THE KARLUK HATCHERY.

By Harry Clifford Fassett,
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The following notes concerning the salmon hatchery maintained by the Alaska Packers Association near Karluk, Kadiak Island, Alaska, are based upon an inspection made in accordance with instructions of Captain Moser August 8, 1900.

The plant is a model one. It is located on the southern shore, at the eastern end of the Karluk Lagoon, near the outlet of Karluk River, where a streamlet, called by the hatchery people Shasta Creek, enters the lagoon from the hills to the southward. From the rising ground immediately back of the hatchery Karluk Head, 3 miles west (magnetic), may be seen over the intervening low points, with the cannery buildings of Karluk Spit showing to the right of it. Here ground was broken for the hatchery May 28, 1896, and on August 29, the same year, construction work was so far advanced that stripping was begun. The actual cost of the present plant is said to be fully $20,000, and the annual expenditure about $10,000 for maintenance, repairs, and labor. Considering the extent of the establishment, the rate of wages necessarily demanded from its isolation, the long period of incubation, and expensive methods of securing stock fish, this hardly seems excessive.

In 1897 a party from this vessel visited this hatchery, the results of whose observations are contained in Captain Moser's report upon "Alaska Salmon and Salmon Fisheries, 1897," pages 155–157, to which attention is invited.

Since then the establishment has been considerably improved, without, however, increasing the egg capacity of the hatching-house; in fact, this has been reduced by one trough, which was removed to make room for the hot-water drum of the heating system. A number of new ripening ponds have been made, the rearing or nursery pond enlarged, and the original ponds remodeled. In the main building the dining room and kitchen have been moved upstairs, an additional room built out in front, the basement enlarged and partly cemented, heating system enlarged and improved, and an electric-light plant installed. The latter has a capacity of about 40 lights, with 25 outlets at present, and the power is generated by a small Pelton wheel fed by a 6-inch pipe under a head of about 60 feet.

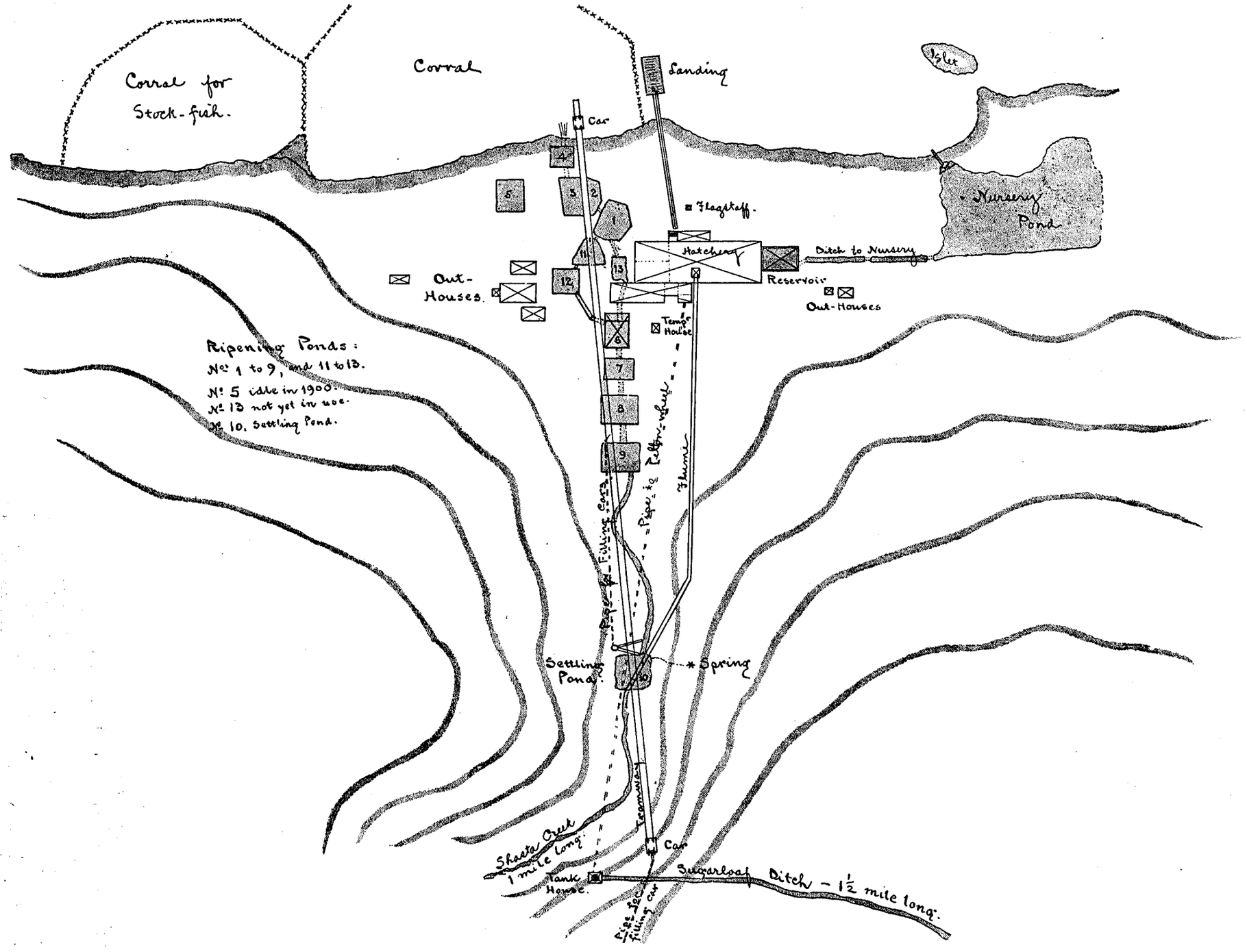
The main building, 32 feet by 100 feet, faces to the northward (see sketch). Immediately west of it are a tramway and line of ponds, the latter extending down the slope along the original bed of Shasta Creek northward to the beach. Abutting the eastern end of the hatching-house is a covered pond known as the "reservoir," and beyond, in the same direction, a narrow ditch leads to the nursery pond. A plank walk extends from the hatchery steps across the narrow beach flat to a short wooden pier which ends at a condemned lighter weighted with stones, forming the landing place. Immediately westward of the landing are the corrals. On either flank of

the main building are small outhouses, sheds, etc., and close to the rear entrance is a small shed where the thermometers are kept. South of the hatching-house, at the head of a small ravine and on the edge of a narrow undulating terrace in the hills, the present sources of the water supply are brought together.

Shasta Creek is a tiny rill draining the low hills to the southward and westward, and has an average volume of about 10 miner's inches of clear water of excellent quality; it is about a mile in length from its source to the lagoon. "The Ditch" comes in from the eastward, and carries the waters of a small creek flowing down the side of a mountain, about a mile distant, which is locally known as Sugarloaf Peak. The bed of the ditch is now well settled and ballasted, smooth, free from sudden drops, falls, or riffles, of a very gradual pitch, and carries an average of between 25 and 30 miner's inches of clear, colorless water of excellent quality; it is about 1½ miles long. At the end of the ditch its waters are received by a shed-covered tank (the "tank house"), in the bottom of which is the connection to a line of 6-inch piping leading to the hatchery below; a branch of this system supplies the Pelton wheel. The escape or waste from the tank-house finds its way into Shasta Creek, close by. From this point to the lagoon beach is about 200 yards in a straight line.

The waters of Shasta Creek are first tapped by a line of iron pipe a short distance above the tank-house; this pipe is used for filling a car at the upper end of the gravity tramway, which is close to the tank-house. The creek passes to northward and westward of the tank-house and plunges down the small ravine previously mentioned, and about one-fourth the distance to the beach ends in the highest pond. From this pond, called No. 10, or the "settling" pond, a wooden flume carries part of the water into the upper part of the hatching-house, while the overflow escapes via the old creek bed to the next pond below. The settling-pond also receives, in its northeastern corner, the waters of a small spring running the year round; this corner of the pond never freezes. The escape of pond No. 10 is tapped to supply another short line of piping which leads northward to the next pond, where it is used in connection with the tramway. This pond, No. 9, is the upper ripening pond and located about midway between the tank-house and the beach. In close order, terraced northward down the gentle slope, are ripening-ponds No. 8, No. 7, and No. 6, the latter housed in. From No. 6 the waste water escapes through open ponds No. 12 and No. 11 into No. 1, and, by another outlet, to pond No. 13 and thence to No. 1. From pond No. 1 the water passes in turn through No. 2, No. 3, and No. 4, and thence into the East Corral. Pond No. 5 is out of the direct line of the system, and was not in use in 1900. No. 13 was built this season, but had not been placed in use at the time of my visit. None of the water used in the ripening-ponds goes into the hatching-house.

The supply for the hatching-house is first by the pipe-line which leads from the ditch (via the tank-house), and next by flume from the settling-pond. The settling-pond is quite deep, much more so than any other, and receives its feed so gently as not to stir the sediment from the bottom and roil the water. As its name implies, its function is to allow the small débris carried by the creek to settle before passing on into the flume or to the lower ponds. The discharge, whether from the pipe line or the flume passes into a filter in the upper story of the hatching-house, thence into a tank, from which it is piped to the troughs. The waste water discharges into the



SKETCH PLAN OF SALMON-HATCHING PLANT, OPERATED BY ALASKA PACKERS ASSOCIATION AT SHASTA CREEK, KARLUK LAGOON, KADIAK ISLAND.

Scale and dimensions arbitrary.

reservoir, and from it escapes through the narrow ditch already mentioned into the nursery, or rearing-pond, whence it passes through a short flume into the lagoon.

As far as the circumstances have permitted, the ripening-ponds have been dug rectangular in shape, and as opportunity affords they are walled up with rubble and cement. The floors are of broken rock and gravel, but it is the intention to cover these with cement also as soon as time permits. The fish do not ripen well in dirty water, and their frequent violent movements stir up any mud which may be on the bottom or in the interstices of the sides. The same movements of the fish tend to keep in suspension any slime or other foreign material, which thus passes out through the wasteway, and this is so slight where the ponds are walled solidly that no deleterious effects are apparent, even after the water has passed through several ponds full of ripening fish.

All the upper ponds have sufficient fall between one and another for excellent aeration, a most important consideration where many fish are impounded. Covered pond No. 6 has the best arrangement for aeration, which may be described as follows: The feed water passes through a wooden trough suspended horizontally over the pond and extending longitudinally toward the center. The bottom of the trough is about 4 feet above the surface of the pond, and is pierced by numerous auger holes, through which the water falls in tiny streams. Besides giving perfect aeration this method distributes the supply over such a large area that the impounded fish are less excited than is the case where the same volume enters in a single stream; they keep more quiet, ripen more quickly, and if they do leap do not strike against anything which will bruise them, but merely fall back into the pond again. This arrangement will be extended to the other ponds whose relative elevations will admit of it, as opportunity offers. The low ponds, No. 3, No. 4, and No. 5, have not given satisfaction, and this is due probably to lack of adequate aeration. No. 2, however, though on practically the same level as No. 3, is an excellent pond, but its superiority is thought to be due to being tightly walled, and consequently cleaner than its mate. No. 5 is expected to prove satisfactory after it has been cemented.

When a pond is to be gone over for ripe fish the water is lowered to a depth of about 21 inches, or knee-deep, the waste gates being arranged to let it fall to that depth, but no less, for fear of smothering the fish. A panel of slat fencing is then lowered into the water at one end and pushed slowly toward the opposite side of the pond, the spawn-takers wading behind it. The fish are carefully dipped up, examined, and if found ripe for spawning placed in a floating car, made of slats, for future attention; if still green they are freed in the pond behind the fence. This method of handling the impounded fish has proven the best with the delicately organized red salmon, and explains the importance of having the ponds of a regular shape; thus every fish can be handled and every ripe one secured with the least injury. After the operation has been completed the fence is removed and the live-car of ripe fish towed gently alongside the stripping platform, of which there is one at each ripening-pond.

Stock fish for the hatchery are secured by seining crews working under the orders of the superintendent of the association's canneries at Karluk Spit. These crews are composed of natives who are borne on the cannery rolls. The principal seining-ground is on the northern shore of the lagoon, opposite the hatchery, from

the mouth of the river downstream to a rocky point three-quarters of a mile westward. After a seine haul is made the live fish are bailed into two live-cars, composed of old dories and skiffs with square ports cut between each frame, over which galvanized wire netting of 1½-inch mesh is stretched. Two men in another boat then tow the live-cars across to the corrals, where the fish are tallied out. It has been observed that it is much better to impound the stock fish, especially early in the season, in a large inclosure. When first taken they are exceedingly restless, chafing under restraint, and if closely confined soon become scarred and bruised, causing fungoid growths to appear quickly. The nearer the adult fish approaches maturity the more quiet it becomes.

The corrals are two in number, and cover an area of about 3 acres, the East Corral being about twice as large as the West. At high high water there are about 10 feet of water at the outer edge of the corrals and at the inshore edge about 2 or 3 feet; the rise and fall here, extreme range, is about 5 feet. The corral fences are composed of wire and cotton netting, the latter above, stretched between piles and stands of old iron pipe. Everything but the piling is removed after spawn-taking ceases for the season; the piles are secured after the ice loosens them in the winter and are then hauled ashore.

The mortality of the fish seined is greatest in the corrals, as they receive the roughest treatment in the process of first capture. In discharging the live-cars into the East Corral the cars are brought bodily inside the inclosure through a movable panel, after which the fish are dumped out. At the West Corral the cars are towed alongside an opening above the water line and the fish dipped over from the outside.

In taking fish from the corrals for the ripening ponds the seine is again employed, the one used being about 12 fathoms in length. This is hauled into the shoal water off the lower end of the tramway; four large floating cribs of slats are then secured to the cork line outside, two being for bucks and two for females. The fish are then picked out of the net as tenderly as possible and examined; if too green they are passed back into the corral. When the cribs have been filled with a sufficient number they are hauled alongside the tramway and the fish dipped out into a car, previously filled with fresh water, in which they are transported to the pond prepared for them and there left to ripen. When fish which are quite or nearly ripe are secured they are taken care of separately. A number of fish nearly ripe are often taken with the incoming tide from the No. 4 pond, finding their way through the wasteway as the water rises.

The tramway is about 200 yards long and leads from the hill near the tank-house in a straight line, crossing several ponds en route, to the lagoon beach near the eastern end of the East Corral. It is a gravity road, built of plank, and its chief purpose is the hauling of stock fish to the upper ripening-ponds. Two strongly built cars, connected by a manila cable, are used, one at each end of the line. After the lower car, which is much smaller, has been filled with water and live fish the larger one at the upper end is loaded, also with water, its greater weight hauling the lower car to the upper ripening-pond, No. 9, midway of the tramway, where the two cars meet. Intermediate stops, as required, are made at the lower ponds. After discharging the fish from the lower car enough water is drawn from the larger one to change the preponderance of weight, and the cars then resume their original

positions at either end of the line. This method of transportation is an old one, much used by mining men.

As already indicated, there is a spawning platform adjacent to each ripening pond, and as but one of these is covered the spawn-taking is conducted almost wholly in the open air. In 1900 no spawning was done at one of the ponds, it being used for the bucks alone. The methods employed on the spawning platform and in the hatching-house were originally those followed at the salmon stations of the United States Fish Commission, and more especially at the quinnat hatchery at Baird, Cal., the changes inaugurated being the result of subsequent experience in the handling of the more delicate red salmon.

Spawning is done by hand exclusively; strait-jackets are not necessary with these small fish. One hundred and fifty is counted a big day's stripping, though as high as 224 have been handled. The spawn pans are circular, 9 inches in diameter at the top, beveled to 7 inches across the bottom, and 3½ inches deep; a thin coat of asphaltum lacquer prevents their rusting and renders them easily cleansed. Two methods are employed in the taking of spawn; the first method, which is considered the better, is the "dry," the mixing of eggs and milt being done with the fingers. The eggs are not washed, but are placed directly in the baskets within two or three minutes after stripping. The second method is similar, except that after the two or three minutes have elapsed a little water is added; they are then allowed to stand until adhesion ceases and basketed without washing. When circumstances permit, the milt of two bucks is used to fecundate the eggs of one female.

Twenty-five females are reckoned to a full basket, which, at the estimated average of 3,000 good eggs per fish, gives a total capacity of 75,000 eggs per basket. The diameter of the redfish egg ranges between 0.10 and 0.31 inch, with an average of about 0.22 inch. It is much lighter in color than the egg of the quinnat salmon, and has a very delicate appearance. At Karluk it has been found that redfish run from 2,500 to 4,500 eggs, in rare instances 5,000, and that a fair average will be about 3,700; but there is, of course, a certain unavoidable loss in the spawning operation, and frequently a large number of eggs come from the fish dead; 3,000, therefore, is a fair average.

A glance at the sketch plan of the hatching-house will give a fair idea of its interior floor arrangement. There are 12 sets, or sections, of 4 troughs each, and 1 set of 3, making a total of 51 hatching-troughs. These troughs all measure 14 feet in length, 16 inches in width, and 7 inches in depth inside. They are built of clean-grained redwood, all sides surfaced, and all 2 inches thick. In making the joints a thick coating of asphaltum tar is spread over the parts to be joined, with an even layer of cotton wadding as calking material. The completed trough receives a coat of refined tar and two coats of asphaltum varnish. Built in this manner and properly supported the troughs will not warp or spring, and there has never been the slightest difficulty from leaks. This is an important consideration in the hatching-house. Not only do leaky troughs add greatly to the waste of water and keep the employees uneasy concerning the amount of water getting to the eggs, but the unavoidable jarring and other shocks connected with the necessary repairs are frequently fatal to a large number of eggs. A dry trough makes a dry hatching-house, and in a dry house only will the best efficiency of the egg-picking crew obtain. Where one has to stand on a wet

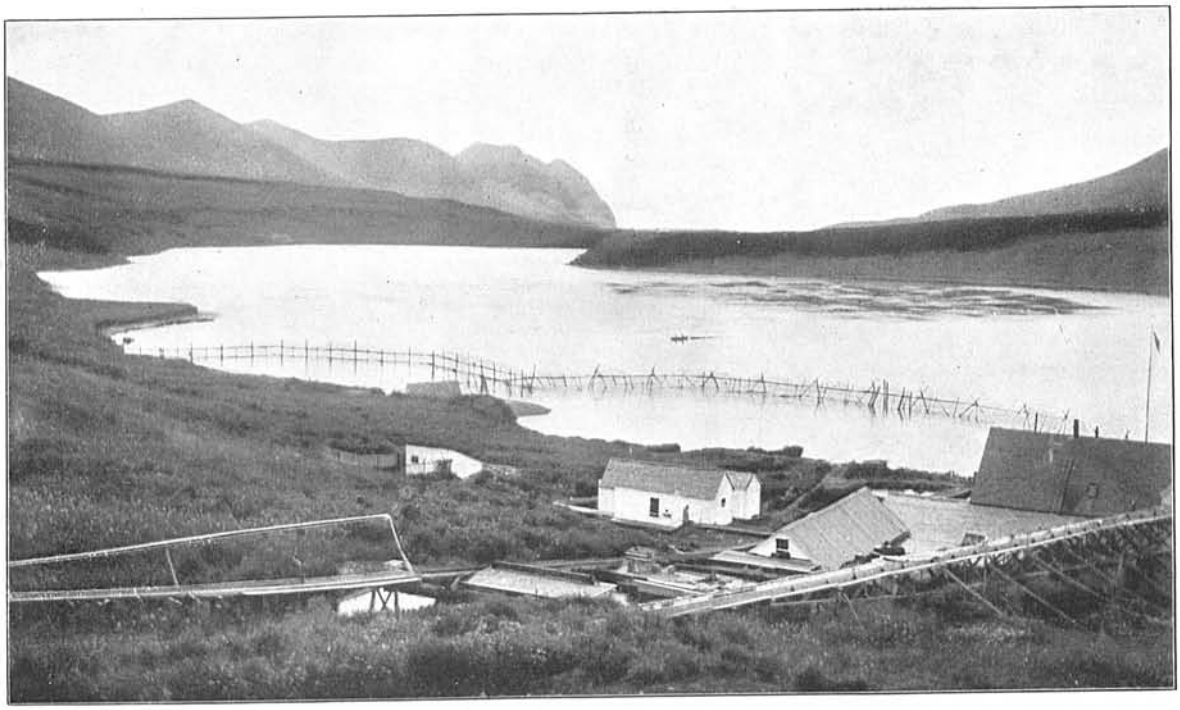
cold floor all day in a chilly, drafty room, at work requiring deftness of touch and close attention, considerable endurance is needed physically, and it is by no means unusual at hatcheries to have to call in new help while the regular hatching-house force are suffering from colds, rheumatic attacks, etc. In a dry, well-lighted hatchery the interest of the fish-culturist does not wane from physical causes, and the eggs and fry consequently receive the benefit of these comforting features. Nearly anyone will hurry through with his allotted number of baskets in a sloppy, cheerless, and chilly barn, slighting the work in spite of himself, and yet the same person would almost always give intelligent attention to a task which he finds extremely interesting under physically comfortable conditions.

Besides the superintendent the permanent force of the station numbers 6, including a cook. All the regular work of fish-culture is done by this force, and a large part of the building and permanent improvements is executed by the same persons. When additional labor is necessary a request is made upon the superintendent of the association's canneries at Karluk Spit.

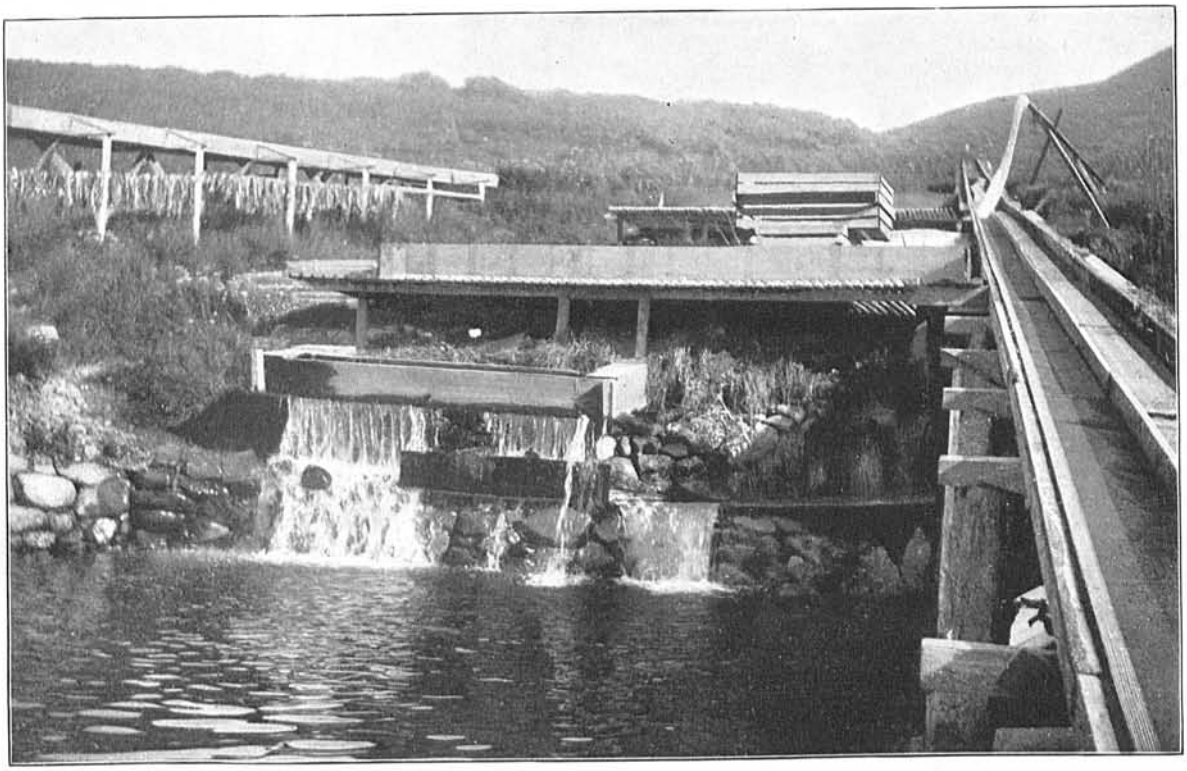
A furnace in the basement of the main building, directly under the hatching-house, heats the water for a system of piping used solely for artificial heating. A set of coils is arranged directly under each section of troughs, and there is also a system of piping on the bottom of the reservoir pond. When artificial heat is employed in forcing the hatching of the eggs the steam boiler is placed in use to drive the pumps. The latter draw the water from the reservoir pond, where it has been warmed, discharging it into the filter upstairs. It will be remembered that the waste of the hatching-house troughs escapes to the reservoir pond, but before using this warm water again filtering and aerating are necessary. Just enough new water is added to freshen the supply without much reducing the temperature, and very little is needed. If the water were not used over and over again in this manner it would be almost impossible and entirely impracticable to heat it sufficiently during the cold winter months, but the system of aerating and freshening is so well controlled that the feed water remains perfectly good after repeated use.

The feed water of the hatching-house, whether received from the flume or pipe line, is thoroughly filtered before passing into the troughs. Much of the coarser débris, such as straws, twigs, leaves, etc., is cleared from the water at the settling-pond and tank-house, and coarse-mesh wire screens in the lower end of the flume are also employed. Referring to the sketch it will be seen that the filter is simply a set of screens of varying degrees of fineness, arranged in a long wooden trough. The water falls from the flume or pipe upon the upper end of the top screen, which is a long board pierced with numerous auger holes. These holes increase in diameter as the farther end is approached, and the board is given sufficient pitch to cause the water to run down and cover it all, the function of the board being primarily to distribute and incidentally to aërate.

Falling next through a fine-mesh screen of wire netting the water is received in very fine spray-like condition by the last and lowest tray or screen. This is made of burlap, tightly stretched over a strong, light wooden frame, and has proven a most excellent filtering material. After it has become thoroughly soaked the jute or hemp of which it is composed swells closely and tightly, efficiently cleansing the



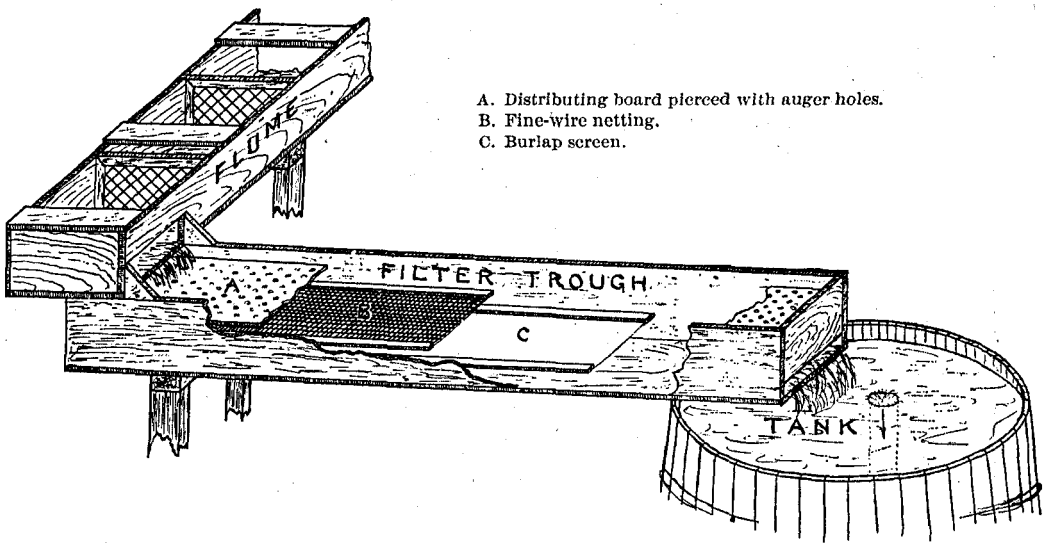
KARLUK HATCHERY, SHOWING CORRALS, AND IN DISTANCE EEL-GRASS BED.



A RIPENING POND, KARLUK HATCHERY.

water of very fine particles. With the more than usually excellent quality of water here, and its lack of foreign material, the above arrangement is found to meet the requirements of filtering. Where a refinement of this feature is necessary, however, it will readily be seen that there is no limit to the extension of the number or fineness of the screens.

The burlap used is of a slightly superior quality to the ordinary bagging, and in addition to its efficiency has its cheapness to recommend it. When stretched on frames it should be evenly secured, as its shrinking tendencies cause it to tear where the strains are unequal. The frames should be small and in sufficient number to allow of at least two changes in addition to the set in the filter trough. This is necessary, as the burlap will rot if left continuously in water, but if removed and thoroughly dried every ten days or two weeks the screens will last a long time. Four or 5 feet is a good length for the frames. When using more than one set of burlap or cloth screens care should be observed that the joints between the ends of the frames do not occur directly below each other; they should be staggered—that is, designed to occur at different intervals—the reason for which is plain.



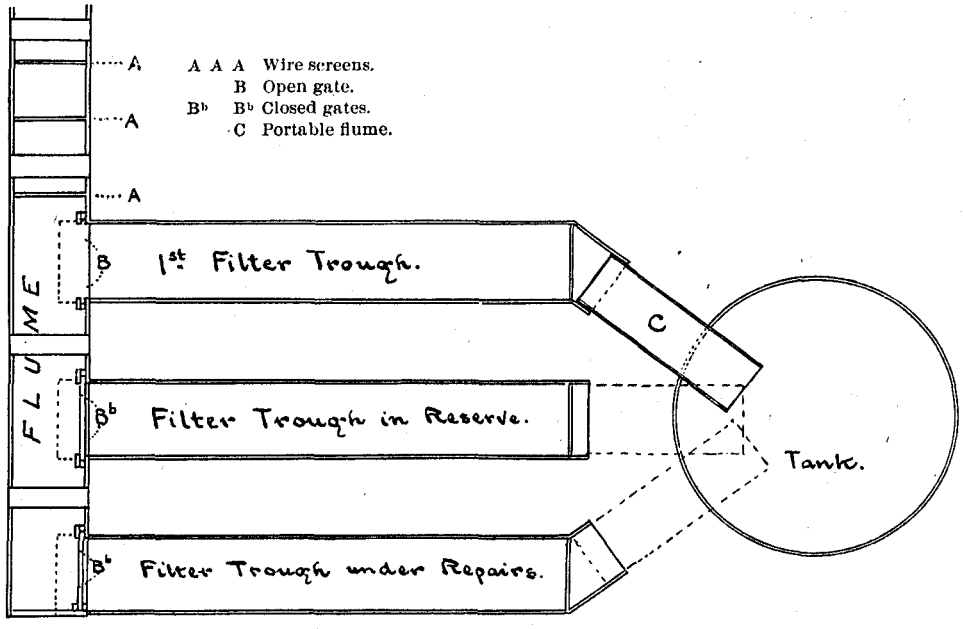
Perspective sketch of Richardson filter.

While there is as yet but one filter trough in the hatchery at Karluk, the superintendent, Mr. James A. Richardson, is a strong advocate of three, arranged somewhat as shown in the sketch. This will allow one to be in use, one in reserve, and the third under whatever repairs it may require. With a long hatching season and a long nursing period little opportunity is offered to overhaul so important an adjunct as the filter if to do so requires that it be placed temporarily out of commission. As the expense is slight, such an arrangement has much to recommend it.

It is stated that fungus has never caused trouble at the Karluk hatchery under the present management; at the old station, less than a mile westward on the same side of the lagoon, much difficulty was experienced from this cause. It is due to dirty water, unclean troughs and baskets, and careless and insufficient picking of the

eggs; it is likewise sometimes caused by too sluggish a current in the troughs, too small a supply of feed water, lack of aeration, or from using the water over too many times. In many cases fungus will not occur if troughs and baskets are kept clean and the water is properly filtered.

The troughs are designed to hold five baskets each, allowing for the necessary space between each for division plates, as well as the compartments at each end for receiving and aerating and discharging the flow of water. The aerators are of tin of the usual pattern and distribute the water well; at the opposite end of the trough is the usual arrangement of drainage plugs. The division plates are arranged according to the so-called Williamson system; that is, the first plate rests on the bottom of the trough with the water flowing over it, and, a short distance beyond, the second plate comes flush with the surface, but allows the flow to pass under it, the most



Plan of Richardson filter troughs.

approved method of conducting feed water through salmon eggs. Instead of rigid plates sliding in grooves at set intervals, division plates of light galvanized sheet iron, thickly asphalted, are used; these are half an inch longer than the width of the trough and are snapped or sprung in at any point desired. A drop of about 1½ inches is given each trough, and the water is used four times before discharging into the waste trough.

The waste trough is a continuous wooden box, built of heavy redwood boards, which passes under the lower, or fourth, trough of each set and carries off the entire waste of the hatching-house; it passes around the south wall and part of the east wall and thence into the reservoir, where it discharges.

The baskets are 24 inches long, 15 inches wide, and 6½ inches deep, inside measurement, made of galvanized-wire netting secured to a single wooden frame. The

frames are of clear sugar pine and redwood, 1½ inches wide by five-eighths inch thick. The netting is five-eighths inch in the length of the mesh and 6 meshes to the inch, which is found the best size for redfish eggs; netting with 5½ meshes per inch has been used, but this is a trifle large. Baskets with a single wooden frame around the top are found quite rigid enough and have a great advantage in the small space occupied by a large number when stored away, the absence of the lower frame admitting of very snug nesting.

While the capacity of each trough is 5 baskets, it is preferred to use not more than 4 per trough, reserving the fifth space for "fleeting" in cleaning. It has been found that redfish eggs require the cleanest of troughs and baskets, as well as the most careful handling. The troughs are therefore cleaned as frequently as circumstances will admit, never less than once a week, and as often as every other day when possible. Thus, by having the fifth space unoccupied the entire trough can be thoroughly scrubbed without lifting a single basket of eggs; all the baskets are moved one space toward the lower end of the trough and returned to their original positions one at a time as their respective spaces are cleaned. By fleeting in this manner jars are avoided and the eggs remain water-borne at all times—an especially essential desideratum during the tender period.

As previously mentioned, a full basket of redfish eggs is reckoned as containing 75,000. Thus, with 51 troughs equipped with 4 baskets each, or 204 baskets, the hatching-house capacity may be conservatively given as 15,300,000 eggs; and by crowding in 5 baskets to a trough, making a total of 255 for the house, the capacity can be increased to more than 19,000,000. These figures merely show the number of eggs which may be placed in the baskets at one time, or what the hatching-house will hold without using the baskets over again. Generally it does not follow that this is the capacity for the season, but unfortunately it does at Karluk. Here the period of incubation is so long that eggs taken at the very opening of the salmon run, say the latter part of May, will not be hatched out until the close of the season, late in September, after which but a trifling percentage of the spawn is taken. The number of eggs basketed prior to July 1 is also quite small, and the gain in capacity is therefore too trifling to be taken into consideration. Hence these figures may be accounted correct as they stand.

It is unfortunate that a full series of data is not available for an analysis of the period of incubation under the various prevailing conditions. Until this season (1900) the superintendent has been unable to keep complete records of anything beyond the merest outline of the season's work. A detailed record of temperatures and the duration of the various stages of incubation, representative of baskets of normal eggs taken at regular intervals during the stripping season, is being kept now, and it is believed this material will be available for study later. These observations will be carried on until the last of the fry shall have been planted. Such data, however, as could be obtained is herewith submitted, believing that much of it will be of interest and that possibly some of it may prove of value in the future.

In 1896 spawn-taking commenced on August 29 and was continued at intervals of two or three days until November 28, 3,200,000 eggs, in fair condition, being basketed during this time. Considering the diseased state of most of the stock fish secured, that this was the first season of operation, and that the plant was still in

a partially unfinished state, the result was deemed good. Impregnation by the methods at first employed was not always assured, and the losses were in consequence somewhat augmented.

After stripping began daily temperature observations of the hatchery water were recorded, from which the table below has been condensed. The highest temperature recorded during the summer (1896) was 48° F., and the lowest, during the following winter, 33° F.

Month and year.	Temperature of hatchery water.			Month and year.	Temperature of hatchery water.		
	Max.	Min.	Mean.		Max.	Min.	Mean.
	°	°	°		°	°	°
Sept., 1896	45	36	42.5	Jan., 1897	35	33	+34
Oct., 1896	40	35	39	Feb., 1897	35	33	+34
Nov., 1896	36	33	35.2	Mar., 1897	34	33	33.8
Dec., 1896	35	33	+34				

These figures represent the temperature of the feed water as it came from the creek under natural conditions. During part of the time the water in the hatching-troughs was warmed artificially and the temperature there was somewhat higher. Unfortunately no exact data of thermal conditions during the forcing or hastening process were kept, but it is stated that the temperature was slowly raised 10° or 12° above that then prevailing, and then kept at that point, about 46° to 48° F.

The temperature of the air outside of the hatchery for November and December, 1896, and January, February, and March, 1897, is summarized as follows:

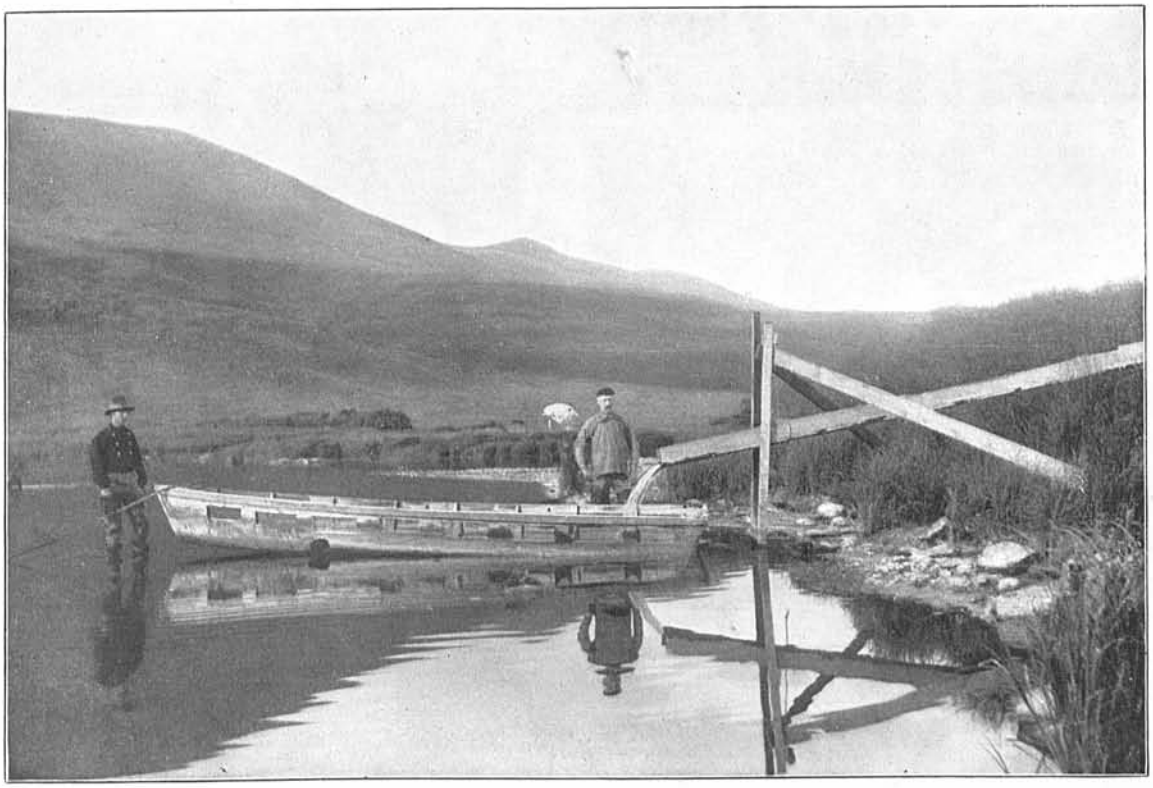
Temperature.	Period.
	Days. hrs.
Between 10° below and zero	2 15
Between zero and 10° above	5 21
Between 10° and 20° above	21 7
Between 20° and 30° above	41 11
Between 30° and 40° above	71 4
Between 40° and 50° above	8 14

The eggs taken August 29, 1896, eyed in 60 days, with the water in the troughs ranging between 45° and 35° and the mean 40.5° F. These eggs hatched out in 165 days. The eggs taken September 16 eyed in 100 days, with the temperature ranging between 44° and 33° and the mean 36.2° F. These also hatched in 165 days, but during the last 42 days of the incubating period artificial heat was used. The eggs taken September 23 were eyed in 111 days, temperature ranging between 43° and 33° and mean 34.5° F. Artificial heat was employed to hasten development during a period of about six weeks at the latter end of this period.

In 1897 spawn-taking was carried on from August 19 to December 9, and 2,285 females were stripped. Less than 1 per cent of them were spawned in August, about 85 per cent in September, and 14 per cent in October, November, and December. From September 6 to 20, only 15 days, 65.5 per cent of the salmon were spawned. The greatest number spawned in one day was 224, on September 25.

Concerning the relative proportion of males to females taken and their mortality in the stock ponds, or corrals, the following note is of interest: Of 6,640 salmon

TRANSFERRING STOCK FISH TO CORRALS AT KARLUK HATCHERY, KADIAK ISLAND.



METHOD OF DRAWING OFF FRY FROM NURSERY POND, KARLUK HATCHERY, KADIAK ISLAND.

impounded in the river corral, 4,170 were males and 2,470 females. Of 3,292 dead salmon removed from the corral, representing the loss in the inclosure for the season, 1,998 were males and 1,294 females.

The amount of spawn placed in baskets during the 1897 season was not learned, but the superintendent stated that "fully 6,000,000 fry were 'turned out' from the eggs taken in 1897." To this should be added the amount of eggs lost in the hatchery troughs, say 20 per cent, and the loss from malformations, etc., say 6 to 10 per cent. It is estimated that about 5,000,000 fry were planted.

The facilities of the establishment had been much improved since the preceding year, spawn-taking was conducted under much better circumstances, and the experience gained may also be considered a material factor in this season's hatching-house results. It was observed that the fry hatched were more vigorous and healthy in appearance, though hatching more slowly. The eggs taken August 19 were *hatched* in 210 days; those taken October 7 and November 2 were 123 and 138 days, respectively, in simply *eyeing out!* No artificial heat was used in hastening the development of the ova that year—season 1897. Beyond the foregoing there are no data available concerning the hatching period, etc.

Preparations were being made at the time of my visit to increase the hatching-house capacity by 13 more troughs, to bring the total up to 64; to extend Sugarloaf Ditch so as to tap the waters of another stream farther to the eastward, a mile or more; to extend the nursery system, and to improve the present retaining or ripening ponds in the manner previously outlined.

The following shows the temperature recorded in the hatching-house feed water:

Month and year.	High.		Low.		Mean.	Month and year.	High.		Low.		Mean.
	Max.	Mean.	Min.	Mean.			Max.	Mean.	Min.	Mean.	
	°	°	°	°	°		°	°	°	°	°
Apr., 1897...	37	−37	33	34.7	35.8	Nov., 1897....	39	+36	33	35.1	35.5
May, 1897...	47	43	34	37.7	40.3	Dec., 1897....	39	36	33	35.3	35.6
June, 1897...	50	47.7	40	42.5	45.1	Jan., 1898....	36	34.8	33	34.3	34.5
Sept., 1897 ..	52	46.3	37	42.8	44.5	Feb., 1898....	36	34.6	33	34.2	34.4
Oct., 1897 ...	45	39.1	33	37.7	38.9	Mar., 1898....	39	36	33	34.6	35.3

The temperature of the air, dry bulb, outside the hatchery during the winter is summarized as follows, for November and December, 1897, and January, February, and March, 1898:

Temperature.	Period.
	Days. hrs.
Between 10° below and zero	0 2
Between zero and 10° above	12 13
Between 10° and 20° above	11 19
Between 20° and 30° above	31 22
Between 30° and 40° above	83 20
Between 40° and 50° above	10 20

The records for the spawning season of 1898 are again woefully incomplete. Some fish are reported as spawned in June, and from July 5 to November 30, 5,000,000 eggs were placed in baskets. Of the latter 80 per cent were taken prior to October 4; the remainder were obtained in gradually diminishing numbers until November 30.

No temperature records whatever are available, but the hatching periods were noted as per table below. The lack of thermal data is deplored, but is accounted for by the unavoidable absence of the regular superintendent the greater part of the time.

Eggs taken in 1898.	Hatched first.		Hatched last.		Mean hatching period.	Range in hatching.	Eggs taken in 1898.	Hatched first.		Hatched last.		Mean hatching period.	Range in hatching.
	Date.	Days.	Date.	Days.				Date.	Days.	Date.	Days.		
July 5..	Oct. 19,1898	106	.....	.....	.....	.....	Sept. 9.	Feb. 14,1899	158	.....	.....	.....	.....
July 8..	Oct. 20,1898	104	Nov. 20,1898	135	120	31	Sept. 10.	Feb. 18,1899	161	May 15,1899	247	204	86
July 11..	Oct. 21,1898	102	.....	.....	.....	.....	Sept. 12.	Feb. 19-20,'99	160	May 15,1899	245	203	85
July 15..	Nov. 6,1898	114	.....	.....	.....	.....	Sept. 14.	Feb. 26,1899	165	May 22,1899	250	208	85
July 17..	Nov. 7,1898	113	Dec. 6,1898	148	132	35	Sept. 15.	Feb. 22,1899	160	.....	.....	.....	.....
July 19..	Nov. 9,1898	113	.....	.....	.....	.....	Sept. 16.	Feb. 21,1899	158	.....	.....	.....	.....
July 21..	Nov. 12,1898	114	.....	.....	.....	.....	Sept. 19.	Feb. 26,1899	160	May 23,1899	246	203	86
July 23..	Nov. 26,1898	116	.....	.....	.....	.....	Sept. 22.	Feb. 23,1899	154	.....	.....	.....	.....
July 25..	Nov. 27,1898	125	Jan. 10,1899	169	147	44	Sept. 27.	Mar. 3,1899	157	.....	.....	.....	.....
July 29..	Nov. 30,1898	124	.....	.....	.....	.....	Sept. 28.	Apr. 11,1899	195	.....	.....	.....	.....
Aug. 3..	Dec. 28,1898	147	.....	.....	.....	.....	Sept. 30.	Apr. 10,1899	192	.....	.....	.....	.....
Aug. 14..	Dec. 27,1898	135	Jan. 20,1899	159	147	24	Oct. 4..	May 1,1899	209	.....	.....	.....	.....
Aug. 26..	Jan. 6,1899	133	Apr. 11,1899	228	182	95	Oct. 7..	May 3,1899	208	.....	.....	.....	.....
Aug. 30..	Jan. 6,1899	129	Apr. 11,1899	224	177	95	Oct. 10..	May 5,1899	197	.....	.....	.....	.....
Sept. 5..	Jan. 15,1899	132	Apr. 18,1899	225	179	93	Oct. 13..	May 8,1899	207	.....	.....	.....	.....
Sept. 6..	Jan. 30,1899	146	May 3,1899	239	193	93	Oct. 20..	May 6,1899	198	.....	.....	.....	.....

From this record the following summary has been prepared:

Eggs taken in 1898.	Hatch first (in days).	Hatch last (in days).	Average hatching period.	Average range in hatching.
July	113	151	133	37
August	136	204	169	71
September	161	242	198	88
October	204	(?)	(?)	(?)

In 1899 there were spawned 2,837 red salmon, as follows:

Spring run.		Fall run.	
Date.	No.	Date.	No.
June 27-30	14	Aug. 28-31	23
July 1-31	1,357	Sept. 1-30	1,178
Aug. 1-10	60	Oct. 1-31	195
		Nov. 3	10
Total	1,431	Total	1,406
			1,431
Grand total for season, 1899			2,837

Of the season's take the spring run therefore amounted to 50.4 per cent as against 49.6 per cent for the fall run. Considering the season as a unit, the monthly percentages of fish spawned are as follows: June, 0.5 per cent; July, 47.9 per cent; August, 2.9 per cent; September, 41.5 per cent; October, 6.8 per cent; November, 0.4 per cent.

Taken at the usual hatchery count of 3,000 eggs per average spawn fish, there should have been basketed more than 8,500,000 eggs, but the superintendent has only credited the hatching-house with 6,000,000, "owing to shrinkage in various ways."

The first eggs were taken June 27 from a few fish, but were not basketed; the milt curdled when it came in contact with the eggs, and it was not thought impregnation would take place. Spawning was again carried on June 30, when the milt once more curdled upon contact with the eggs, and none of the latter were basketed. July 3 the first eggs were placed in the troughs, although the same condition of milt was met with. This curdling tendency continued in a diminishing degree for about a week longer, when it ceased; strange to say it did not affect the vitality of the sperm as far as could be judged. Spawning was carried on about every other day in July, the run slacking up toward the latter part of the month; in August eggs were taken three times up to the 10th, from which time until the 28th none were taken. With the beginning of the fall run work went on once more every other day until the end of September; during October spawn was taken on an average of about once a week, and the last stripping of 10 fish was done November 3. On the last-mentioned date about 40 adult salmon, still unripe, were released from the reservoir and turned into the river.

The period of incubation varies with the temperature of the water, of course, but it is also believed to be of less duration with eggs taken from the spring run than is the case with those of the later or fall run. That is, the eggs of the spring run of redfish seem to have a more vigorous vitality, hatching more rapidly under similar thermal conditions; but this is still a matter of opinion and must remain so until the collection of sufficient data from which to draw careful conclusions.

From the meager figures at hand for the 1899–1900 season the following table has been prepared:

Eggs taken in 1899.	Eyed.	Hatching period.			Hatching range.	Premature births.	Remarks.
		First.	Last.	Mean.			
July 3	30	74	109	92	35	23	
July 13	40	.....	125	.....	.....	.....	
July 15	.....	109	132	121	23	.....	
July 31	.....	93	185	139	92	62	Delicate period, Sept. 1–Oct. 15.
Aug. 3	.....	.....	.....	.....	.....	90	
Aug. 10	.....	127	202	165	83	75	
Aug. 28	65	126	199	163	73	74	Delicate period, Oct. 20– ?
Sept. 7	64	161	266	184	45	.....	
Sept. 10	62	158	214	186	56	.....	
Sept. 14	75	154	218	186	64	.....	
Sept. 20	81	162	223	193	61	.....	
Sept. 30	89	207	237	222	30	.....	
Oct. 14	110	199	230	215	31	.....	
Oct. 27	125	186	.....	.....	.....	.....	
Summary.							
July 3–15	35	91	122	107	31	.....	Spring run.
July 31–Aug. 10	.....	110	193	151	83	.....	
Aug. 28–Sept. 20	69	152	212	182	60	.....	Fall run.
Sept. 30–Oct. 27	108	197	233	215	36	.....	

Eggs taken in 1899.	Eyed.	Hatching period.			Hatching range.
		First.	Last.	Mean.	
Spring run	35	100	158	129	58
Fall run	88	174	222	198	48
Season	61	137	190	163	53

NOTE.—In the above table a day of 24 hours is the unit.

It would appear from the above that the eggs eye very much faster with the spring run, and that the hatching range covers a much longer period. It is also apparent that in considering the hatching of redfish at Karluk the two runs must be treated separately—the runs are so marked and the prevailing conditions so radically different. For example, eye-spots have appeared in 30 days in spring-run eggs, and have with fall-run eggs been as long as 138 days before being visible. With the early run eye-spots are looked for between 35 and 40 days, the interval advancing with the season; with fall eggs the eye-spots are not expected until more than two months have passed, the time again increasing with the advancement of the season. The "tender stage" is a variable quantity, difficult to calculate; it is carefully looked for within about three weeks from the stripping, but may not occur for as many months. Its duration is also variable, anywhere from one to five or six weeks, depending upon the temperature, and it is thought, other conditions not yet known. This season, 1900, no tender condition had made its appearance up to August 8.

The period of incubation ranged in 1899 from 74 days to 237 days, and there is a maximum record for some prior season of 244 days. The early run in 1899, under natural conditions of temperature, hatched in an average of 129 days, whereas the fall run required 198 days. Seven months is supposed to be the period of incubation under natural conditions, with the temperature at a mean minimum during the coldest months of between 33° and 35° F., and this seems to be a fairly correct approximation, judging from the record of the October eggs of 1899 and the following temperature record:

Temperatures in hatching troughs, winter 1899–1900.

Month.	Mean maximum.	Mean minimum.	Mean.
	°	°	°
October, 1899	42	40	41
November, 1899	40	38	39
December, 1899	+37	36	−37
January, 1900	−37	+35	36
February, 1900	37	35	36
March, 1900	38	36	37
April, 1900	39	36	+37

In 1900 the seining crew delivered into the river corrals 79,753 adult salmon. Of this number 13,123 escaped from time to time through the water gate when opened to admit live-cars, and through breaks in the corral fences during the time the corrals were in use, 114 days; there were also lost 7,334 stock-fish at a time when the fencing of one of the corrals blew down. The proportion of males to females among these 20,457 fish which escaped alive is, of course, unknown. The remaining 59,296 comprised 33,523 males and 25,773 females, which are accounted for as follows:

	Males.	Females.	Total.
Died on hand	14,324	19,498	33,822
Returned to river alive	19,199	6,275	25,474
Total	33,523	25,773	59,296

Of these fish 7,270 males and 15,579 females, or a total of 22,849, were transferred to the ripening-ponds during the season, as follows:

Month.	Males.	Females.	Total.
June	1,931	3,974	5,905
July	2,296	5,574	7,870
August	2,225	3,658	5,883
September	818	2,373	3,191
Total	7,270	15,579	22,849

No report of the egg-take for the season has been received, but 5,524 females were spawned in all. Applying the usual Karluk hatchery factor of 3,000 per average fish, the take would appear to have been 16,582,000 eggs. Allowing, however, for "other shrinkage in various ways," and judging from the hatchery capacity, 15,000,000 eggs would appear to be a fair estimate.

According to a report from the hatchery, under date of November 3, 1900, all the June eggs and part of the July eggs had hatched out, producing an excellent lot of healthy fry. It was found (1900) that the earlier eggs and the September eggs were the best, while a portion of those taken during the middle of the season were of indifferent quality.

The following temperatures of the water in the hatching-troughs are recorded:

Month.	High.		Low.		Mean.	Remarks.
	Max.	Mean.	Min.	Mean.		
	°	°	°	°	°	
May, 1900	48	43	36	38.7	40.9	
June, 1900	57	49.3	39	41 7	45.5	57° June 28.
July, 1900	57	51	43	45	48	57° July 9.
August, 1900	56	50.2	42	46.3	48.2	
September, 1900	48	46.1	39	43.1	44.6	
October, 1900	46	41	34	40	40.5	
November, 1900	39	36.6	34	36.1	36.3	
December, 1900	38	35.3	33	34.7	35	33° Dec. 22 and 31.
January, 1901	36	34.4	34	34.3	34.3	

The eggs of the redfish readily admit of forcing, but to what extent is not known. Judging from the fact that "freaks" or malformations and prematures occur anywhere from 20 to 80 days, 90 days would seem the limit of safety, but at what temperature the limit is reached is not yet known. At Karluk fall-run eggs have been successfully forced to hatch in 165 days, or say 45 days sooner than would have been the case under natural conditions. To do this the temperature during the last 42 to 45 days—that is, after the one hundred and twentieth day—was artificially raised to 46° and 48°, or 10° to 12° higher than otherwise would have obtained. It has been observed that during warm misty or rainy weather eggs which are nearly ready to hatch will be hastened by several days.

After a basket of eggs has been placed in a trough at the Karluk hatchery it receives the most tender care. For the first two or three days the basket is not touched, but remains "buried" under the canvas tarpaulin; it is then handled once a day for the next four or five days by the superintendent himself, who merely floats the eggs once, very gently, and picks off the dead eggs and "empties" showing on top; after

this, and until the "unctuous" stage has passed, an expert egg-picker removes the bad eggs, the superintendent having previously floated them on top. When the unctuous stage, lasting from eight to twenty days, during which the eggs are very delicate and have a certain indescribable oily appearance, has passed, the basket is henceforth in the hands of one of the hatching-house force, who is responsible for it until the end.

Ordinary tin forceps are employed in picking, but they are critically examined by the superintendent before they are used, to see that there are no sharp edges or corners to cut the tender skin of an egg. Frequent inspection of the forceps continues throughout the season. The eggs are picked very thoroughly until the second tender period begins, usually a short time before eyeing takes place; after this stage has passed the eggs may be handled with greater freedom, but vigilance and tender care are observed throughout the season. Jars, sudden knocks, rapid changes in temperature, or other shocks are particularly guarded against, and a basket of eggs is never lifted from a trough when it can be avoided. In affixing to the trough the small pasteboard tag describing the basket, no hammer is used, but the broad-headed and short, sharp-pointed tack is forced home with the thumb. Great care is taken to keep the troughs and baskets clean, and to have the feed water well filtered. As yet there has not been the least trouble from fungus. There is a slimy vegetable growth which forms on the sides of the troughs under certain conditions, which must be removed, but which does not spread to the eggs like fungus; it is probably some species of fresh-water algæ.

After the fry are hatched out they escape to the bottom of the trough, there being one-half inch clear space on either side of the basket, somewhat more than that under it, and in addition there is the large area at the end of each trough created by the removal of the fifth basket; this gives the fry plenty of room, and they do very well in the troughs. As they age they require more space, but they are usually held in the parent trough until the egg—or umbilical—sac is absorbed, a period of about ten weeks, depending upon the temperature of the water.

The fry must then be fed, which is sometimes done in the trough and sometimes in the reservoir pond. The only food ever used at Karluk has been tinned salmon flesh, "do-overs," furnished from the canneries at Karluk Spit. This is removed from the can, thoroughly desiccated, and then ground up in a fine-cutting sausage mill. For some reason the fry do not seem to thrive on this diet, refusing to take it after ten days or two weeks, and it is therefore the endeavor to plant them as soon after becoming free feeders as is possible; it makes a wonderful difference in the quick growth and development of the fry if they can obtain natural food. The fry appear to be of a generally dormant temperament during the time the sac is being absorbed, and there has been very little loss at Karluk during this period; the greatest losses to fry occur at the time of first feeding.

As they become free feeders they are allowed to escape from the troughs via the wasteway into the reservoir pond, and thence through the ditch into the rearing or nursery pond—a large, irregular-shaped excavation, with an area of about three-fourths of an acre. Owing to the cannibalistic tendencies of the larger fry, the young with the egg sac still attached are kept by themselves. The tiny free feeders, however, seem pretty well able to take care of themselves. As opportunity offers, the fry are taken

from the large nursery pond and planted; or, if the nursery be frozen over, they are taken from the reservoir and parent troughs, where they have been held on this account. After the fry are three or four months old it has been observed that they seem to deteriorate in the nursery ponds, and they are never held beyond this time.

When the ponds and upper part of the lagoon are frozen over, the fry are placed in tanks prepared for them, transported on sleds to the open water, and planted. These tanks are made of clean, strong, salt-salmon barrels thickly coated with asphaltum varnish and rigged with handles, or beckets, of rope. Three of these are a sled load, and comprise a "plant," which usually numbers about 100,000 by this method. When the ponds and lagoon are open and free from ice, the fry are driven out of the rearing-pond at high water, through a short flume, into a live-car made of an old skiff. This skiff, which has a number of square ports cut in its sides, covered with fine mesh wire netting, is brought directly under the short flume, which leads from one corner of the pond to the lagoon beach. It has a capacity of over 200,000 fry. When the live-car is loaded the wire-screen gates are let down across the inner end of the flume and the further exit of fry stopped.

Planting is done at high water along the shores of the lagoon between the mouth of the river and the upper end of the village at Karluk. The location selected depends upon the existing conditions, ice, waves, and the movements of predatory species being considered. As far as possible a rocky shore whose crevices afford safe retreats, away from the entrance of fresh water where trout are attracted, is chosen, and the fry released without further preliminaries. It is claimed that no salmon fry has ever been planted at Karluk with the egg sac not entirely absorbed.

The superintendent firmly believes that the strong free-feeding fry early crave salt water, and he usually has a barrel containing a small quantity of salt submerged in the large nursery pond. It has been observed that the fry collect about this like flies after sweets, and the salt appears to act upon them like a tonic, making them more sprightly and vigorous in their movements.

After being set free the fry have been observed to work downstream alongshore toward the salter portions of the lagoon, which is fairly brackish except at the higher tides, when it is quite salt, or at the lowest tides when the river is full, when the lagoon is practically fresh. Later the fry are seen along the outside beaches in the vicinity of the shaded rocky points, but return to the lagoon at frequent intervals, working in and out with the tides for a long time, or until late in the fall following their birth. Some fry are much stronger and larger than others and grow very rapidly. Two or three were seen in the nursery pond August 8, 1900, which were from 2 to 3 inches in length and very timid. In April, 1897, fry from 1½ to 1¾ inches long were seen in small schools passing seaward from Karluk River, and the fry hatched in the spring of 1898 were from 1½ to 1¾ inches, some 2 inches, in length in the nursery pond in August.

Trout are believed to be the most destructive natural enemies the fry have to contend with. An individual (*Salvelinus malma*) only 2½ inches in length which once found its way into the nursery pond had 12 tiny fry in its maw when captured. The trout are not such active feeders in the winter, and are more sluggish in movement, and it is therefore deemed advisable at Karluk to plant fry at this season. Other natural dangers are also believed to be lessened at this time.

After the trout the greatest enemies to fry are perhaps the sea birds. Flounders and sculpins are too sluggish in their movements, besides being bottom fish, to be very destructive. Sudden storms, raising a heavy sea on the shore along which the fry are schooling, are also dangerous.

The loss of the hatchery in the ratio of fry planted to the number of healthy eggs basketed it is believed at present will not amount to 25 per cent from all causes, although during the first season it was figured at not far from 40 per cent. The greatest present loss is from dead eggs and "empties," or unfecundated eggs. This is not now as much as 15 per cent, and gradually diminishing as experience is gained. The loss from freaks and abortions and premature births, all combined, is nominal, but is greatest in the eggs of the spring run. It is not of itself considered a factor, but is lumped with the losses from other causes. Deaths due to smothering of the tiny fry during the period of absorption of egg sac, through injuries received in various ways while in the troughs and reservoir, with the other losses just mentioned, will make up a conservative total loss of 25 per cent. The superintendent believes his 1900 loss should not be much in excess of 20 per cent unless from some unlooked-for calamity.

The superintendent believes in the *parent region* theory, and thinks that the Karluk fishery has already this year (1900) felt the value and effects of artificial propagation. He thinks that the largest and strongest of the fry planted in the winter of 1896–97 and spring of 1897 have become matured, that this year they returned as breeders, and that their numbers were sufficient to make an appreciable increase in the runs of salmon schooling off Karluk Head, and possibly Ayakulik River. He believes they first put in an appearance as grilse, invariably males, which are thoroughly matured, and that these grilse are 2 years old, that is, from birth. Part of the breeders, he thinks, return in three years, while others of slower development return in four or five years, and it is not beyond the bounds of reason to presume that some may be delayed for an even longer period before reaching full maturity.

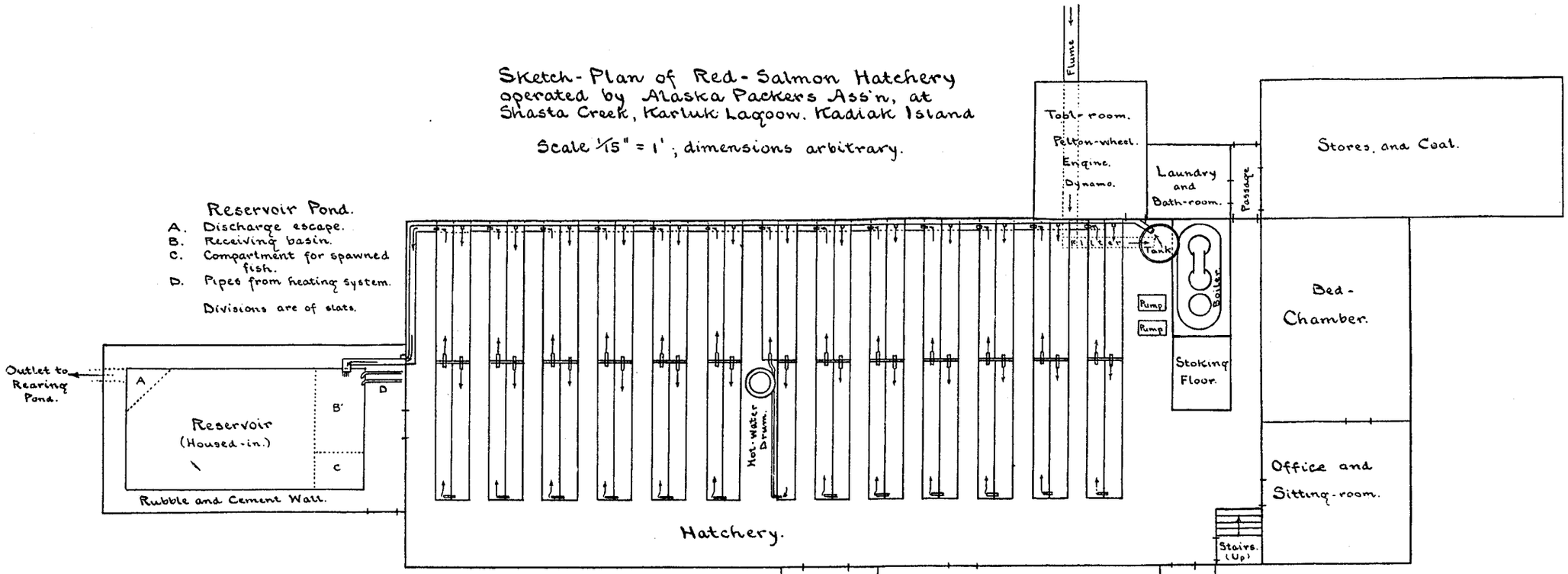
In 1897 the adipose fin was cut from 513 fry, part of which were liberated in Karluk River and part in the lagoon.

The approximate output of the Alaska Packers Association's redfish hatchery at Karluk is estimated as follows:

	Fry liberated.
Season 1896–97	2,000,000
1897–98	5,000,000
1898–99	5,000,000
1899–1900	6,000,000
1900–1901	12,000,000
Total output	30,000,000

Sketch-Plan of Red-Salmon Hatchery operated by Alaska Packers Ass'n, at Shasta Creek, Karluk Lagoon, Kadiak Island

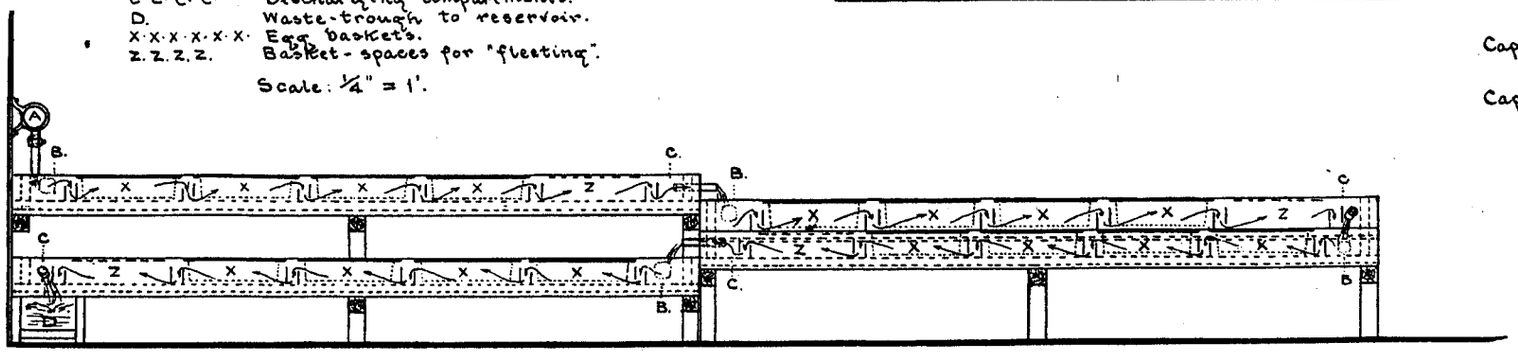
Scale 1/15" = 1'; dimensions arbitrary.



Section of Set of 4 Hatching-Troughs.

A. 6" Supply-pipe from filter-tank.
B·B·B·B· Receiving and aerating compartments.
C·C·C·C· Discharging compartments.
D. Waste-trough to reservoir.
X·X·X·X·X·X· Egg baskets.
Z.Z.Z.Z. Basket-spaces for "fleeting".

Scale: 1/4" = 1'.



Hatching House.

Troughs: 12 sets of 4, 1 set of 3. Total 51.

Capacity of troughs:
4 Baskets each ordinarily.
5 " " if necessary.
204 to 255 Baskets.

Capacity of baskets:
25 females at average of 3,000 eggs, or 75,000 Eggs.

Capacity of hatchery:
Under ordinary cond^ns, 15,300,000.
If necessary, 19,125,000.