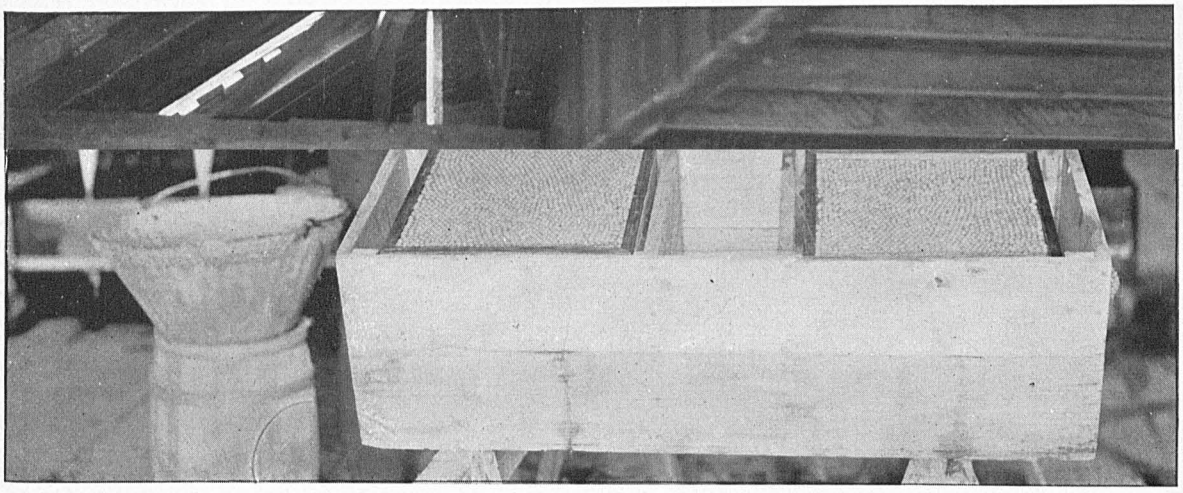
State to which consigned.	Number of eggs sent from McCloud River.	Received at State hatcheries.	Loss in hatching and transporting to waters.		Young actually introduced.	
			Number lost.	Per cent.	Number.	Per cent.
Colorado	565,000	565,000	92,100	16	472,900	84
Connecticut	1,410,000	1,390,000	191,714	13	1,198,286	87
Illinois	1,030,000	930,000	362,300	39	567,700	61
Iowa	1,050,000	1,100,000	86,800	8	1,013,200	92
Kansas	400,000	400,000	20,600	5	380,000	95
Kentucky	355,000	350,000	232,275	66	117,725	34
Maine	215,000	165,000	77,300	47	87,700	53
Maryland	4,645,000	4,440,000	1,175,601	29	3,264,399	71
Massachusetts	740,000	728,000	259,000	36	469,000	64
Michigan	3,908,000	3,808,000	618,979	16	3,249,000	84
Minnesota	2,825,000	2,627,500	1,751,750	64	875,750	36
Missouri	410,000	400,000	64,000	16	336,000	84
Nebraska	710,000	600,000	110,000	18	490,000	82
Nevada	250,000	250,000	50,000	20	200,000	80
New Hampshire	555,000	467,000	37,960	8	429,540	92
New Jersey	2,480,000	2,430,000	330,371	14	2,099,629	84
New York	1,135,000	980,000	144,790	15	835,210	85
North Carolina	1,100,000	1,117,500	369,500	33	748,000	67
Ohio	500,000	500,000	127,500	26	372,500	74
Pennsylvania	2,440,000	2,385,000	483,500	20	1,901,500	80
Rhode Island	340,000	220,000	40,000	18	180,000	82
South Carolina	250,000	333,000	121,000	36	212,000	64
Tennessee	100,000	(a)	(a)	(a)	(a)	(a)
Utah	600,000	625,000	114,500	18	510,500	82
Virginia	1,270,000	1,285,000	358,500	28	926,500	72
West Virginia	810,000	785,000	47,625	6	737,375	94
Wisconsin	1,100,000	1,130,000	300,400	27	829,000	73
Total	31,193,000	30,071,000	7,567,465	25	22,504,035	75

a No report received.

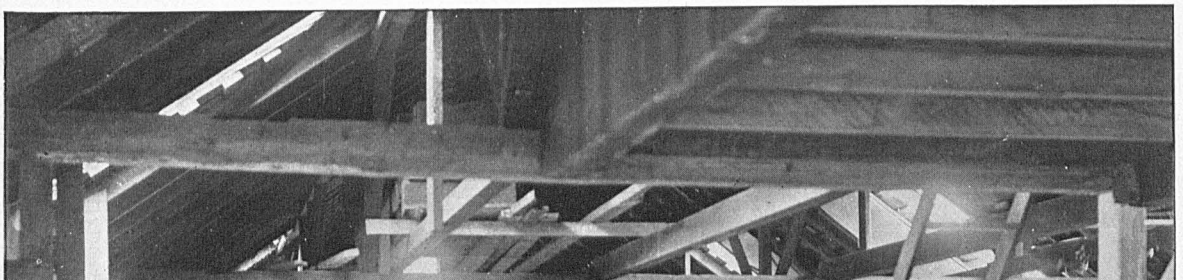
It will be seen by the above table that the gratifying average of 75 per cent of all the 30,000,000 eggs distributed from Baird station in the ten years from 1872 to 1881, inclusive, were actually hatched out, and the fish deposited in the waters of the Atlantic States.

[1] United States Fish Commissioner's Report, 1881, page 837.

PACKING SALMON EGGS AT CLACKAMAS HATCHERY.



PACKING SALMON EGGS AT CLACKAMAS HATCHERY.



I will, in conclusion, quote some remarks on the results of salmon breeding in California from the report of the California State Fish Commission for 1893-94:

Our salmon fishery is of the greatest importance to us, as it furnishes a larger supply by 800,000 pounds than any other food-fish, the catch being 4,848,816 pounds in 1892. Hatching operations were inaugurated in 1873. In 1875 the take (of salmon in the Sacramento and San Joaquin) was 5,098,781 pounds; in 1878, 6,520,768 pounds; and in 1880, 10,837,400 pounds.

In 1884, it became necessary to close the spawning station at Baird, as the salmon were prevented from ascending Sacramento River to that point by blasting operations above Redding, occasioned by the building of the railroad. Consequently, the planting ceased and this station was not operated until 1888. The result was that the catch decreased until the effects of the resumption of the artificial hatching again began to show in 1892. Since 1892 the increase has been very marked, and the results of the planting of fry each year are again demonstrated.

Since 1892 the salmon pack at the canneries has steadily increased, while at the same time there has been a much larger demand for salmon in the markets of the State.

The following table shows the decrease in the pack to 1892 and the subsequent increase, which we hope to see continued:

Year.	Pounds.	Cases.
1888	4,039,200	61,200
1890	1,618,471	25,065
1891	672,121	10,353
1892	170,425	2,281
1893	1,496,927	23,336
1894	1,940,009	28,463

Through the kindness of Mr. J. P. Babcock, chief deputy of the California Fish Commission, I have just been furnished with the following interesting statistics, illustrating the increase of salmon in the Sacramento, from 1893 to 1895. October of 1895 being a close month, the total number of pounds given for that year is, of course, less than it would otherwise have been. If, to supply the deficiency, we add the average of October, 1893 and 1894, to the total of 1895, which would then put the latter year on a basis of fair comparison with the two previous years, it makes the total of 1895 3,040,000 pounds, or a gain of nearly 25 per cent over the year 1893.

Table showing number of pounds of fresh quinnat salmon handled in the San Francisco markets in 1893, 1894, and 1895.

Months.	1893.	1894.	1895.
	Pounds.	*Pounds.*	*Pounds.*
January	137,460	128,556	161,041
February	93,263	103,801	146,250
March	139,401	163,131	155,791
April	374,478	211,552	365,387
May	325,170	242,126	401,787
June	70,216	138,675	161,989
July	149,217	117,516	115,592
August	575,609	576,991	447,094
September	(*a*)	(*a*)	(*a*)
October	249,753	403,340	(*a*)
November	183,789	276,768	431,453
December	155,090	192,153	326,474
Total	2,453,446	2,554,609	2,713,458

a Closed season.

NOTES ON THE NATURAL HISTORY OF THE QUINNAT SALMON.

The quinnat salmon (*Oncorhynchus tschawytscha*) has almost as many local names as the North American panther (*Felis concolor*). I think its first popular name was the "Columbia River salmon," and its first scientific name, in general use, was *Salmo quinnat*. Time and closer acquaintance with the fish has robbed it of both these names. What its most accepted popular name is at present it would be hard to say, but its generally received scientific name is now *Oncorhynchus tschawytscha*, this Russian cognomen having been found to supersede by many years the *Salmo quinnat* of Gairdner & Suckley. The origin of the term "quinnat" is involved in obscurity. Several explanations have been offered for it, but the most probable seems to be that the name was derived from the Indian name (*Quinnault*) of a tributary of the Columbia, where the finest salmon of the river were supposed to be caught. Everyone knows the tendency of every article to take the name of the place where it is found at its best; accordingly, the best Columbia River salmon being found in Quinnault River, all the Columbia River salmon came to be called *Quinnault*, or *quinnat*, salmon, the latter word being the former with the *l* dropped.

Other popular names of this salmon are "spring" salmon and "chinook" salmon, by which names it is commonly known on the Columbia River. On the Sacramento River it is known simply as "salmon," there being no other kind of salmon to amount to anything in the Sacramento. Its name in the Chinook dialect is "tyee" salmon (king salmon), by which latter name it is known farther north and on the Yukon. The local Indian name for salmon on the McCloud is "noolh."

The following is Dr. Suckley's description of the quinnat salmon, taken from the United States Fish Commissioner's Report, 1872–73, page 105:

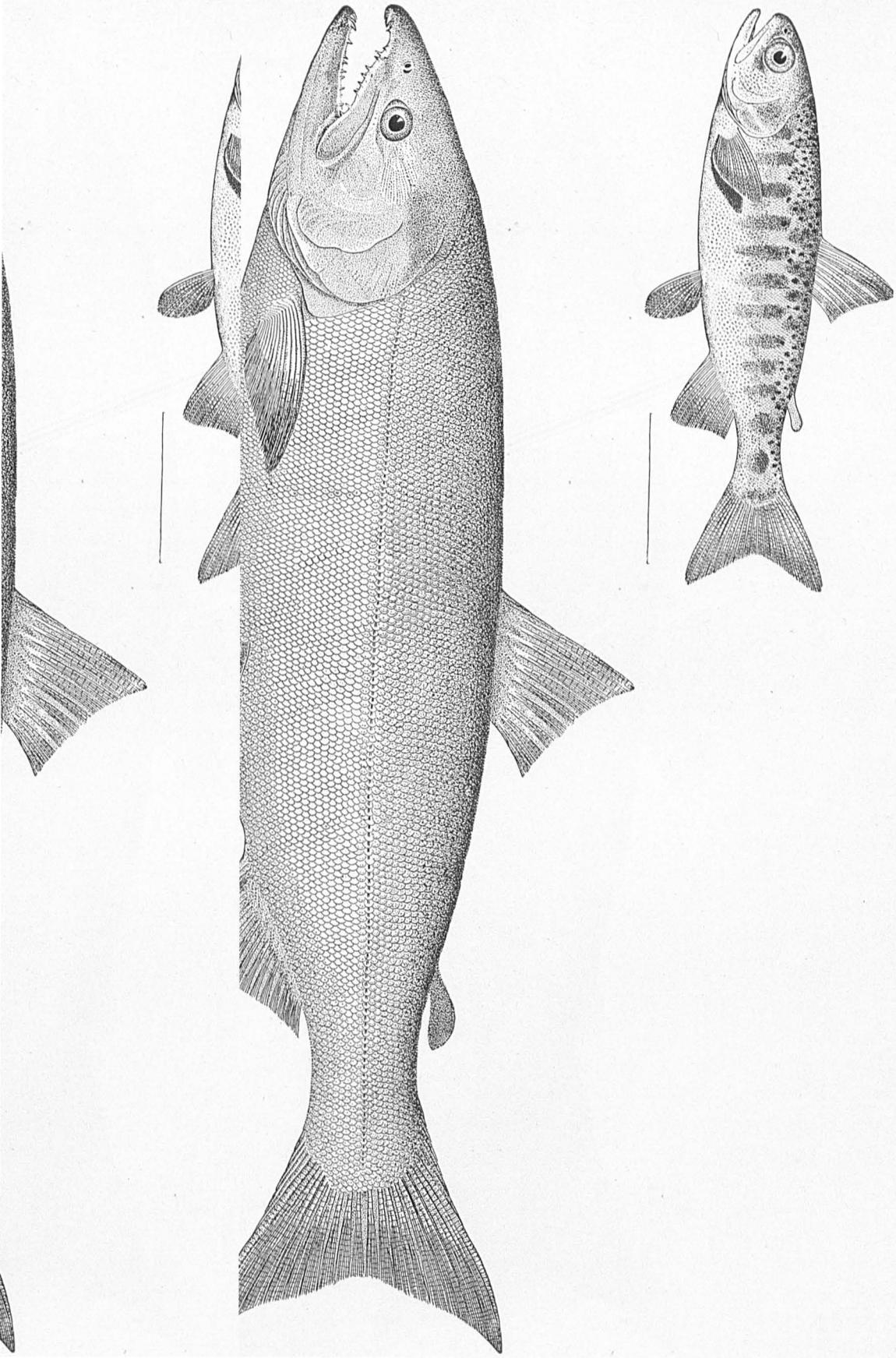
Salmo quinnat Richardson.

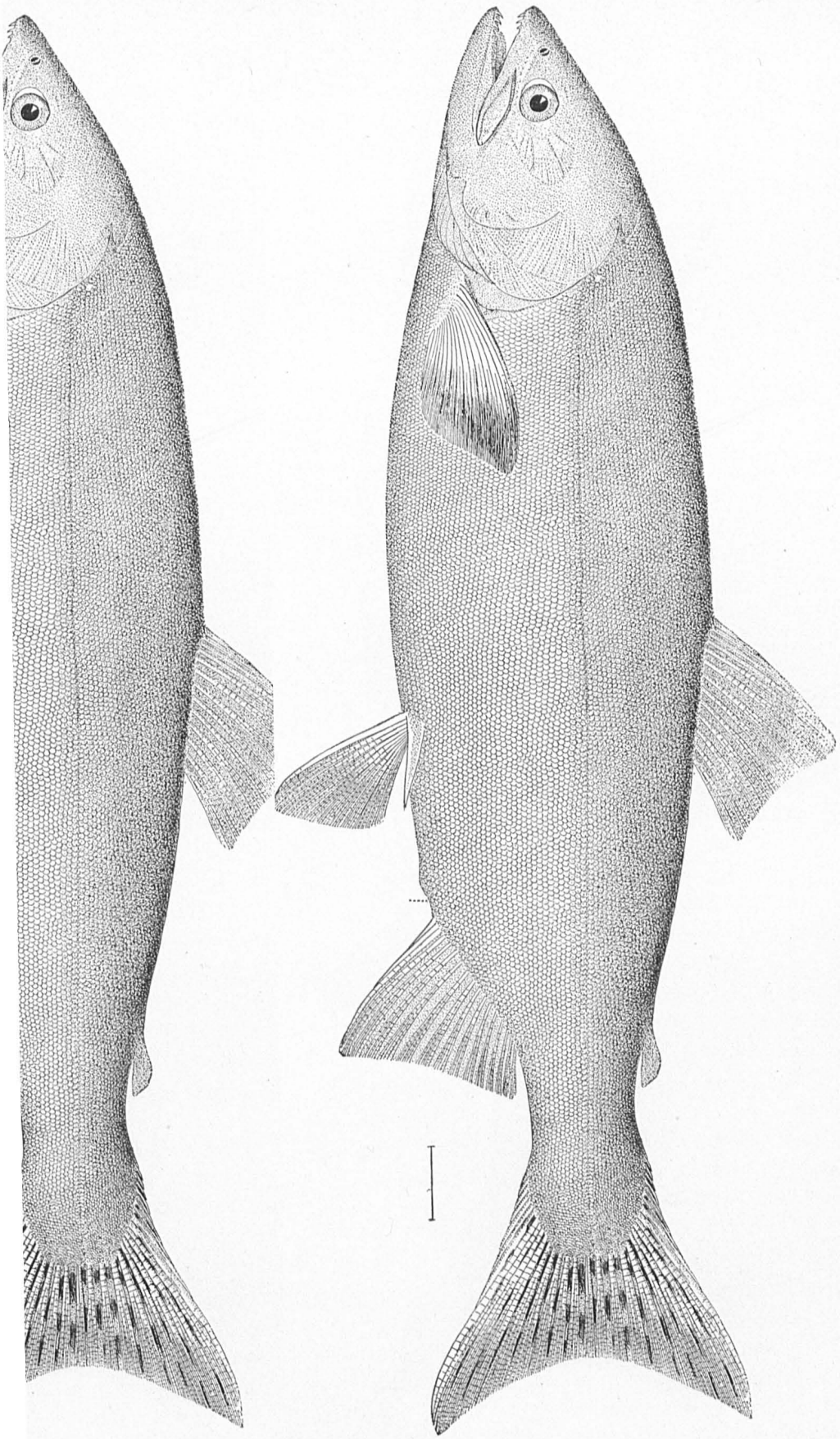
Sp. Ch.—*Adult.*—Head pointed and large, forming about a fourth of the length from the snout to the end of the scales on the caudal. Dorsal outline regularly arched. Caudal deeply cut out (in the dried specimen forked), snout cartilaginous, as in *S. salar*. Chin pointed, a triangular bare projection extending beyond the teeth.

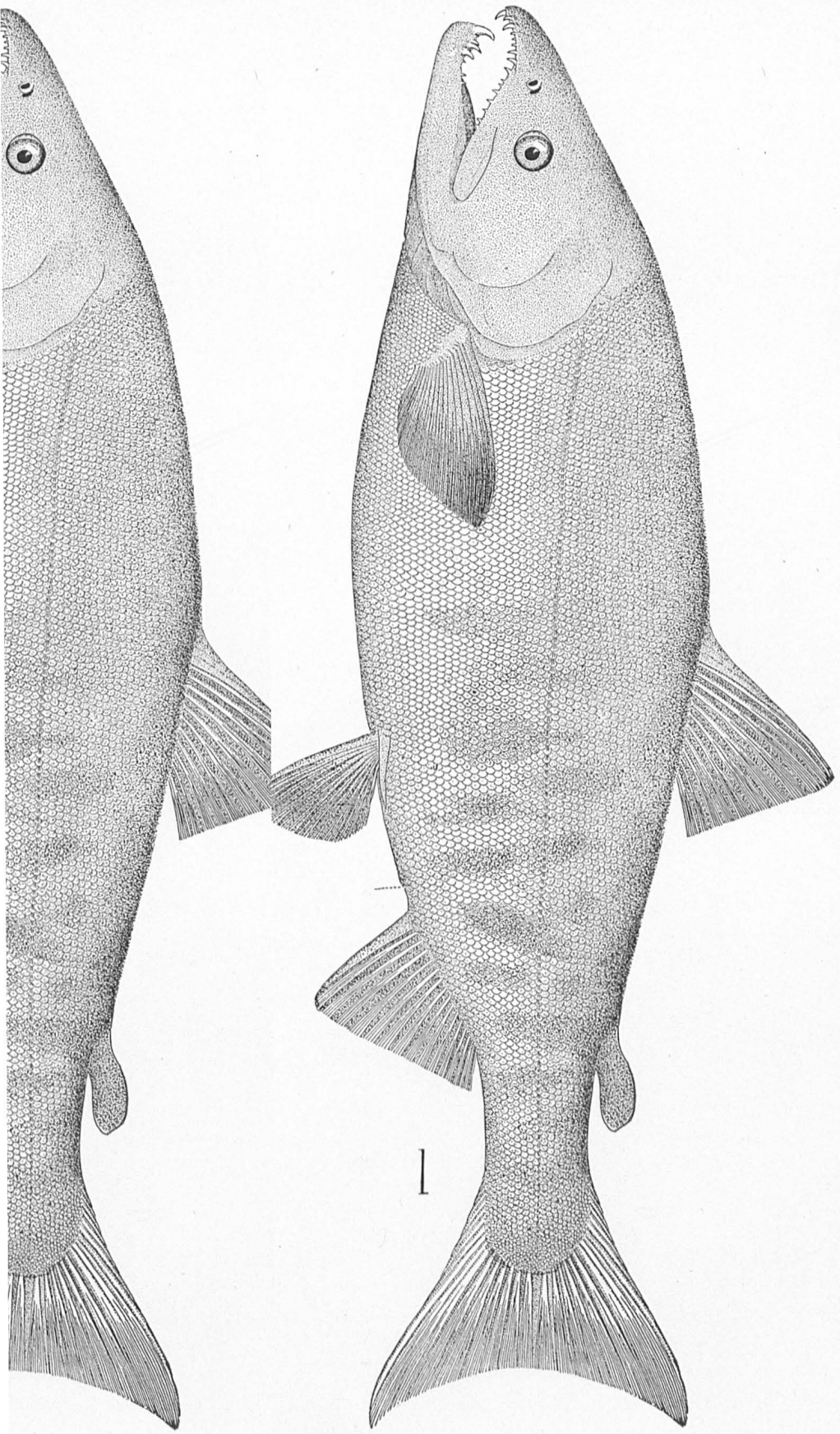
General tint of the back, bluish gray, changing after a few hours' removal from water into mountain green; sides ash-gray, with silvery luster; belly white; back above the lateral line studded with irregular rhomboidal or star-like spots, some of them oscillated; dorsal fin and gill cover slightly reddish; tips of the anal and pectorals blackish gray; the dorsal and caudal thickly studded with round and rhomboidal spots; back of the head sparingly marked with the same. The whole body below the lateral line, with the under fins, destitute of spots. (Gairdner in Rich., F. B. A., Fishes, 220.) Scales large. Branchiostegal rays varying from 16 to 20.

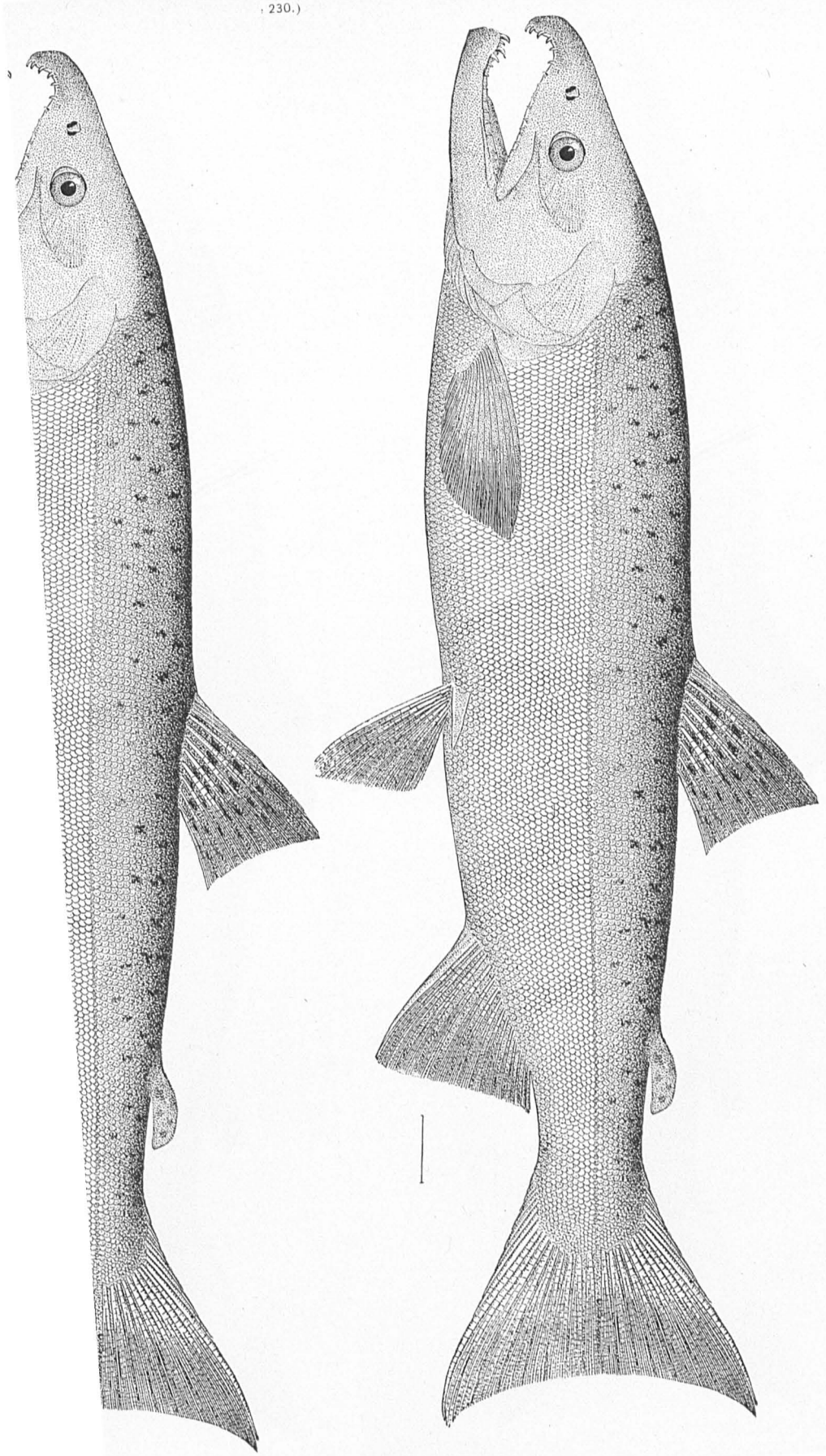
The quinnat salmon or chinook salmon is very widely distributed on the Pacific coast. As far south as the mild climate of Santa Cruz in California it is caught, and as far north as the frozen waters of the Arctic it is found in abundance; and no Pacific Coast stream from the Sacramento to the Yukon is found without it.

The quinnat salmon, when freshly caught and in its prime, is a very handsome, plump-looking, silvery fish, more or less covered with fine black spots; and though it shows its claim to royal lineage in its whole appearance, it does not possess the graceful hues and curves of its Atlantic cousin, *Salmo salar*, which, however, it very much resembles. In flavor, also, its flesh, though good when cooked, suffers from









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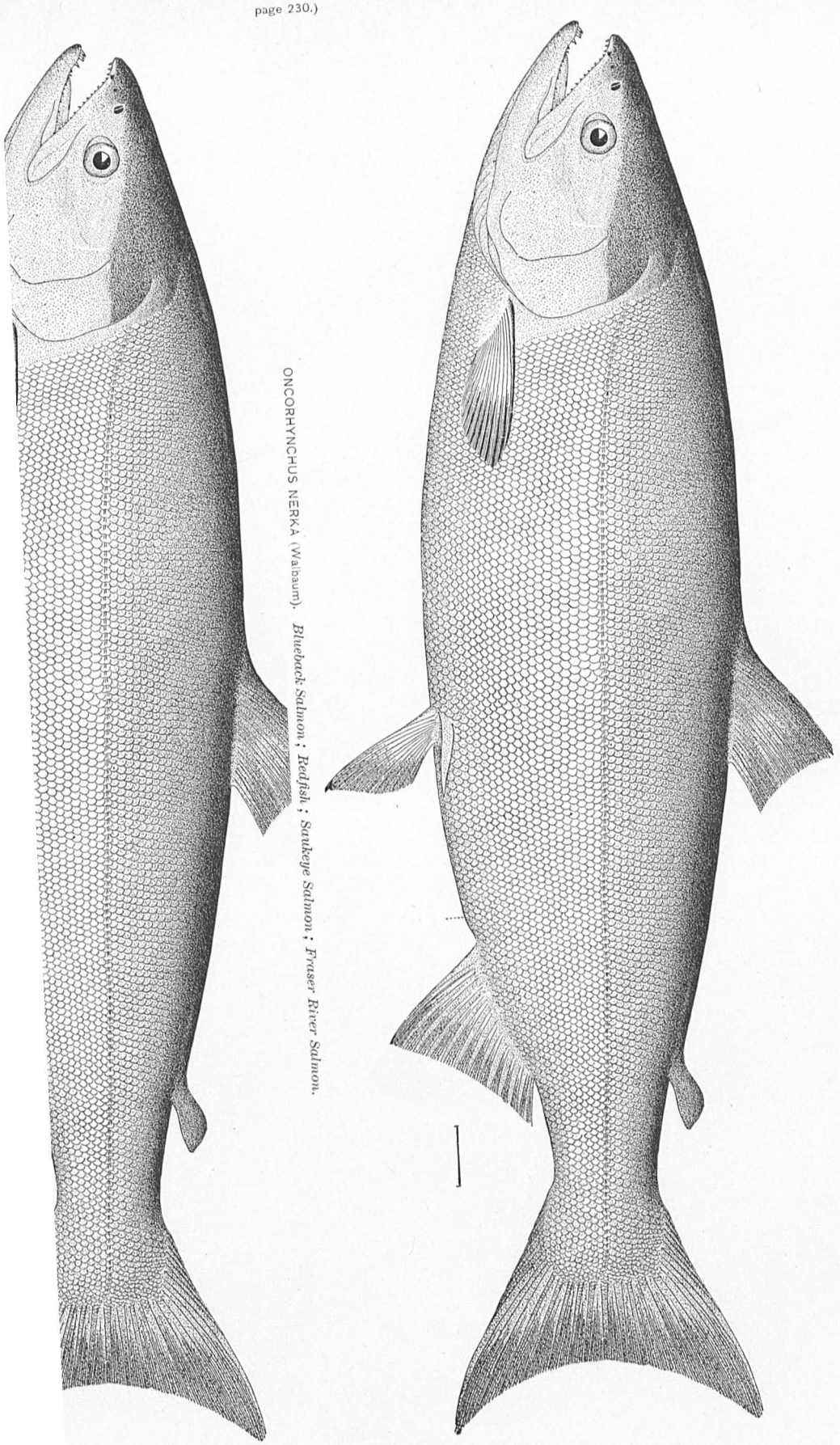

ONCORHYNCHUS NERKA (Walbaum). *Blueback Salmon; Redfish; Sockeye Salmon; Fraser River Salmon.*

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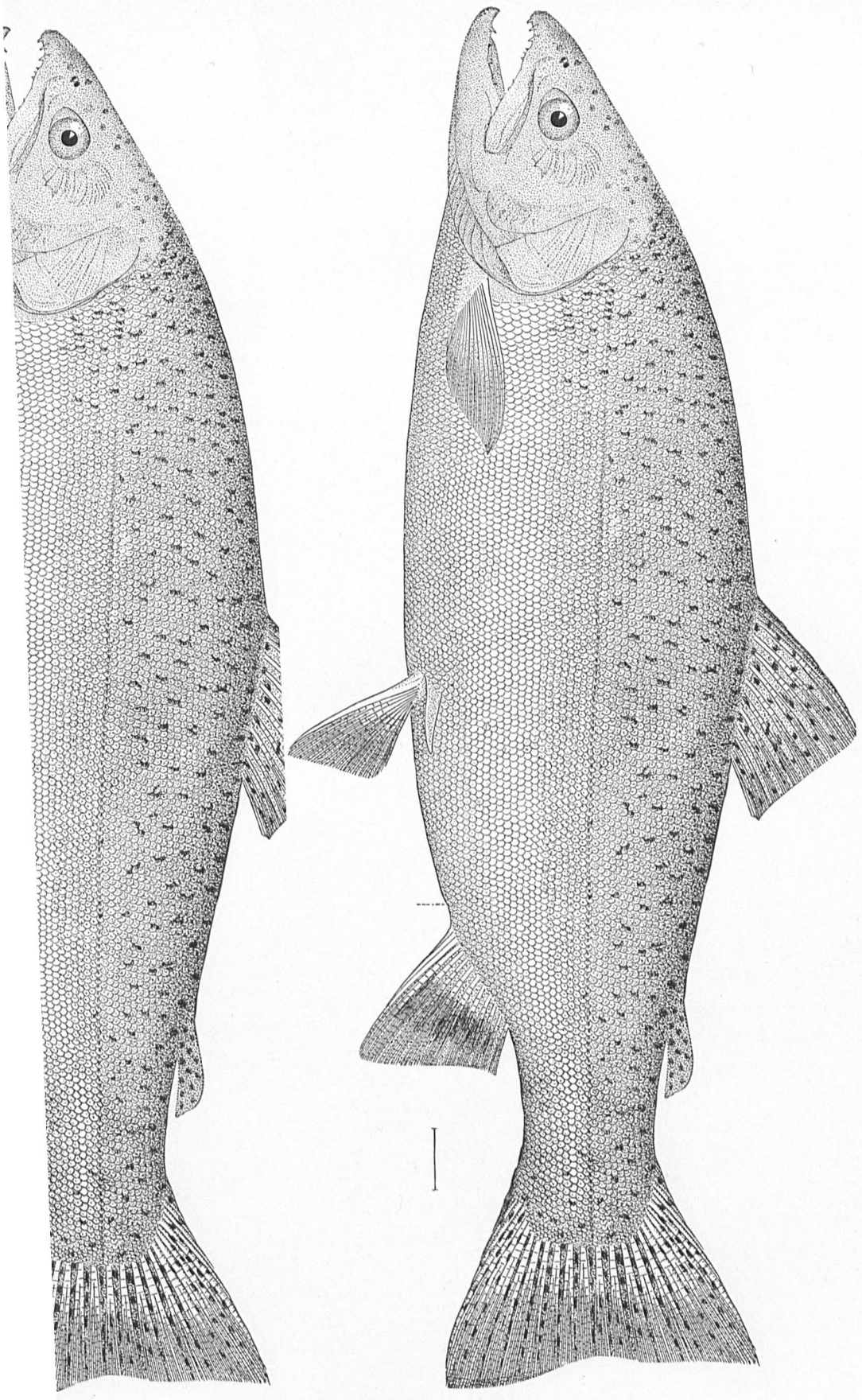

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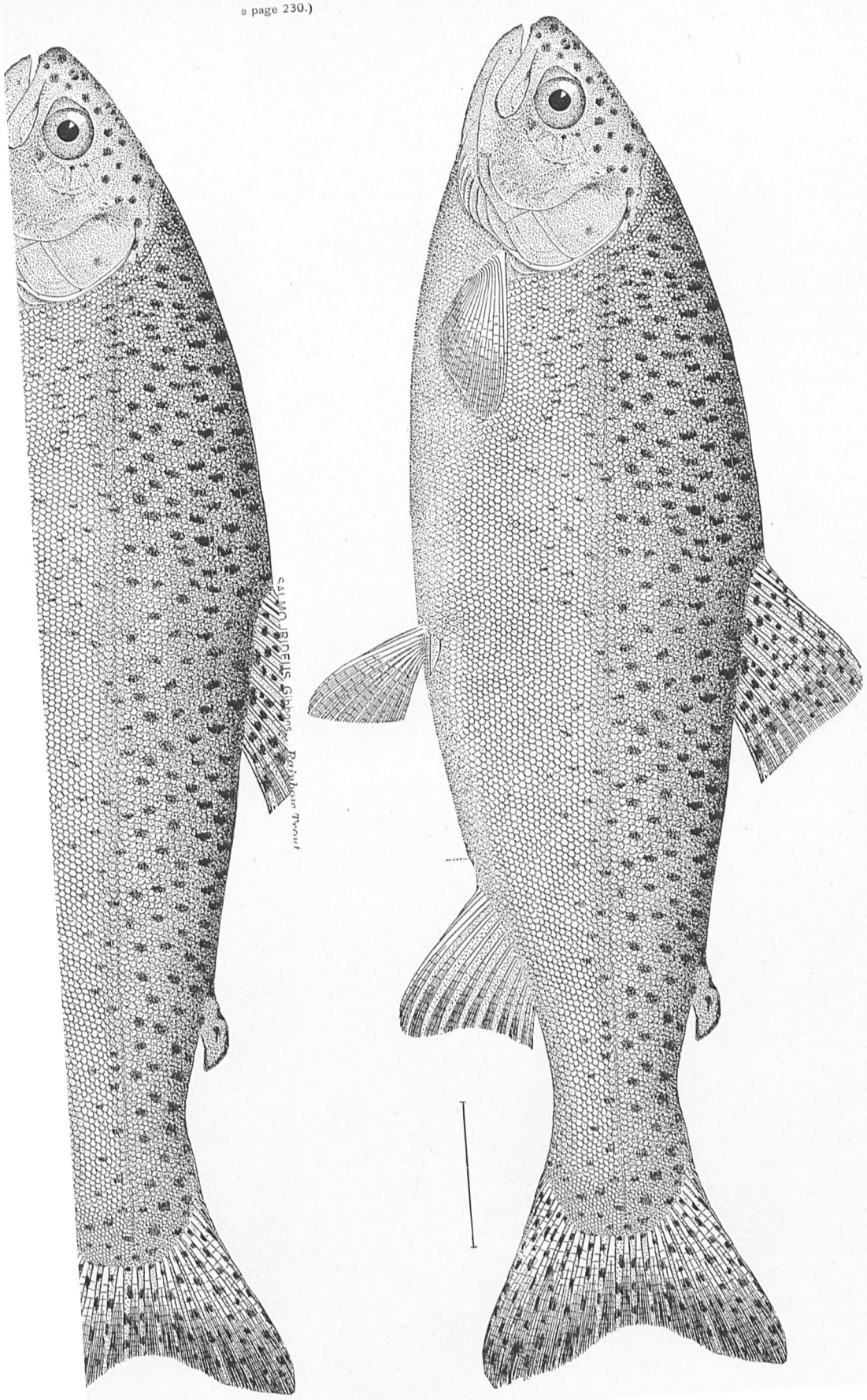
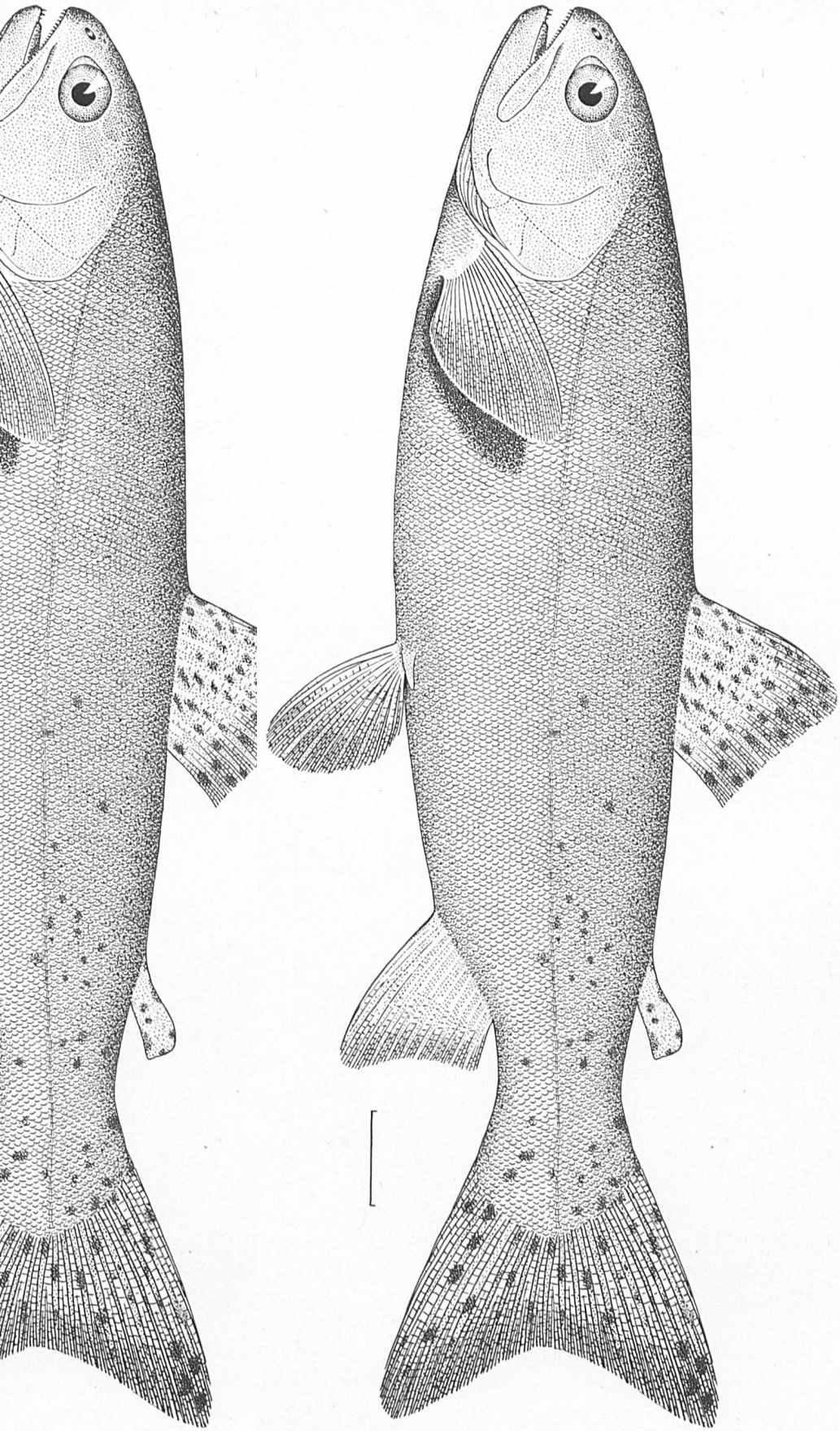
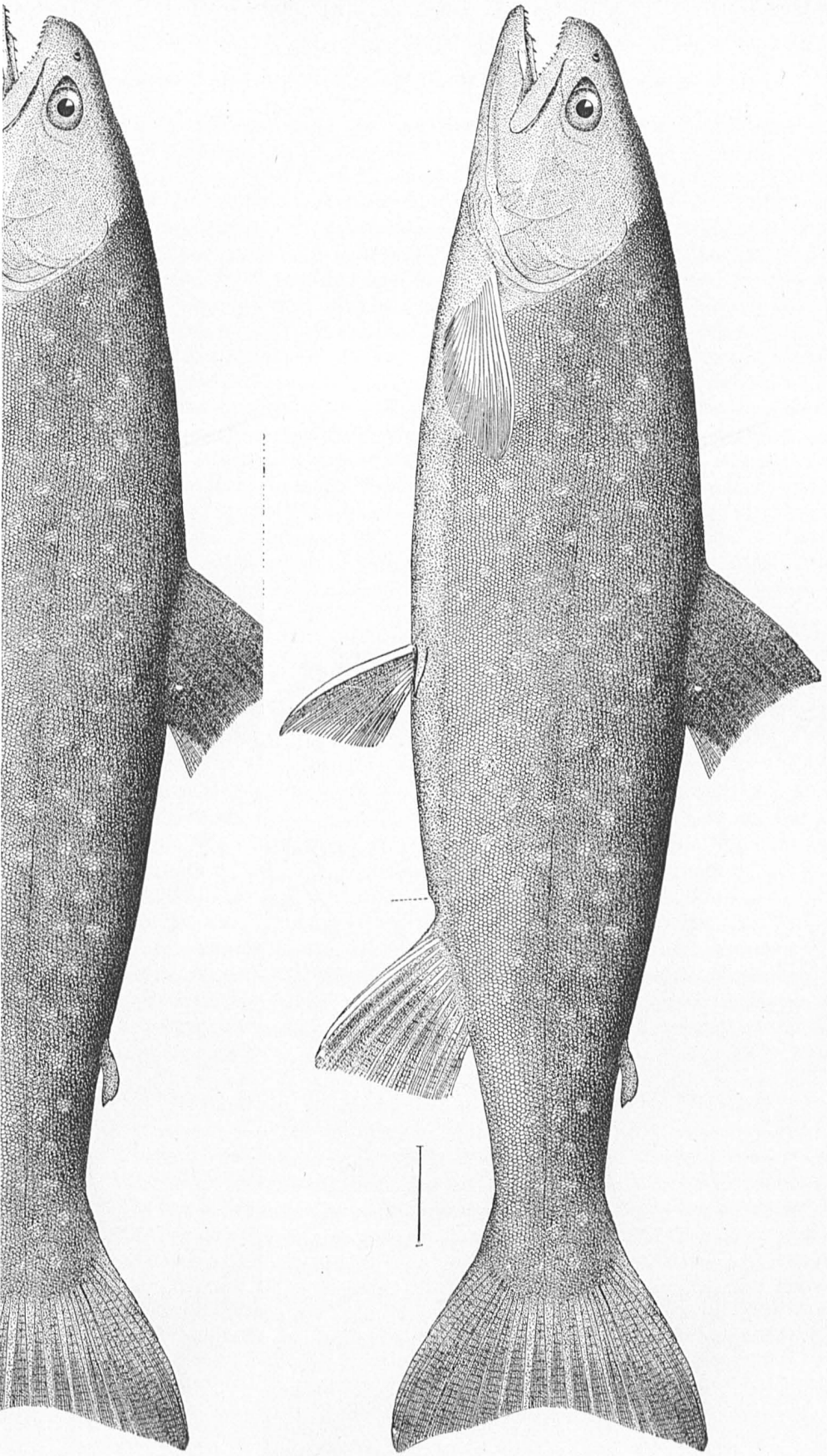


SALMO IRIDEUS, Gibbons. Rainbow Trout





comparison with the inimitable salmon of the Atlantic; and still another charge is brought up against it, viz, the old but true indictment that it does not rise to the fly. Nevertheless, with all these handicaps, it holds a high place among the fishes of the seas for beauty, gameness, food value, and commercial value, in the two latter points of which, on account of its almost incredibly vast numbers, it completely eclipses the Atlantic salmon. In all the rivers in which it is found it occurs in great multitudes, and in the upper waters of these streams the old story, so hard for the skeptical to accept, is true, that the salmon are found at certain seasons so thick that one could cross the stream dry-shod on their backs if he could keep his balance.

There is no month of the year when there are not salmon in the Sacramento, but their first appearance in abundance on the Pacific Coast of the United States is at Santa-Cruz Bay, in January. Here they are caught in very considerable numbers by hook and line, either by trolling or from a boat at anchor, as mackerel or perch are caught. Through January and February they are increasing in the main Sacramento, but do not become abundant till March, when they swarm up the river and are caught in great quantities in nets, as also in April. In May, June, and July they fall off, but reappear in great numbers in August. They fall off a little in the latter part of September, and continue to grow scarcer in the main river till the end of the year.

The number of fresh salmon shipped from Rio Vista to San Francisco in the year 1872 was as follows:

January	792	August	1,496
February	1,581	September	2,335
March	1,945	October	583
April	3,354	November	441
May	4,408	December	390
June	1,201		
July	1,145	Total	19,671

Their movements in the Columbia are quite different. Here they make their first appearance in February, though in very small numbers. The main body arrives in May, June, and especially in July, when the run is enormous. The May salmon are largest. Perhaps the most correct view to take of the running of the salmon is to consider all the salmon as included in one run, beginning in February, increasing in May and June, and culminating in July; though they might also be legitimately divided into three runs, the first or meager run coming in February, March, and April, the second or full run in May and June, and the third or maximum run in July. After July they diminish rapidly, and soon almost entirely disappear from the main river.

The writer has always been told by the professional fishermen on the Sacramento and Columbia that the salmon come down the ocean from the north to the mouths of the rivers, but their regular appearance on the coast of southern California early in January, their subsequent appearance in the Sacramento in February, and their still later appearance in the Columbia in March seem to indicate quite conclusively that the salmon came up the coast to these rivers from points farther south, to which they have migrated for a sojourn during a portion at least of the winter months.

It is probably true of most anadromous fish which leave the ocean to go up fresh-water streams to spawn, that they eat little or nothing after they get above tide water. At all events, as soon as the quinnat "salmon, coming from the sea, strike fresh water their appetites begin to weaken, their throats begin to narrow, and their stomachs begin to shrink. This does not at first, however, entirely prevent them from feeding, but it changes them enough to enable them to overcome the temptation to return to

their well-stocked feeding-grounds in the salt ocean; and the longer they remain in fresh water the greater the changes become, and the temptation to turn back for food correspondingly less. There is probably no one specified time when an abrupt change comes which deprives them in an instant of their ability and desire to feed, but in the writer's opinion the transformation comes on gradually, increasing constantly day by day from the time they leave tide water till, at the near approach of the spawning season, their throats and stomachs become entirely incapacitated for receiving food, and the desire and ability to feed leave them entirely; but, notwithstanding their scanty supply at first and their entire abstinence afterwards, the great reserve of superfluous flesh and blood, which they bring with them in their own bodies from the bountiful ocean, enables them with little or no food in their stomachs to keep their vital organs in vigorous activity until their momentous mission up the fresh-water streams is accomplished."[1] In the ocean their staple food consists of smaller fish.

It is a singular fact regarding the quinnat salmon that those, at least, that spawn a long distance from the ocean never return to it again alive. *They all die on their spawning-grounds.* This fact, I am aware, has been disputed many times, and is by no means universally accepted now, but its truth has been proved so repeatedly and conclusively that it is no longer open to question. My report for 1872–73 says on this point:

> In March, when the salmon first arrive in the McCloud, they are in fine condition. They are now bright and silvery, with shining scales. They are fat and excellent for the table, but not very large. The spawn in the females is very small. Their flesh is of a deep red color. The males and females are almost indistinguishable at this time. This state of things remains till August, except that the salmon gradually deteriorate in quality and the eggs increase in size. The first marked change in the fish takes place a little before the middle of August. The salmon then become very black. The males grow deep and thin, and the dog-teeth begin to show themselves and to increase rapidly in size. The females are now big with spawn, and the sexes are easily distinguishable. From this time they rapidly deteriorate. Their flesh shades off to a light, dirty pink. They become foul and diseased, and very much emaciated. Their scales are wholly absorbed in the skin, which is of a dark olive hue, or black. Blotches of fungus appear on their heads and bodies, and in various places are long white patches where the skin is partly worn off. Their fins and tails become badly mutilated, and in a short time they die exhausted. By the first of October most of the fish that were in the river in August are dead.

And again:

> At the spawning season the changes, especially in the male salmon, are very marked. Both sexes lose their bright and silvery coat. Their scales become absorbed into the skin, which grows very slimy and perfectly smooth, like that of a catfish or bornpout. Their color changes into a dirty black, and then into a dark, unclean olive color. Blotches of fungus and large patches of white, caused by abrasion of the skin, appear all over them. The fins and tail become mutilated. Their bodies grow foul and emaciated. Their eyes get more or less injured; they often become blind; swarms of parasites gather in their gills and stick to their fins. Their bodies reach the extreme point of attenuation, and, as soon as the spawning is accomplished, they die.

No anadromous fish varies so much in size as the quinnat salmon, and this is one of its most notable characteristics. In the Sacramento the average weight at Sacramento City in 1892 was thought to be about 20 pounds, and the largest weighed 60 pounds. In the Columbia the cannery men put the average weight at about 23 pounds, and the largest on record weighed 83 pounds.

[1] "The Chinook Salmon:" Transactions of the American Fisheries Society, 1894.

In the Yukon 100-pound salmon are said to be not rare, and the writer met on Kadiak Island a professional salmon fisherman who said he had seen a Yukon salmon that weighed 125 pounds. The smallest quinnat salmon that the writer has ever seen weighed 3½ pounds, and was a female with perfectly developed ova, which were taken and afterwards hatched into healthy young salmon fry.

The salmon that are taken at Baird station, on McCloud River, in California, vary widely in size in different years. Leaving out the grilse, or partly matured males, the average weight of the salmon manipulated at this station the last few years is estimated at about 13 pounds each. On the other hand, in 1878, the average weight of the spawners taken in August, after the eggs had been expressed from them, was only 8¼ pounds.

Below will be found the weight of 82 salmon spawned and weighed after spawning, on the 29th of August, 1878:

Number.	Weight in pounds.	Number.	Weight in pounds.	Number.	Weight in pounds.	Number.	Weight in pounds.
1	16	22	17	43	5	64	5
2	8	23	7	44	5	65	6
3	10	24	7	45	7	66	8
4	9	25	8	46	7	67	7
5	14	26	15	47	8	68	7
6	6	27	9	48	7	69	5
7	12	28	8	49	7	70	5
8	7	29	7	50	7	71	7
9	8	30	11	51	6	72	6
10	7	31	14	52	8	73	7
11	8	32	14	53	9	74	7
12	15	33	7	54	6	75	7
13	7	34	17	55	6	76	7
14	8	35	13	56	5	77	6
15	6	36	8	57	8	78	11
16	8	37	7	58	7	79	5
17	7	38	9	59	7	80	7
18	7	39	14	60	7	81	8
19	7	40	5	61	10	82	5
20	8	41	7	62	6		
21	7	42	17	63	8		

In the Sacramento and the Columbia the appearance of the salmon is very regular, the numbers, however, showing a very marked dependence on the number of young fry hatched at the breeding stations the corresponding years.

There has never been to the writer's knowledge a serious failure of the salmon in any year to make their appearance in the Columbia, and only one instance of failure in the Sacramento, viz, in 1866, which was doubtless caused by the débris (slickens) turned into the river by the operations of the hydraulic miners.

In ascending the rivers the males usually precede, followed closely by the females. This continues through the season, in consequence of which, at the end of the season at a breeding station, there are usually females left over after the run of males has ended.

The rate of progress of these salmon up the rivers varies at different seasons of the year. In ascending the Columbia, they are usually from one to three weeks passing from the mouth of the river to Clifton, about 20 miles. They first appear at The Dalles in the middle of April, about two months after their first appearance at the mouth of the Columbia. They appear in great quantities at The Dalles about the middle of June, or two months after they appear in large numbers at the bar. The falls of The Dalles are 200 miles up the river, which would indicate that their rate of progression to that point is about 100 miles a month.

It will be noticed, however, that these statements are made in regard to the early run of salmon. The later fish probably travel more rapidly, and the fall run, in the Sacramento at least, make very quick time from the mouth to the headwaters of the river.

To what extent the salmon in the ocean are destroyed by larger predaceous fish is, of course, not known, but there is no doubt that great numbers are destroyed full grown at the mouth of the Sacramento by seals and sea lions. After the salmon ascend the rivers they are comparatively safe, except from otters and ospreys and fisher cats, but the number that these destroy is very small compared with the whole.

Strange to say, the quinnat salmon is spawning somewhere on the Pacific Coast waters of the United States seven months in the year. In January they are spawning in Eel River; in July the summer run are spawning at the headwaters of the McCloud and Little Sacramento; in August and September farther down these rivers; in October the fall run has begun at the McCloud and below, and this run continues spawning through November and into December.

In the Columbia and its headwaters there is, so far as I can learn, only one spawning season, beginning at the headwaters possibly as early as July. At Clackamas station, 125 miles from the mouth of the Columbia, they begin to spawn about the middle of September and continue until November.

When the salmon are prime (just from the ocean), both sexes look very much alike—in fact, they are almost identical in their appearance; but as the spawning season approaches, and they gather on the spawning-grounds, the difference in the looks of the males and females becomes more and more marked, and during the spawning season the difference is very conspicuous.

The now fully developed ova of the female gives her sex a peculiarly rounded and plump appearance, but the shape and expression of her head does not change much. On the other hand, the male grows very deep and thin. His head flattens, his upper jaw curves like a hook over the lower, his eyes assume a peculiarly sunken and malicious expression. Large, powerful white teeth, like dogs' teeth, appear on both jaws, and the whole creature acquires an ugly and ferocious appearance.

A few days before they are ready to spawn they hollow out cavities with their heads and tails in the gravel beds of the river where there is a vigorous current, and here in due time the eggs and milt of the parent fish are deposited. They cover the eggs to a certain extent after they are deposited, but not so much as eastern salmon (*S. salar*) do. After spawning, they gradually drop down the river with the current.

The quinnat salmon is not so prolific as the Atlantic salmon, 300 or 400 eggs to each pound weight of the parent fish being about a fair average. An early report of the writer placed the average much higher, but there must have been some mistake about it, for subsequent observations have not confirmed the statement. At Baird station the summer run of salmon usually begins to spawn about the 20th of August and continues until the last week in September. The fall run begins to spawn about the 25th of October and continues probably till Christmas or later, the high water at that season rendering it impracticable to ascertain just when the spawning of the fish ceases.

The eggs are about five-sixteenths of an inch in diameter, and of a deep salmon-red color, with a specific gravity sufficiently greater than that of water to cause them to sink at once to the bottom when placed in water.

The first eggs of the summer run taken at Baird station hatch in about 35 days, in an average water temperature of about 54° F. In their natural spawning-beds in the river itself, the eggs of the summer run are probably all hatched by the first week in December, and most of the eggs of the fall run by the 1st of March.

It is not known what percentage of eggs is hatched in the natural beds of the river, but by careful impregnation 95 per cent or more can be hatched artificially, even when the hatching is conducted on a large scale. Very little trouble is experienced in hatching the eggs, and when they are hatched no more beautiful sight can be imagined than that of the swarms of young, exquisitely colored alevins in the hatching-troughs. The alevins also remain very healthy with a suitable supply of water, and in two or three weeks develop their singular instinct to dive down underneath everything that they can get under. In consequence of this instinct, when left to their natural conditions in the rivers they bury themselves under the gravel bed of the stream, where, although without any means whatever of defense or escape and utterly helpless, they are nevertheless, by this wonderful provision of nature, absolutely safe until, their yolk sac having become absorbed, they have to come out of their places of refuge to get something to eat.

After the young fish come out of their hiding-places in the gravel, they at first gather together in schools, but soon begin to separate, after which they are so rapid in their movements that it is a pretty active bird or fish that succeeds in catching many of them. In the course of the summer following the hatching season, they flock together like blackbirds in the fall, and make their journey to the sea; and the next time we see them they are ascending the rivers to continue their endless round of reproductive life.

I can not close this subject without referring to the mystery which hangs over the question of the length of the stay of the quinnat salmon in the ocean. The problem is this: There is not a shadow of a doubt that more than nine-tenths, if not ninety-nine hundredths, of the summer run of salmon that come up the tributaries of the Sacramento to spawn end their lives immediately after spawning, but the next year, before their progeny are 6 inches long, another set of full-grown, mature salmon come up the river and spawn and die, and the next year the same, and so on. Now, the question is, Where did this second lot and third lot come from, and *where were they the year before they came up to the spawning-grounds?* If, being anadromous fish, all the Sacramento quota of salmon in the ocean came up to spawn any one year and died on the spawning-grounds, how could there be any run to come up the next year and the next? It seems almost as puzzling as the old question, Which came first, the hen or the egg? If the hen laid the first egg, where did the hen come from?

The mystery in regard to the salmon has so far remained unsolved, and probably will remain so for some time to come. The writer does not claim to furnish an answer, but would merely suggest that it may be possible that out of each annual batch of eggs that are hatched different portions of the fish created from them may remain in the ocean different lengths of time before they reach the reproductive stage of life, which hurries them up the rivers to perpetuate their species. This would supply a solution of the problem, but, like the theory of evolution, it is not at present supported by evidence.