

FISHERIES RESEARCH BOARD OF CANADA

Translation Series No. 1039

Artificial propagation of salmon in Japan

By T. Mihara, S. Sano and H. Eguchi

LIBRARY  
FISHERIES AND OCEANS  
240 SPARKS ST., 8th FLOOR WEST  
OTTAWA, ONTARIO, CANADA  
K1A 0E6

Original title: Sake, Masu Jinkoo-fuka Jigyo.

From: Booklet No. 5. Vol. 5 of the series on the propagation of the marine products. Published by: Nihon Suisanshigen Hogo Kyookai (The Japan Soc. of the marine products protection), Vol. 5, July 25, pp. 2-60, 1964.

Translated by the Translation Bureau(TM)  
Foreign Languages Division  
Department of the Secretary of State of Canada

Fisheries Research Board of Canada  
Biological Station, Nanaimo, B.C.

1968

Memorandum

(memorandum 1)

To the Client

FRB 1039

From the translator:

1) I could not find reasonable corresponding English for the following Japanese.

juseiha ----- p. 27 (original p. 27)

mihooshutsuran ----- p. 29 ( " p. 28)

tamasuji-gyomo (fishing net) ----- p. 57 ( " p. 46)

isada (fishing implement) ----- p. 57 ( " p. 46)

I am now asking for the right translation to the author and as soon as I get an answer I shall be glad to inform you.

2) Recently I found a new booklet (published in Dec. 1967), which you might be interest in it, at the library of the Fisheries Department. This booklet is the vol. 14 of the same series of books. The vol. 5 is rather introductory and vol. 14 is more scientific.

The title and contents are as follows;

T. Akita, S. Sano and K. Taguchi:

Propagation of the Chum Salmon in Japan

I. History

Development of the science and technology of Japan.

Prehistory of the artificial incubation method.

Introduction of the artificial incubation.

Incubation experiment in the early stage.

Foundation of the Chitose Central Hatchery.

The natural resources protection system.

The law of the protection of the marine resources.

II. The present aspect of the propagation of salmon and trout (s. and t.) in Hokkaido.

Migration of s. and t.

Present state of s. and t. fishing.

Present condition of the rivers in which s. and t. propagate.

III. The outline of the recent investigations of the reproduction of sake (O. keta).

Sake, Masu Jinkoo-Fuka Jigyo

(Artificial Propagation of Salmon in Japan)

T. Mihara, S. Sano and H. Eguchi

Vol. 5 of the series

of

The Propagation of the Marine Products

Preface

The salmon and trout grow in the fresh water and after they matured in the ocean, they return to the fresh water again and there they spawn. Their reproduction base is almost fixed. To maintain or increase these fish resources, one must increase the reproduction of these fish. This is confirmed between Japanese investigators as well as foreign investigators and they are working to increase the reproduction of the salmon and trout in the fresh water region.

The propagation of the salmon and trout can not expect to increase till an integrated plan of artificial propagaion, such as the protection of both the upstreaming parent fish and the downstreaming fry, and consolidation of the hatcheries, are effectively excuted.

In the thinly inhabited and under-developed regions, the protection of the matured fish is a matter of primary concern, however in the more developed and more dangerous regions a more collective artificial propagaion has been excuted. In Kamchatka and Alaska, a primitive state still exists and except for the natural handicaps the conditions are favorable for the propagation of the salmon and trout. Therefore the protection of both the upstreaming parent fish and the matured ones in the spawning ground is a most important matter. While, in the northern part of Japan, the natural environment is ruined and the human handicaps are increased, therefore an positive aid, such as the artificial incubation, breeding and releasing, must be given for the propagaion of the salmon and trout.

The ecological investigations of the salmon and trout have made remarkable progress in the last ten to twenty years. By utilizing these investigations the propagations protection policy developed and contributed to the security of the salmon and trout resources.

In this booklet the present authors deal collectively with the actual circumstances of the artificial propagation, and they expect criticism, suggestions guidance and encouragement of the people who are interests in this field of science.

1. The migration of salmon and trout to the coast of Hokkaido and its upstreaming period

p.3

Among the upstreaming salmon and trout, sakura-masu (O. masou) are the earliest ones migrate to the coast of Hokkaido. They begin to enter the rivers in April, when snow thaws and enters into the rivers. The best season is from the middle of May to the end of June. Then karafuto-masu (O. gorbuscha) go upstream between the middle of July and the middle of September. Finally, sake (O. keta) go upstream from the middle of September to the end of November.

4

Shiro-sake (O. Keta) is the largest number among the species of salmon, which migrate to Hokkaido. The fishing situation of shiro-sake is as follows. Among the shiro-sake of the North Pacific Ocean, the ones, which appear at the latter term, swim down southward to the east coast of Hokkaido (Nemuro Bay and its vicinity), part of them swim further to the south along the Pacific coast of Hokkaido and some enter to the Sea of Okhotsk. Some other schools move off the Pacific coast of Hokkaido, and pass through the Soya Strait, then one part swim north and enter the river Ishikari, and the other part swim north and enter the rivers in Honshu. Another school moves off the Pacific coast of Hokkaido to the coast of Iwate Prefecture in Honshu. The number of those salmon are unknown. In general, more salmon appear in the east and Pacific coast of Hokkaido than in the west of Cape Erimo (south coast of Hokkaido) and Sea of Japan. It is approved throughout Hokkaido that more sake appear at the mouth and its neighbourhood of the river which have hatcheries, than the coast where there is no river.

The water temperature of the coasts and rivers, in the migrating season is shown in Tables 1 and 2.

Table 1. The temperature of the coast of Hokkaido in the salmon fishing season

<u>Coast</u>	<u>Fishing Season</u>	<u>The best season</u>
Hakodate	5.0 to 17.3°C	12.0°C
Urakawa	4.6 18.1	6.0 to 15.0
Kushiro	2.4 17.3	4.0 8.0
Nemuro	3.5 18.4	6.0 10.0
Nonbetsu	4.7 19.1	12.0 13.0
Soya	4.4 19.2	12.0 13.0

Table 2. The relation between the river temperature and the salmon upstreaming

Sea Division	River	Upstreaming	The best season	Remarks
Sea of Okhotsk	Tokoro R.	1.2 to 13.2°C	7.0 to 9.0°C	at the mouth of river
Sea of Okhotsk	Upper part of Tokoro R.	0.5 to 14.2	3.0 to 7.0	upper part
Sea of Japan	Chitose R.	8.0 to 17.0	10.0 to 11.0	early stage schools
Sea of Japan	Chitose R.	2.0 to 8.0	4.0 to 5.0	latter stage schools
Nemuro Bay		1.5 to 14.0	8.0 to 11.0	
East of Erimo	Tokachi R.	0.1 to 12.1	7.0 to 9.0	
West of Erimo	Yuurapp R.	1.0 to 20.0	3.0 to 5.0	

Sakura-masu are the earliest upstreamer. They swim the main stream up to the very upper part (the coldest water region). They stay there till the end of September and during this period their ovaria reach maturity. Karafto-masu also begin to go upstream from July and they stay at a depth, a little lower part of the stream than sakura-masu. Therefore, their ovaria are not ripe when they start upstreaming.

Sake begin to upstream from the end of August and October is the best season in the eastern Hokkaido, and November in the southern Hokkaido. Sake ripe fairly fast except the early upstreamers. Therefore their breeding period is short and breeding is not so difficult as sakura-masu and karafto-masu. The condition of sake ovary is shown in Table 3.

Table 3. Condition of sake ovary

Location	Date	(1957)	Numbers Measured	Weight of ovary (g)	Mean Weight of ovary (g)
The mouth of Ishikari River	Sep. 9 to Sep. 30		15	360 to 580	495
The mouth of Ishikari River	Oct. 1 to Oct. 20		10	440 to 680	536
Ishikari River (at Otoe)	Sep. 4 to Sep. 25		15	260 to 560	451
Ishikari River (at Otoe)	Oct. 3 to Oct. 26		20	490 to 1130	737

#### 11. The Capture of the parent fish and their breeding

The artificial propagation work of salmon in Hokkaido starts with the capturing of upstreaming parent fish. The time when salmon and trout migrate to the coast of Hokkaido in search of their rivers and the time of upstreaming are shown in Table 4.

Table 4. The time when salmon and trout reach the coast and the time of upstreaming

	Coast	Upstreaming
<u>Sakura-masu</u> ( <u>O. masou</u> )	May to June	May to June
<u>Karafto-masu</u> ( <u>O. gorbuscha</u> )	June to August	July to September
<u>Sake</u> ( <u>O. keta</u> )	August	September to November

Salmon and trout, evaded from fixed net at the coast, upstream in search of their spawning ground. In the early stage of upstreaming their ovaria are not well matured and the fish caught near the mouth of the river are unsuitable for collecting spawn and they must be bred. However, long term breeding was technically difficult, so far. Therefore, catching farms were built near the natural spawning ground of salmon and trout and there they were caught and bred. Generally catching farms were located far up the streams. Among the salmon and trout species, the natural spawning ground of sakura-masu is in the most upper stream in the noman's land and the karafuto-masu spawn in the stream a little down and the sake spawn further down the stream. In Hokkaido, the catching facilities built near the natural spawning ground is called Urai, and the catching place is called catching farm or egg collecting farm.

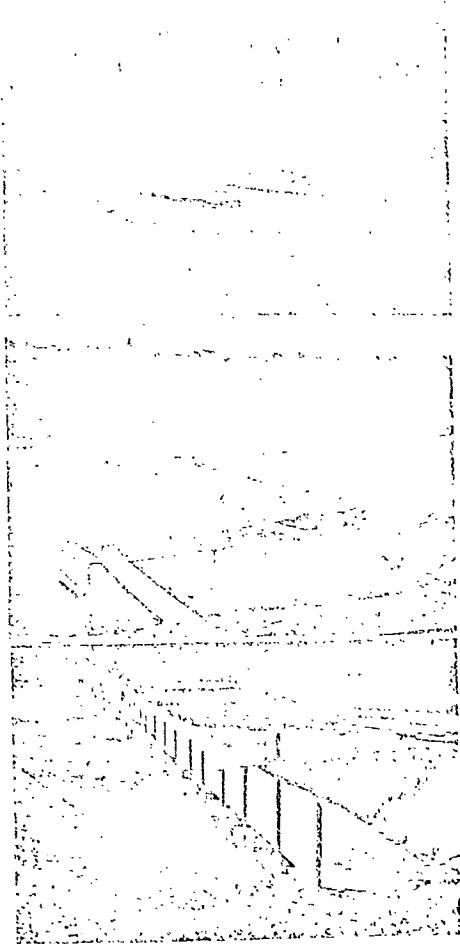
The marine products protection law 25 forbids people sake fishing in the rivers. The Hokkaido fishing control regulation 47 protects sakura-masu and karafuto-masu in the same way as sake. Therefore to catch salmon in the river, a special permission is needed. In the river one cannot catch salmon and trout for the purpose of fishing. The special permission is given to catch parent fish for collecting spawn. In Hokkaido, there are 74 catching farms in the 61 water systems which are controlled by 6 hatching branches. The rest are handled privately but controlled by the Government. The list of the catching farms are shown in Table 5.\*

## 2) Selection of location for parent fish catching

The parent fish catching is the first necessary procedure

---

\* Table 5 is attached at the end of this booklet.



(上. 中. ウライ, 下. ウライと電気柵)

Photo 1. Upper and Middle:  
the urai.  
Lower: the urai and  
and electric fence.

of the artificial propagation of salmon and trout. For this purpose, fences (which are called Urai in Hokkaido) are built in the river. Before World War II, fish were caught at the very upper streams and there they were already well matured and their spawns could be collected at once. However, after the War, the number of poachers increase because of the increase in population and also because the social evils ensued. Both to protect fish from poachers and to catch more parent fish, the catching farms were moved down to lower streams. There, we catch as many parent fish as possible and breed them and wait for them to reach maturity.

Salmon spawn after they enter the river, as mentioned above, but their

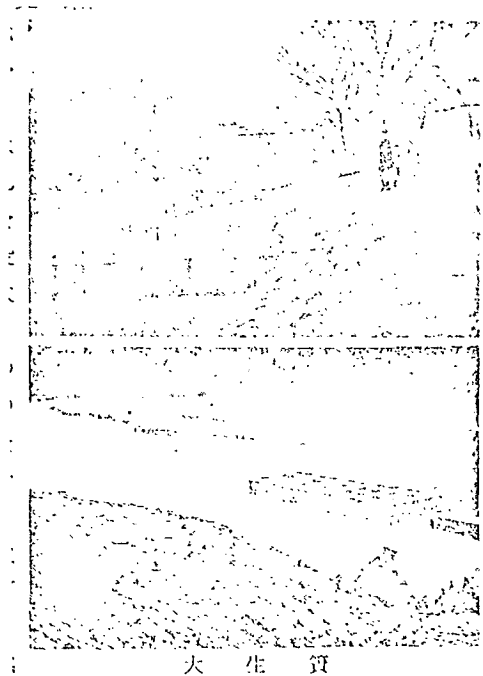
ovaria are not well matured, though the degree differs from river to river, right after they enter the river. The spot where they become mature also depends on each particular river. Therefore to choose catching farm locations, the following conditions must be considered for each river. The ideal way is to catch fish and collect spawns at the mouth of the river. It is best to do so wherever this method can be applied, but this is impossible at almost all the rivers.

(1) The condition from the viewpoint of promotion of ovaria maturity

As spawns cannot be collected at once from the caught parent fish, these fish must be bred until they reach maturity. The parent fish caught in the early stage of their upstreaming must be bred for about 20 to 30 days and the facility must be fairly large to keep all the fish, which are caught every day. Conditions such as the condition of the river bank condition, the rise of the river, necessary rest for fish and the speed of current, restrict the catching farm structure. From previous experiences, such as size, number, and maturity of caught fish, the following facilities are now used: a wooden crawl (3.6 m x 1.5 m x 0.9 m) for small rivers; a large wooden drawn (54.4 m x 3.6 m x 2.5 m) for medium size rivers. If the condition of the river permits, a double fence fish pond can be used (that is, a part of the river fenced on both upper and lower side, and fish are kept free inside). If it is permissible to dig a fish pond by the river bank and the water conditions are suitable (waterhead and circulation) a fixed fishing pond can be constructed.

The necessary conditions to be considered to build catching facilities are as follows:

- A. Transportation of both parent fish and collected spawns.
- B. easiness of fish breeding near the catching farm.



大 生 質

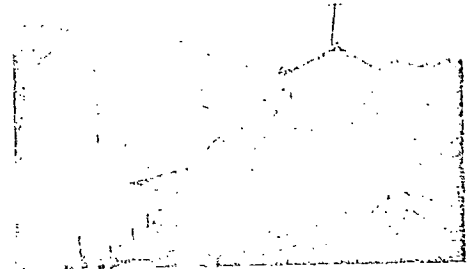
Photo 2. Large Crawl

- C. No possibility of the river rising. The possibility of fixing double fence fishponds.
- D. Parent fish can be matured within a short period.
- E. Investigation of necessary oxygen consumption for fish breeding and estimation of the fish keeping capacity of the pond.
- F. Investigation from the viewpoint of transportation to the hatchery, which is the place to incubate spawn collected.

The road:

In many cases, people living near the river rent river-side lots from the public office which controls the river and river bank. (In the case of Hokkaido, the Bureau of River Development controls the primary river, the public work Supervising Office controls the secondary rivers, and city, town or village municipalities control their own river.) If one does not investigate carefully before hand, it so happens that sometimes one

must trespass on other people's rented ground. If no road exists or nobody is renting the lot, a new road must be constructed within the limit of the budget. It may be better to construct catching farms near the existing public road.



蓄 養 池

Photo 3. Fishpond

- G. Lighting:

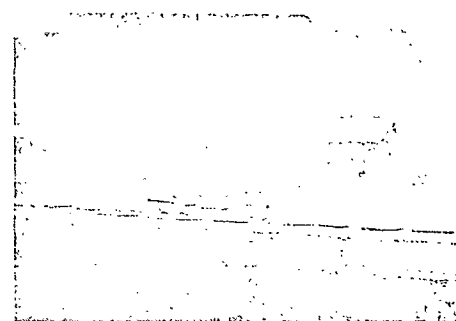
Many river banks are unexpectedly far from electric facilities. Especially in Hokkaido, unlike Honshu, many places are left uncivilized. Rivers in such remote places have no electric facilities at all and kerosene lamps or independent power plants are necessary. It is recommended to use a good Diesel engine which is now available.

p.11

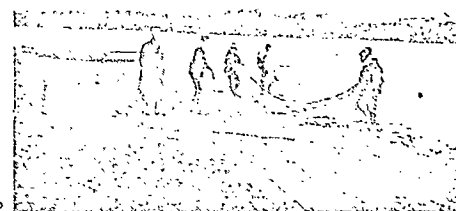
H. Easiness of supervising fish breeding.

(2) Conditions from the standpoint of the catching facilities, construction, and the usage of catching gear.

Among the many methods of salmon and trout catching, both the drag net and the river blocking methods are in use in Hokkaido. To block the river, posts are set up at the same intervals in the river and they are covered with blinds or net, the former is called Ki-urai\* and the latter is called ami-urai\*\* These facilities are the operation in the river and the equipment set up in the river. Therefore, according to the law of rivers, application for permission of both the river site occupancy and the works in the river



木製小生簀



曳網

Photo 4. Top: Small wooden crawl.  
Bottom: Drag net

\* Japanese word Ki means wood.

\*\* Japanese word Ami means net.

must be presented and approved by the Governor of Hokkaido\*.

Recently catching farms tend to be built in the lower streams where water is deep. Their location is best selected from the simplicity of construction. The conditions are as follows.

- A. The river should not be too wide.
- B. Shallows are preferred, however the range is best at 50 to 100 cm.
- C. Sands and pebbles are preferable for the river bed, posts can easily be set up and hold tight. Mud beds are unfavourable as they are easily washed away from the post base and make same lose and let fish escape.
- D. Slow current flow is preferable and it is best to have stagnant water down the facility.
- E. The degree of the increase of water level at the flood time must be taken into account to decide the shape and height of the facility.
- F. The water level above these facilities in the river increases and water pressure acts strongly near the junction of these facilities and the river bank. Sometimes this pressure will destroy the reinforced river bank and cause flooding. The bank reinforcement must therefore be well constructed.
- G. The ease of supervising poaching.
- H. Generally, the construction of these facilities starts from June

p.12

---

\* Details are shown in Subheading (4) which follows.

to August, before the autumnal river rise season. Any delay from the schedule increases the chance to meet the autumnal increase of water, thus completion of the facilities prolonged further and sometimes the first upstreaming schools may be missed.

It is best to select the location and design of the facilities as soon as possible and prepare materials and finish the construction before the river rises in the autumn.

(3) The shape of the fishpond and quality of water.

When one designs the catching farm, the method to keep and ripen the unmaturred caught fish also must be considered. Nowadays, cathing farms are moved near the river mouth where the captured fish are usually unmaturred and it takes a long time to mature them.

In constructing a fishpond the following terms must be considered.

- A. The fishing pond should be close to the catching farm and fish can be transported easily.
- B. Water supply to the fishing pond is easy to obtain and the water exchange is smooth and adjustable.
- C. The fish in the fishpond cannot escape from the pond even if the river rises.
- D. if the river contains too much organic substances, marine bacteria are apt to develop at the snout or the wounds of the fish. One part of the oxygen shortage in the water is also

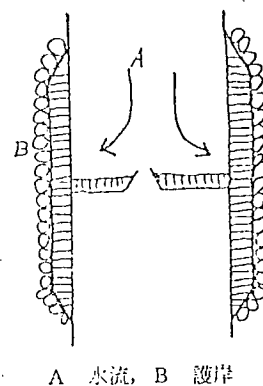


Fig. 1 A. Water flow  
B. Bank reinforcement

attributed to these bacteria or organic substances. Mud is not recommended as the bottom of the fish pond.

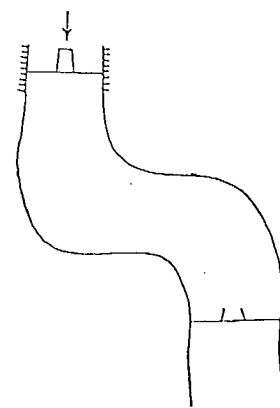
E. Avoid direct sunshine and choose a site in the shade. Salmon and trout are referred to as the short-day animal, therefore, better maturity results are obtained as the sunlit period is shortened.

F. In general, depths and shades help fish to have a rest. Many types of fishponds are now in use in the rivers of Hokkaido. They can be classified into four main types.

1) Double fence fishpond:

Both the upper and lower part of the river is blocked with fences and that part of the river inbetween is used as a fishpond. The fact that the natural river itself is used as a fish breeding ground is the main characteristic of this type of fishpond and it is best suited for fish. It is desirable that some part of the pond be deep, sluggish and shaded by trees. The fishpond must be carefully managed or the fish may escape when the river rises. A large area pond is therefore desirable to prevent loss of fish.

The dead fish flow down and are caught at the fence and are easy to clear but the ones buried under the river bed may rot later and cause oxygen shortage in the water. Accordingly, the river must be carefully cleaned after the fish are caught for spawn collection.

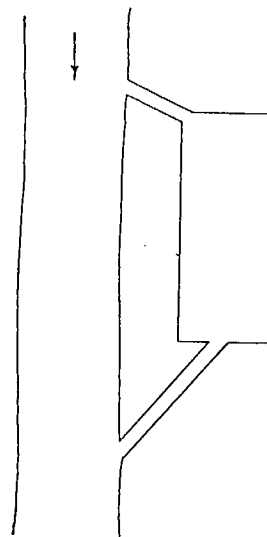


二重柵の一般図

Fig. 2. Double fence fishpond.

2) Wooden fixed fishpond:

This is a pool dug up close to the fish catching farm; wooden walls are used to prevent circumference soil to collapse it and the bottom is covered with gravel. The water supply and drainage must be regulated. Both the water supply and the conditions for fish must carefully be observed or a large number of dead fish may be found. The construction cost is high so the necessary conditions must be considered in detail.



木造固定密養池

Fig. 3 Fixed wooden fishpond.

3) Box-shaped crawl:

This is a box built with 3 cm. square lumber on all sides and water circulates well. As its area is small, it can only be used for a small number of fish. It is not suitable to keep fish for any length of time.

4) Vinyl pool:

A vinyl pool is used where conditions are not suitable to build a fixed fishpond near the catching farm. At first the present authors tried round shaped ones expecting good water circulation and large fish-keeping capacity but it resulted in exhausted fish, shortage of oxygen and finally many dead fish and was therefore unsuccessful. Good supervision must be carried out in the use of vinyl pools.

3) Supply and quality of water for fishpond:

Sometime sudden death of fish is observed in the fish breeding ground such as the fixed wooden fishpond and the fishpond built on the ground. The main reason of this handicap is the unbalance between the oxygen content of water supplied and the oxygen volume consumed by the fish.

p.14

In 1958, a large number of salmon died in the fishpond at Kitami-Yubetsu catching farm which is 248 m<sup>2</sup> (75 tsubo\*) in area. In this catching farm, from the middle of September to the end of December, fish are usually bred for two to three weeks before they become matured, except for the latter part of the catching season when eggs can be collected immediately from the caught fish. At Kitami-Yuubetsu catching farm, 30,000 salmon are caught yearly. Of this amount, 3 to 4 thousand are kept for breeding purposes. However, available water volume and ground area restrict the size of the fishpond at 45.5 m (25 ken\*\*\*) in length and 5.45 m (3 ken) in width.

Water is supplied in this pond through natural stream and by two pumps, 10HP and 15HP, respectively. Water volume in the several positions of the pond are shown in Table 6. (These data were observed by technical officers Fumoto and Kimura of the catching farm.)

---

\* tsubo is the old Japanese area unit.

$$1 \text{ tsubo} = 1 \text{ sq. ken} = (1.8182\text{m})^2 = 3.3058 \text{ m}^2$$

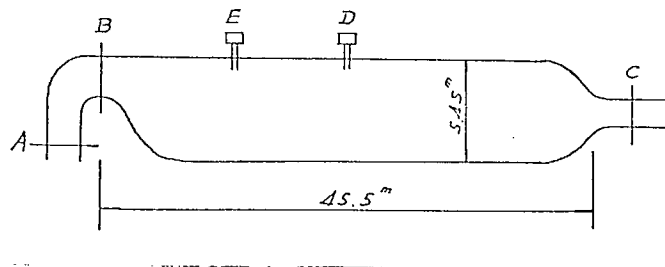

---

\*\* ken is the old Japanese length unit

$$1 \text{ shaku} = 0.3030 \text{ m}, \quad 1 \text{ ken} = 6 \text{ shaku} = 1.8182 \text{ m}$$


---

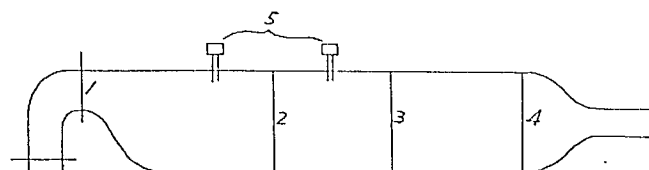
Table 6. The water flux in the fishpond.



Position	Width of river or diameter (cm)	Mean depth at the most bottom	Flow speed m / min	Water flux l / min
A	60	28	13.70	1960
B	165	23	4.82	1835
C	90	19	23.72	4032
D	30	30	32.00	2270
E	30	15	41.40	1460

If more than 2,000 salmon are released into this fishpond, some of the salmon become upset and nervous in approximately ten minutes. In the case of over 2,500 salmon, some of them usually die. The natural inflow is from a spring, therefore it is usually lacking in oxygen. No other objective conditions, which let fish die, were observed in this fishpond, accordingly death may be attributed to oxygen shortage. Oxygen contents of the fishpond were investigated at several points under the condition of 2,500 salmon in the pool. The results are shown in Table 7.

Table 7. The oxygen distribution in the fishpond.



Water Collected	Atmospheric temp. (°C)	Water temp. (°C)	pH	O <sub>2</sub> (cc/l)	O <sub>2</sub> (%)	Condition of fish
1	5.8	7.6	6.6	5.119	61.0	normal
2	"	8.0	6.7	4.798	57.7	normal
3	"	9.0	6.7	3.547	43.6	abnormal but no dead fish
4	"	9.0	6.7	2.859	35.3	extremely abnormal, dead fish are found
5	"	10.0	6.7	4.731	59.7	pumped in water

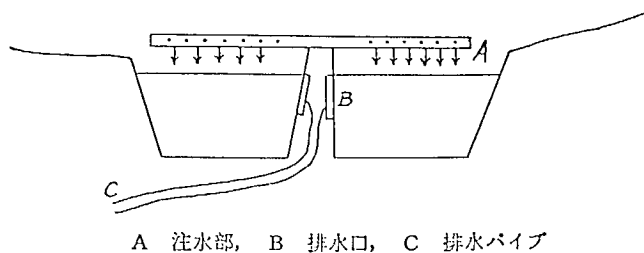
The table shows that the 4th point is highly lacking in oxygen so the fish tried to move from this section to the oxygen-rich water inlet section and those first, second and fifth positions are always overcrowded with fish.

From these results it is clear that if the oxygen volume drops down less than 3 cc per liter, salmon under breeding become wearied and begin to die. Therefore, the least allowable oxygen volume in the salmon fishpond is 3 cc/l. (Kimura, 32.2\*)

\* Probably 32.2 means February of the 32nd year of Showa and this is equivalent to February, 1957.

Fig. 4.

- A. water supply
- B. drain opening
- C. drain pipe



Similar results were observed in a vinyl pool. Two vinyl pools were investigated, the size of these large and small pools were about 12.8 m and 10.4 m in diameter, 1.5 m and 1.2 m deep, and 148 m<sup>3</sup> and 84m<sup>3</sup> in volume, respectively. These pools have been in use at Tokachi No. 33 catching farm since last year\*.

Pumped water is poured into the small and large pools at a rate of 2 and 3 tons per minute respectively and is drained from the center of the pool. Oxygen deficit zone was built up near the drain hole and, moreover, water flowed to a fixed direction, therefore fish could not rest. Consequently they died quickly in this oxygen deficit area.

p.16

Generally salmon consume 1.2 cc of oxygen/per 1 kg of its weight. per minute  
Fish keeping capacity of a fishpond can be calculated from its oxygen content, as follows:

$$W = \frac{R (Q - B) K}{E}$$

---

\* probably 1963 as this booklet is published in 1964.

where

W = capacity

R = water supply to the fishpond per unit time

O = oxygen dissolved in the water (cc) (normally 5 cc/liter)

B = maximum volume of oxygen which is not utilized by fish.

Salmon are killed if the oxygen volume is lower than 3 cc/l, therefore B can be estimated as 3 cc/l.

E = oxygen consumption of individual salmon per minute, which is estimated as 0.8

For example, the possible capacity of Yuubetsu fishpond is given

as

R = at point B, 1835 liter = 5565 liter

at point D, 2270

at point E, 1460

O = 5 cc/l

B = 3 cc/l

E = 4 cc/min/individual fish

W =  $5565 (5-3) 0.8 / 4 = 2200$  fish.

In the case of a double fence fishpond, a large volume of water is always supplied and it is unlikely to have dead fish caused by oxygen shortage. However, in the case of those fixed wooden fishponds and vinyl pools which are built in the ground, the oxygen content and fish condition

must be investigated continuously.

4) Construction and execution of catching facilities

After the catching farm location was chosen, the construction started with the foundation work. The specification of the foundation work are shown in Tables 8 and 9\*, and in Figs. 5, 6, 7, 8, 9 and 10\*\*. The normal construction is 30 days.

pp17-24

5) The procedures for the catching farm

(1) Application for the special permission for parent fish catching.

It is specified in the 25th article of the marine products protection law that no salmon should be caught in the rivers. However, the provision of that law tells that one who is permitted by the Minister of Agriculture and Forestry or prefectural governor can catch them. Therefore, salmon catching must be done under this special permission.

In the case of trout, the fishery controlling regulation prohibits trout fishing in the inland waters. Accordingly trout parent fish catching farms in the rivers must be run as for salmon.

In Hokkaido, special permission for catching salmon and trout is allowed to the Hokkaido Salmon and Trout Hatchery only; the Hatchery

---

\* and \*\* These figures and tables are attached at the end of the paper.

runs its own catching farms and when it is inconvenient to do so, the Hatchery entrusts the private fish catching farms to catch parent fish under their supervision. The special permission is not allowed to individuals or fisherman's unions.

p.25

Table 10. Application form for the special catching

I hereby apply for a special permission for catching. Details are figen as follows:

1. Purpose
2. Ships to be used
3. Name and amount of marine animals or plants to be caught
4. Location
5. Catching terms
6. Base
7. Type, scale, and number of fishing implements

Allows me the special permission for catching, which is mentioned above.

Application for the Special Catching

Date

To: The Prefectural Governor:

Applicant: Address

Name

Seal

(2) Application for the permission of using the river and its surface.

In the case of salmon or trout catching under special permission, the use of the site for catching farms must also be granted permission by the prefectural governor.

The necessity conforms to the regulations for the enforcement of the law of rivers. Three copies of the application form, which includes the explanation of the plan, plane figure, quadrature figure, sectional plan, longitudinal plan, structural plan, and a statement of accounts must be prepared. These application forms are applied through the neighbouring engineering work office. If any plan for the improvement of the river already exists, one must ask the executor's consent. Rent is charged for the usage of the river.

III. Artificial spawn collection and fertility

It is ideal to catch the parent fish for artificial spawn collection at a time when they are matured and immediately before they enter their spawning ground. With the increase of all kinds of obstacles in the rivers, fish catching farms have moved closer to the mouth of the river and consequently the number of unripened parent fish has increased. Therefore, to utilize these parent fish effectively, it is necessary to put them into the fishpond and breed them. Spawn must be collected from the best conditioned parent fish.

(1) Artificial spawn collection

The ripened parent fish, which had already matured when they were caught or reached maturity in the fishpond are clubbed to death to

shorten their pain. It is necessary to hit them accurately on the head. If their abdomens are hit hard, it gives a serious effect upon their spawn. Usually live male parent fish are used. Sometimes when male fish are lacking, they are returned to the crawl after their milt is collected and used again.

Ova and milt should be collected as soon as possible after the death of the parent fish. It must be noted that their fertility decrease quickly after the death of the parent fish. Ova leak from matured female when the fish is hung tail down. It is best to carry the fish gently to the collecting bench by holding its head and tail at the same time and then collect ova from the fish.

It is better to use a bench specially designed for the use of collecting spawn, but an ordinary bench may be used. In the latter case, prepare another lower bench and put egg-pan on it. Ova are taken from female abdomen by incision. It is done as follows; insert a surgical knife from its anus and incise its abdomen to the front: care must be taken not to insert tip of the knife too deep into the abdomen and not to touch the heart. The assistant holds the head of the fish and the collector grasps its tail with his left hand, incises the fish and scrapes the ova out of the abdomen and puts them into the egg-pan.

After the ova are taken from about six females, the milt from two or three males is squeezed onto the ova. They are mixed well with a feather or something similar and after that while adding water they are mixed again and left to sit. The volume of the ova to be collected on each spawning-pan depends on the volume of spawn each fish has. If too

many ova are collected on one egg-pan (diameter 40 cms, depth 5 - 6 cm) ova mixing and water adding is difficult; therefore, when a school of fish contain much ova, the number of fish to be used per each egg-pan must be reduced. One male fish is enough to fertilize the ova in one egg-pan, however, it is possible that some males are not fertile, therefore it is always safer to use more than two males.

The above mentioned method is called the dry method and the fertility of this method is more superior than the so called wet method, in which ova are put into water and then milt is added to them.

The handling of the parent fish before the spawn collection has great influence on the fertility of the spawn and incubation results. Therefore they must be carefully treated; a bruise on the abdomen causes dead ova and water sucked into the abdomen produces swelled ova. All these can cause the decrease of the fertility.

If the water temperature added to the mixture differs too much with the water temperature where they have lived then sometimes fertility decreases. Both very high or very low temperatures in the collecting room also harm the fertility, so the room temperature must be controlled carefully.

## (2) Artificial fertilization

The artificial fertilization is one of the best artificial propagation methods and its fertility is rather better than the natural spawning. The wet method was devised following the natural spawning situations, in this method ova and milt are fertilized in the fresh water. However, with this method the fertilization rate is rather low because

both the milt and the ova lose fertility in the fresh water.

The activity of milt can be retained for a long time by those well known methods in which milt is kept at low temperatures under oxygen-lacking conditions instead of diluting them with water. However, they can be diluted with the body fluid or the equivalent Ringer's solution.

p.27

If milt is not diluted and kept by the above method, it retains its activity as good as fresh milt from one to two days and sometimes even ten days. The one diluted with the body fluid or the equivalent Ringer's solution also keeps its activity from two to three times and sometimes even several times longer than the one diluted with fresh water.

On the other hand, the fertility of ova can be kept effectively for a long time when they are kept out of water or kept in the body fluid or the equivalent Ringer's solution after they were collected from their parent fish. In this way ova can be retained from several hours to twenty days or so without losing their fertility.

Both ova and milt maintain their fertility for a long time in the body fluid or in the equivalent Ringer's solution. Therefore one may conclude that artificial fertilization can be done effectively in these liquids. However in these liquids ova and milt do not fertilize until fresh water is added to them. The dry method, which is widely used today is an excellent fertilization method. The body fluid or the Ringer's solution can keep fertility of ova and milt for a long time so these liquids are useful in a case where a shortage of male or long distance transportation of ova is required.

It was already mentioned that ova and milt quickly lose their fertility when they contact with fresh water. However, the fertility

may be increased as follows; mix milt to ova well and distribute milt evenly before adding water and after water is added, continue to mix them thoroughly. Insufficient mixing causes decrease of fertility. The addition of water stimulates sperm to action and one of them intrudes into the egg through the entrance. Then a series of changes such as closing the entrance, diffusion of juseiha take place. This prohibits the intrusion of other sperm and fertilization begins.

After the ova and milt are mixed and the water is added, they are left as they are for at least five minutes then are washed clean with a large amount of fresh water. It is necessary to stir occasionally to supply a sufficient amount of oxygen.

After the ova are fertilized, they absorb water within thirty to sixty minutes and their membranes become hard and the ova can resist pressure. They are then carried to the incubator at this stage.

Though ova at this stage can resist pressure, they are extremely weak to impact and they must be treated carefully. The ova-carriers are filled with ova and packed under slightly high pressures and this protects the ova from impact.

Ova are so weak to impact after they absorbed water that more than 50% will die when they are dropped from 10 cm high even though they can stand the static pressure fairly well and each ovum can bear a weight more than 500g.

### (3) Natural spawning

The density of the school of upstreamers decreases as they come close to the upper streams, and before they arrive at the spawning grounds, each male and female forms pairs and find an adequate spawning ground and prepare for spawning.

Generally, the spawning ground is in the upper part of the rivers and a river bed, rich in middle size gravel mixed with a little sand and mud, is chosen.

Sake choose a region where subterranean water flows out. In such a place the temperature in the gravel is kept constant and even in the coldest season when the river temperature falls and sometimes freezes, their fertilization can be proceeded with safely and such condition is an important factor of a spawning ground.

Sakura-masu and karafuto-masu, unlike sake, spawn in the river bed of a rapid stream. Their spawning season is fairly early and their eggs and fry develop quickly during autumn when the river temperature is still warm. Therefore, they rarely suffer damages from freezing but sometimes extremely cold winters or an unusually early arrival of winter may damage them.

Sake spawn in the river 30 cm or less in depth, sakura-masu and karafuto-masu at about 60 cm. Their spawning behaviour is more or less alike and the species which spawns in a fast stream builds a large spawning bed.

Mainly females work in the spawning ground; with her strong tail and utilizing the current flow, she scoops out a basin up to 100 cm in diameter and 50cm in depth. When the spawning bed is ready, male and female sit on the bed side by side and spawn ova and milt.

Spawning takes about 10 to 20 seconds and immediately after the spawning the fish cover the ova and milt with gravel. Usually they spawn two or three times. Each time it takes about an hour for making a bed, two hours for covering it and most of the work is done by the female.

In the case of sake, the temperature in the bed is usually 7 to 8°C and none of the beds are lower than 4°C as so far observed. The temperature of spawning beds for sakura-masu and karafuto-masu changes with river temperature and it is about 12 to 13°C at their spawning time.

In the spawning bed, ova and milt are spawned at the same time and with the aid of the slow movement of water in the bed, they are mixed well and show good fertility rates. The fertilized ova sink between the gravel in the bed and almost no ova are to be seen on the bed even immediately after the spawning.

In one experiment the spawning bed was dug out after the spawning and it was found that more than 90% of the eggs were growing in normal condition. The dark and calm environment in the gravel is suited to the growing of the eggs.

The eggs suffer fairly large damages from many kinds of handicaps such as freezing, lack of water, washing away of eggs at its spawning time, danger from cannibalistic fish and mihoran-ransi. Therefore it is thought that 35% of the naturally spawned eggs can become fry.

p.29

Fry developed in the bed stay there as long as they have yolks and when they use up their yolks they pass through the gravel into river and search for their food. If the river bottom around the spawning bed consists of fine sand or mud, / <sup>fry insects</sup> are unable to leave the bed. Fry eat larvae of many kinds of aquatic insections, however, those larvae also do not develop well where fry are killed. Therefore fine sand or mud river beds are unsuitable for a spawning ground.

Nature provides the know-how of the developing of the salmon and trout species, therefore it is more important to observe in detail the

natural spawning process and egg development and make sure the reason of these natural processes and give effective artificial aids to them.

#### IV. Propagation control

##### (1) Egg transportation

Fertilized eggs are transported in tanks and immediately put into incubating basins and stored in the incubator. Their numbers are counted and they are developed in the flowing water in the incubator. The Atkins type incubator, painted with japan or asphalt lacquer has been mainly used in Hokkaido. The vertical incubator which was invented by R.E. Burrows and D.D. Palmer, U.S.A., was tested for three years in our hatchery. The incubator was improved and is now in use at the Abashiri experimental station. In case of the Atkins type of incubator, 100,000 eggs are stored in the four incubating trays. After the eggs are stored in the incubator, the first removal of dead eggs is done on the same day or on the day after. These eggs are referred to as being dead during the transportation to the incubator and the mean value of its rate has been estimated at about 5% (between 1948 and 1950). The remaining 95% are left in the incubator and developed.

##### (2) Incubation and breeding

During the dangerous period ( a period between 48 hours after the fertilization and the eyed stage) care must be taken to prevent eggs from shocks. It must always be kept in mind that they are very sensitive to mechanical shocks at this period. The sensitivity of eggs depends upon their growth degree during a period between eggs first being collected and when their blastopore are closed (in this stage, eye-spot is also observed clearly) and specially at the latter term of this period, they are

extremely weak and the inner membrane of eggs is easily broken by a slight shock. This easily causes serious damages such as successive outbreaks of dead eggs, infection from aquatic bacteria. Therefore, during this period it is best to avoid egg transportation and minimize the removal of dead eggs. Aquatic bacteria can be found on the dead eggs in five to seven days after they are killed. If the bacteria are not eliminated, they will kill the surrounding live eggs and finally all the eggs may be killed. This is in common with the artificial propagation of the fresh water fish and many methods have been devised to protect eggs. Dead egg extraction method, which has been used for a long time, is simple but this is not an efficient and appropriate method as it takes a great deal of labour and it affects weak eggs. The chemical disinfection method is used today, in which incubators are not moved and prescribed chemicals are poured into the incubators. In this method, antiseptic solution is dropped into the incubator through the intake opening and all the eggs in the incubator are disinfected at one time. The skill of the egg checking is measured by whether dead eggs are removed quickly without giving shocks to the sound eggs. This operation must be done most carefully or it will result in killing many eggs rather than removing a few dead eggs. Therefore it is better to avoid the egg checking method unless many dead eggs are found and aquatic bacteria spreads around. It is advisable to take negative protection, such as keeping the eggs in a stationary state, circulating the water well and wait for the eggs to reach maturity. A temperature change during the egg checking time must be minimised. Handa (1918) studied the effect of rapid change of the water temperature on the incubation of eggs and their development. He found that when the environment of the eggs, in their early stage of development, were changed from

8°C to 0°C, then 9 to 11% of the eggs died and 10 to 14% became malformed fry. A change of temperature more than 5°C retard the egg development even if it may not lead to immediate death.

### (3) Disinfection

For the purpose of the chemical disinfection, Formalin, potassium permanganate, malachite green, etc. have been used. Recently, malachite, which is very effective against aquatic bacteria, has been used. The aquatic bacteria are effectively eliminated by the disinfection twice a week, each time for one hour with malachite 1/200,000 to 1/400,000 solution. Application of appropriate volume of malachite into the incubator eliminates the necessity of ead egg removal procedure. A disinfection method, using a constant flow siphon was studied between 1943 and 1946 at the experimental station of U.S. Department of Fisheries in Leavenworth, Washington. They reported that the application of 1/200,000 malachite solution every half week for one hour is very effective as a disinfectant. p.31 This method was adopted in our hatchery and efforts have been made to improve incubation results. The malachite solution can be prepared as follows. Suppose 1 to\* (about 18 l) per minute water flows into an incubator; then the necessary malachite to make 1/200,000 solution in the incubator can be calculated as follows:

(1) Convert the volumn unit of water which flows into the incubator from to into cubic centimeters

sho\*\* = 1.8 l, therefore 1 to = 18 l

(1 litre = 1,000 ml [1000 cc], 1 ml = 1cc then 1 to = 18 litre = 18,000 cc).

---

\* and \*\*: to and sho (and go) are the old japanese volume units.  
 10 go = 1 sho, 10 sho = 1 to.  
 1 sho = 1.8039 litre therefore 1 to is about 1.8 litre.

(2) The necessary weight X of malachite per minute is calculated by the following proportion:

$$1 : 200,000 = X : 18,000$$

$$X = \frac{18,000 \times 1}{200,000} = 0.09 \text{ G (per minute)}$$

Therefore, 0.09 g of malachite per minute is needed in the incubator. Now the density of the condensed solution in the siphon must be calculated. First the opening of the siphon is adjusted to 30 ml (30 cc) per minute so that during one hour 1800 cc of the malachite solution will drop into the incubator. Therefore, 1 cc of condensed solution must contain malachite of one-thirtieth of 0.09 g, that is 0.003 g per cc. Consequently 0.3 g of malachite is needed for 100 cc of water and this makes 0.3% malachite solution. For one hour disinfection, 1,800 cc solution is required, so more than 2,000 cc solution must be stored in a 1 litre siphon bottle. Dissolve 3 g malachite into 1,000 cc water or 6 g malachite into 2,000 cc water. Maximum solubility of malachite in water is 1 to 150, therefore if one adds more malachite than this ratio to make a more concentrated solution, it simply despoits in the water and one cannot make more condensed a solution. Therefore, to maintain the density of the solution lower than this limit, the flow rate of both the water and malachite solution into the incubator are restricted to less than 1 to 6 sho 8 go (about 30 litres) and more than 30 cc, respectively.

When the solution is prepared, the disinfection procedure starts. There are two ways of disinfection and it depends on the condition of the p.32 hatchery. Whichever method is used, the solution and the water are poured into the highest incubator at the same spot from there it passes through all the incubators. In the first method the anticeptic solution and

water are applied to the incubator for thirty minutes then the outlet of the incubator is closed and both solution and water supply are stopped for the next thirty minutes. Then both the water inlet and outlet are opened and water is supplied as normal, and the antiseptic solution is washed away. In the second method, solution is supplied for one hour while water passes through the incubator continuously. This method is used when the incubator is in bad condition and water leaks so much that if the water supply is stopped (like the first method) the eggs will be exposed to the air. Both methods are effective for the disinfection of aquatic bacteria however the former method costs less money and disinfection apparatus are used more effectively than the latter method. Disinfection must be done twice a week or best results cannot be expected.

The results of the constant flow-siphon obtained at Kitami branch in 1953 showed that both the malachite solution of  $1/800,000$  or  $1/400,000$  concentration can suppress the generation of the aquatic bacteria and they had no bad effect on the eggs. At the beginning, some of the trout eggs already had bacteria on them but their hypha were gradually consumed, reduced and killed by the repeated application of the antiseptic solution. When the  $1/400,000$  malachite solution was used, no bacterial generation was observed with the naked eye and disinfection effect was pronounced. Also in the Abashiri station, the chemical disinfection method eliminated damage, such as increase of the dead eggs by the egg inspection. By the careful use of the chemical disinfection method, all that is necessary is to inspect the eggs when they are put into the incubator and count dead eggs at the end of the incubation period. The application of the chemical disinfectant improves the incubation rate and

decreases the working man hours in the hatchery.

A schematic diagram of constant-flow siphon bottle is shown in the figure at right.

The bottle is 16.6 cm in outside diameter and 35 cm in height. The parts C, E, H and J are glass tubes and F, I and K are rubber tubes.

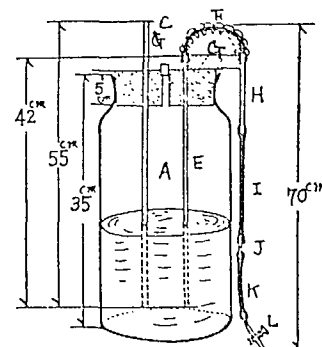
The outside diameter of the glass tubes and rubber tubes is 9 and 11 mm respectively.

F, G and L are specially designed. In place

of a U-shaped glass tube, the rubber tube F is used and is about 20 cm long. A coil was made from a piece of wire 1.75 mm in diameter and the rubber tube F was inserted in it and this was bent to the U shape. F was connected to H, then F and H were fixed with a tin plate G, 1.5 cm in width (18 cm in length). L is a tip of a burette which simplified the regulation of the flow. The lid was made of wood, 9 cm in diameter and 5 cm thick, and vaseline was used to seal it between the lid and the mouth of the bottle. After the bottle is filled with the malachite solution, the inlet opening is plugged with a cork and if necessary vaseline is used to prevent air passing through this part.

#### (4) Water for incubator

The water temperature in the incubator has a great influence on the speed of egg development. Low temperatures suppress its development, while high temperatures accelerate it. However, if the incubation is at too high a temperature, eggs develop so quickly that the fry obtained are very weak. In the case of sake, 17°C is the highest temperature limit for them to live even if the oxygen content is sufficient in the



定流式サイフォン装置

Fig. 11 Constant-flow siphon

water. Low temperature water, as far as it is not frozen, does not cause physiological damages to eggs. However, if the temperature of the water is too low, it prolongs incubation time and increases the rate of the dead eggs. Therefore, the most favourable incubation temperature is believed to be between 4 and 10°C. This agrees with the temperature of the natural spawning bed. The temperatures in the gravel of the spawning beds so far studied are between 7 and 8°C. There is not much difference between these natural temperatures and those temperatures of 7 to 9°C reported in artificial incubators (Handa 1933, Kawajiri 1927).

It is important for the incubator water to maintain its temperature variation as small as possible. In the Chitose branch, 8°C spring water is used as incubator water, here the incubation begins on the 60th day after the fertilization and almost all the eggs are incubated within a few days after the 61st day and incubation is completed at least on the 69th or 70th day. However, with 9°C water, incubation starts about five days earlier than usual. In the Chitose branch, the temperature deviation of water is small. In such a case, if the mean temperature of the water is known, then the approximate incubation days can be calculated from the total incubation temperature, that is the multiplication of the mean temperature and the necessary days, as in this case 480°C days ( 8 x 60). Incubation-days depend on other factors, such as, oxygen content and pH change. Both lack of oxygen and alkaline pH tend to prolong incubation-days (Okada 1936), therefore the total incubation days give an approximate incubation time.

The eggs consume oxygen as they develop so if too many eggs are stored in one incubator, it causes choking of the eggs directly and

indirectly promotes bacteria development and bacteria spores have more chance to come in contact with eggs. Pronounced development of bacteria prevents water flow and this introduces shortage of oxygen and causes death of eggs. The volume of incubator water controls the incubation results, the standard incubation water volume for sake being more than 1 to 5 sho (27.06 litre), which contains 7.0 ppm oxygen per minute. With this volume of water, 500,000 eggs can be safely incubated with the new improved incubator arrangement (Handa 1933). An improved incubator, designed to utilize water very effectively, can incubate 100,000 to 200,000 eggs with 1 sho 1 go (2 litres) of water per minute and can be used until the fry swim around (Burrows 1956). The quality of the incubator water should be equivalent to the drinking water, that is colourless, transparent and containing none or very small amounts of impurities (mud).

p.34

As for the oxygen content in the water, it is reported that less than 4.5 ppm prevents the development of eggs, consequently more than 7 ppm is desired. Handa (1935) studied the effects of the inadequate oxygen content in water. He took eggs which were stored 30 days in the incubator (oxygen content of the water was 11.2 ppm) and cut the oxygen content to 2 ppm and the eggs died. He took eggs which were stored for 40 days under the same conditions and cut the oxygen content to 2.1 ppm and the eggs died. In this experiment, seemingly dead eggs (with the naked eye) were transferred into fresh water and they revived 24 hours later. The 50th day eggs died when the oxygen content decreased to 1.5 ppm, however one or two eggs were still alive. Almost all the 60th day eggs, that is the incubation-day eggs, died with 0.3 ppm oxygen.

Okada (1936) studied pH degree and reported that about pH 7.0 (neutral) gives the best incubation results and both increase

of acidity and alkalinity give unfavourable results, eggs in the acidic water tended to die before the eyed-stage and in the alkaline water, after the eyed-stage.

Iwabetsu Hatchery in the Shiretoko Peninsula, opened in 1937, and at that time spring water in the hatchery was used as the incubator water and many eggs were killed. Later it was found that the spring water had a pH 4.0. This spring is believed to be the water from the Red River (strongly acidic, pH 4.0) which comes from the Utoro mine (an iron mine). The well water in the Abashiri station near Lake Abashiri is colourless and transparent but it is strongly alkaline, pH 9.1 and it is also inadequate for the incubation water. This contains very small amounts of lime and magnesia (usually, lime or magnesia rich water shows alkalinity) and it contains organic nitric compounds in the same level as the normal water. It is believed that the high pH value is originated from the putrefaction of these organic nitric compounds. p.35

In our hatchery, the water for the incubation and breeding purposes are analyzed chemically to see if it is suitable for these purposes.

#### V. Breeding and releasing of fry

The incubated fry carry large yolks and stay piled on top of one another so underlying ones are killed by choking. Therefore, fry must be transferred to a fishpond immediately and there they are bred. The fry stay still under the stones or in the shadows and they do not seek for food until they dissolve their yolks. About 30 days later they come out of their shelter and begin to seek food.

##### 1) Fry breeding

Fishponds are usually square in shape and 2 m in width and 40 to

60 m in length and up to six ponds are arranged in parallel. The bottom is covered with gravel and the water depth is 25 to 30 cm and the flow-rate is more than  $0.005 \text{ m}^3$  per second.

Fry are weak to direct rays of the sun until they dissolve their yolks, so the whole surface of the fishpond must be covered with sun shades to protect the fry; wooden boards are usually used as the sun-shade and this also keeps warmth in the winter and keeps the fallen leaves out of the pond, protecting the fry from their enemies.

In natural spawning, eggs are covered with gravel and are developed in complete darkness and calm. After the incubation, they still continue to stay between the gravel bits while dissolving their yolks and after 80 or 90% of the yolks have been dissolved they come out of their shelter through the gravel.

A great deal of effort is made to keep the fry in an artificial environment as close as possible to the natural one. Immediately after the incubation the fry have almost no resistance to the direct rays of the sun. Such a condition lasts for about 30 days after the incubation. The resisting power of fry gradually increases with their growth and after 50 days from their incubation, they are so strong that the rays of the sun no longer affect them. At this stage, their yolks are almost dissolved and some of the fry begin to seek food such as floating small creatures and larvae of gnat-like-flies.

The temperature of the fishpond also has a great influence on the growth of the fry, very low temperatures detain their growth and up to a certain temperature limit (11 to 12°C) the fry grow fast as the temperature rises. At low water temperatures, such as 1 to 2°C, it takes 150 to 200 days before the fry come out of their shelter while on the other hand

7 to 8°C water accelerates their growth and they come out and seek food within about 50 days. Nowadays, in some fishponds, spring water is used to keep the water temperature constant and this promotes the growth of the fry. Then, they are released in the stream in early spring, when the living enemies are not in activity.

The density of fry in the pond is 20,000 to 30,000 per 3.3 m<sup>2</sup>\*, it is more than ten times the density of the most dense natural spawning ground therefore an artificial help must be added to the water, oxygen, food, etc. Adequate water volume for each 130 m<sup>2</sup> pond is 0.005 m<sup>3</sup>/sec to 0.01 m<sup>3</sup>/sec and necessary oxygen content for this pond is 3 to 4 cc/l. Flow speed must be controlled so as not to wash away the fry, and adequate flow-speed was determined to be 1.6 to 2.0 cm/sec.

If above mentioned conditions are realized, about one million fry can be bred in one fishpond, 130 m<sup>2</sup> in area and 30 cm in depth.

The fry, bred in the fishpond of high fry density, need lots of food, therefore artificial feed must be supplied to protect them from consuming their energies. At the first stage of breeding, the cod spawns and the livestock livers are one of the best feeds, however, one or two weeks later, mixed food is also needed. These artificial feed can be obtained in frozen packages.

The combination feed, such as Koo-meal\*\* and Oriental-feed\*\*\*, are on the market. With these combination feeds, fry grow from their beginning weight (320 to 350 mg), to 600 to 700 mg within about 20 days,

---

\* 3.3 m<sup>2</sup> is equal to the old japanese area unit 1 tsubo.

---

\*\* and \*\*\* commercial names.

and 70 to 80% of the fry are stronger and healthier.

About 3,500,000 fry were bred in Hokkaido in 1962 and a plan to breed more than 10,000,000 fry is under consideration for 1963.

The naturally spawned fry come into the river after they dissolved about 80 to 90% of their yolks, at this stage their digestive organs are well developed and they are ready to search for food. They grow quickly, eating the larvae of the aquatic insects around the spawning bed. Both the developing season of these eatable creatures and their numbers have important relation with the development and survival of the fry. The parent fish scooped out of the gravel and cleaned them in their spawning time. This improves the water flow through gravel and promotes the development of the eatable creatures. Therefore, a region where many fish spawn is also suitable for the development of the eatable creatures and consequently fry also grow well. p.37

The main natural food of the fry are the larvae of the gnat-like-flies, caddis-flies and the ephemerae, and they are especially fond of the larvae of gnat-like-flies. Meanwhile, these larvae are the main creatures developed around the spawning ground, therefore the development of salmon and trout is rationally controlled by the nature.

The fry go downstream to the sea, shortly after their incubation, and many kinds of biological changes take place in them. The fry can adapt themselves well to the sea water in a period of about 90 days after their incubation. However, between the 90th day and 150th day from their incubation, they cannot stand the sea water and some are killed because of some kind of biological impediment.

One of the ways to increase the numbers of fry, which succeeded

in entering the sea, is to release them into the streams as soon as possible after they come into the water. Therefore the artificial fish breeding in the fishpond is done as follows; the breeding period with artificial feed is limited to 20 to 30 days (in this period fry double their weight) and they are released into the stream.

The combination and nutritive component of the above mentioned artificial feed for the fry breeding is shown in the Tables 11 and 12. Frozen combination feeds is 4 kg square shaped packages and they are hung in the fishpond and let the fry eat freely.

Table 11: The combination feeds.

<u>Combined component</u>	<u>Rate</u>	<u>Remarks</u>
fresh fish meat	40.0 %	roughly ground cod meat
liver powder	15.0	Riken-vitamin * 7-E
skim milk	5.0	
yeast	5.0	beer yeast
liver oil	0.5	
minerals	0.2	Takeda minefeed C **
monoglyceride	4.3	diffuser

\* and \*\*: commercial names.

Table 12. The nutritive component of the above-mentioned combination feeds and cod eggs.

<u>Component</u>	<u>Combination feed</u>	<u>Cod egg</u>
protein	20.25%	10.36%
fat	5.13	1.42
calcium	2.07	0.61
cellulose	0.01	0.024
soluble non-nitric substance	3.51	1.19
water	69.03	86.40
calorie	145.1 cal.	60.6 cal.

## 2) The releasing and dwonstreaming of the fry

When the fry come out of the shelter and begin to seek food, some of them are fed artificially and others are released directly into the stream. p.38

The size and strength of the fry have an important relation with the decrease of the number of them while they go downstream to the sea. The fry may have more power of resistance to many kind of handicaps as they eat nutritious food and consequently more fry may arrive at the sea. One method to increase the number of fry to arrive to the sea safely is to release them in the streams in early spring, when the water temperatures in the rivers and coasts are still cold and the enemy creatures are not in full activity. However, the early releasing is usually difficult because the fry may be short of well matured and their food catching ability is not well developed.

In the spring, as the temperature rises, many handicaps such as

enemy creatures, the water pumping for the irrigation and the fishing on the coasts prevent the fry from entering the sea. These obstacles and the maturity of the fry must be taken into consideration to decide the best time to release them. In some part of Hokkaido, the fry are transported to a safety zone and are released into the rivers.

The size of the fry at their release time is 35 to 40 mm in length, and 320 to 350 mg in weight. They eat their food eagerly, grow quickly and by the time they arrive at the mouth of the river they are 100 to 120 mm in length, and 300 to 500 mg in weight. In Hokkaido, the fry release season lasts for five months, from the beginning of February to the end of June. The results of the tagged experiment obtained at the Chitose River shows that the fry released from the Chitose hatchery on April 28th, passed Kamaka, 20 Km down the river, on April 29th (therefore 24 hours later) and arrived at the mouth of the Ishikari River, 70 Km down the river on May 22 (25 days later). They then moved into the sea and arrived at the coast of Hamamasu on May 31 (34 days later) and the coast of Rumoe on June 2 (36 days later) 110 Km and 150 Km from the hatchery, respectively. Consequently, some of the fry moved about 150 Km, including 70 Km in the river, within about one month. However, it is well known that the fry stay in the rivers or near the coasts for a fairly long time. The fry, which come into the water in January or February, are inactive until the beginning of April because of the cold water in the river and their distribution is localized. They live together with the dace fry, etc. in swamps near the springs in the upper part of the river. As the temperature rises, they float into the river and stay still at the bottom or in the shade of trees or grass at night. At this stage the fry are 27 to 34 mm in length (excluding their tails), and their fry-spots are clear and their yolks are almost dissolved

but some fry are still having undeveloped abdomens.

From the beginning to the middle of May, the river temperature rises to 5 to 6°C, and the water of the river rises by the thawing snow. Under these conditions the downstreaming of the fry reaches the greatest peak and everywhere along the rivers the school of fry are found in their full activity. At this stage, they are 40 mm in length and some have scales. By the middle of June the water temperature rises to 12 to 13°C and the school of fry moves to lower stream regions, and almost all the fry are in the mouth of the rivers or near the coasts and very few are left in the slow streams in the upper part of the rivers.

p.39

In the river mouth regions, the earliest school arrives around the middle of February, then from the end of April to the beginning of May the density of the fry gradually increases with the rise of the water temperature. By this time the fry grow to 50 mm in length and they lose their fry-spots and their surface colour turns to silver white. The largest number appear from the end of May to the middle of June and they then gradually move into the sea. By the middle of July almost all the schools have disappeared from the coasts. At this time the water temperature is 17 to 18°C and the fry are 80 to 120 mm in length. The fact that the fry disappear from the coast before the temperature rises to 17 to 18°C suggests the suitable temperature for the fry is limited to below 17°C. Therefore it is best to release fry in the early stage of the season while the temperature is still cold.

The transportation of the fry to the safety region is done by the crawl boats or trucks. The transportation on land by the truck is especially efficient if oxygen is supplied on the way. One truck has 6 canvas

tanks, each  $120 \times 85 \times 85 \text{ cm}^3$  in size and can carry 2,500,000 to 4,000,000 fry at one time. This transportation method is safe and can carry the fry for a long distance in a short time. The truck is superior to the crawl boat (one boat has 2 crawls, each  $180 \times 90 \times 30 \text{ cm}^3$  in size, and can carry 1,000,000 to 1,500,000 fry at one time) in its transporting capacity and speed.

The main purpose of the artificial propagation is the mass production of the fry and the fry releasing in the stream, however, the development of strong and healthy fry and their safe arrival at the sea are also very important. The fry must be effectively protected until they disappear far off the coasts into the ocean.

#### VI. Handicaps

Recently the handicaps in the growth of the salmon and trout increased as the industries developed and their growing ground gradually disappears. The main handicap is river pollution caused by the works on the river, the development of the rivers, the floats carrying timber, the gravel gathering and the mine industry drainage, etc. Of late, these handicaps have changed the natural circumstances of the salmon and trout growing rivers. These handicaps have important influences upon the spawning, growth of the fry, and their downstreaming. The natural mass production of salmon cannot be expected now. The river pollution is the most serious reason and this must be eliminated.

p.40

After the second World War, the development of the natural resources in Hokkaido were accelerated and the mine industry developed quickly. The development of the industries, together with the increase

of population, caused river pollution and damaged many of the primitive industries, especially that of the marine products industry.

These damages can be classified as chemical and physical damage. In Hokkaido the industrial sewage is the main cause of the pollution and the chemical damages are overwhelming. There are five main damages caused by the sewage: the mud, the drainage from the metal mines, the drainage from the gold mines, organic substances, and the chemical industry sewage.

(1) Mud: Floods wash mud out from the mines and electric power stations and this mud usually suspends in the water in the colloidal form. However, when it is mixed with the sea water, it combines with the magnesium or calcium cation in the sea water and hardens or deposits in the bottom. Fish avoid these places and sometimes these deposits block the respiratory organs of shell fish and they die from suffocation.

(2) Drainage from the mines: The drainage from the various mines, especially metal mines, causes great damages. The iron sulfide decomposes to sulfuric acid and iron sulfate when it is exposed to the air and this sulfuric acid combines with the clay to form aluminum sulfate. This aluminum sulfate dissolves into the river and acidifies it. Therefore, the fish in the river are killed and if the acidic water flows into the sea, the fish keep away from that area. If the iron sulfide is mixed in the sea water, it gives damages similar to the mud.

(3) Drainage from the gold mine: Potassium cyanide is used in the gold mines and if the water of the river contains 0.15 ppm of this poison the fish are killed and 0.02 ppm is strong enough to keep the fish away from the river.

(4) Organic substance: The organic substance sewage causes the largest damages in Hokkaido. There are about 2,000 starch factories (potato) along the rivers in Hokkaido. The sewage from these

factories contains nutriments, such as protein and glucose. In such water the bacterio propagate themselves and consume large amounts of oxygen and consequently the salmon cannot go upstream. The alcohol factory and sugar refinery cause similar damages. The pulp factory and paper mill uses calcium sulfate to liquify woods and consequently the sewage from these factories and mills contain sulphurous acid, lignin and glucose. These impurities develop the noro (cotton-like deposit) in the water. (5) Sewage from the chemical industry: Sometimes this sewage contains bad smelling phenol and ammonia and the fish in the river become ill-smelling and they lose their commercial values.

To protect the damage from mud, an inexpensive method was devised by Ishiguro (the sea water mixing method); in this method the sewage is dammed up near the mouth of the river and the sea water is poured into it and they are mixed. The mud contained in the sewage reacts with the sea water and deposits itself on the bottom. After that the clean water is drained into the sea. The acids contained in the mine sewage can be neutralized with the alkalies. Some of the organic substances can be removed as follows; make a 1 m deep gravel bed and pour the sewage water into it. The protein in the sewage is decomposed by the reaction of the bacteria on the stone surface and protein-free water can be obtained. However this method is rather expensive and the factory owners are unwilling to practice it. The present authors believe that some coercive legal measures must be taken. The development of the industry should take into consideration the requirements of the marine products industry, both industries must be compatible to each other.

p.41

The law for the preservation of the quality of the water used by

the public (the water quality integrity law) was established in 1958 for the protection of the rivers and sea from water pollution, promoting many kinds of industries utilizing water and eliminating the bad influence of the contaminated or ill-smelling water upon our daily life. This law provides the following articles; investigation of the present situation of the rivers and the sea water pollution and if it is necessary, specify the contaminated region and restrict the degree of contamination under a certain level (the standard quality of the water). Moreover, if it is necessary, reconcile the conflicts caused by the water pollution. Under the provision of this law, a basic investigation was planned by the Economy Planning Agency. The investigation of the water quality of the rivers and sea are now going on. The Hokkaido Government is left in charge of this kind of investigation from the Economy Planning Agency and the research organization of the Hokkaido Government is executing the field investigation. The basin of the river Ishikari was investigated in 1959, 1960 and 1961, and the Tokoro River in 1961, the Kushiro river and its coast in 1962. The Tokachi River will be investigated in 1964.

The law was applied to the Ishikari River and its upper part was specified as the chosen river and the standard water quality was decided for this river. This was by notification No. 4 of the Economy Planning Agency on June 13, 1963. As one of the members of the investigating team, when I look back upon the past, a thousand emotions crowded my mind. This was the fifth year since the beginning of the investigation and at the same time this was the third year since the beginning of the sectional meeting for the decision of the standard water quality. In the basin of the Ishikari River the farms and fishermen had been troubled by the water

pollution for many years. The standard water quality limited by the BOD (the bio-chemical oxygen demand) the pH and the suspensions. The BOD has an important relation with the noro, (the most dangerous enemy of the agriculture and fishery) and it is necessary to limit the BOD value under a certain limit. In this way we can hope to return the contaminated Ishikari River to a clean river like it used to be and we can help the farmers and fishermen out of their water pollution troubles. Now that the standard of the water quality is settled, the factories in the basin of the Ishikari River must be equipped with a sewage refinery within six months and keep the quality of the sewage under the specified limit. This is an epoch-making event for the resolution of the long-pending contamination problems of the Ishikari River. The protection of the public welfare and public benefit is not only an important mission of the nation and the local self-governing bodies, but also a social duty of the enterprisers. However, the water pollution troubles are still left as they are in the middle and lower part of this river. All the contaminated rivers, including the Tokoro and Kushiro Rivers (the investigation was already done on both rivers) must be improved as soon as possible. Everyone, as well as the persons concerned with the water-pollution problems must help clean the rivers and sea for the more effective utilization of the precious water resources. p.42

#### 1) The Ishikari River

The water pollution problem of the Ishikari River came into question in 1950 when the sake, which were under breeding in the Otoe catching farm, emitted a foul odour. The effect of the large amount of organic substances discharged from the pulp factories near the city of Asahigawa is excessive.

Aquatic bacteria develop on the river bed and some of these bacteria are seen near Imose about 60 Km down the river. The BOD value at Chikabumi was about 52.4 ppm and it should be less than 5 ppm according to the tentative river pollution prevention plan of the Economy Planning Agency. At Takigawa on the lower river it is still more than 5 ppm. The present authors are asking the BOD value to be less than 3 ppm for the inhabitable limit of the salmon and trout and as far as Ebetsu city, the BOD value is unsuitable. From Takigawa, coal mine sewage<sup>enter</sup>s into the river and this results in both organic and inorganic pollution which obstructs the development of the depth living creatures (fish food) and makes the living condition of fish worse. The length of fry captured at the mouth of the Ishikari River is about 3 cm in length while it is about 6 cm at the mouth of the Tokachi River and the Yuufutsu River. It is believed that this is caused by the shortage of fish food in the Ishikari River. The effect of the pollution from the viewpoint of the fishery is the decrease of the numbers of sake. The number of upstreamers was 48,000 and 27,000 in 1938 and 1942 respectively and it decreased to 13,000 and 11,500 in 1948 and 1955, respectively. Many ayu (fish) were caught before but nowadays there are not any of them in the Ishikawa River. These results suggest that the environment of the Ishikari River, which has the largest amount of fish propagation, has a great influence on the fish reproduction and fish supply has been decreased.

## 2) The Tokoro River

Recently many factories were built on the Tokoro River and sewage has been discharged from these factories. In 1953, pulp factories, in 1957 sugar refineries, and in 1959 starch factories were built and the

river pollution increased rapidly by the sewage discharged from these factories. The first sign of the water-pollution was the colouring of the river and the desolation of the river bed. The noro originated from the invasion of the organic sewage in the river and developed in huge numbers between the outlet of the sewage to 5,000 m down the river and the river beds are completely ruined because of them. Aquatic bacteria flow down the river and cover the surface of the gravel in the lower part of the river and as time passes they become so contaminated that only the earthworm-like small creatures can survive. While at the mouth of the river, the black floating mud, which flowed down from the upper streams, deposited on the bottom of the mouth of the river. In the Tokoro River, according to the fishermen, salmon used to enter the river before a storm however, nowadays they stay in the sea until the storm passes then they enter the river. This can be explained by the following. When the colloidal fine slag, sand, mud and clay flow down from the upper part of the river, the mouth of the river becomes muddy. On the other hand, the mud which was deposited on the river bed is stirred up by the storm and causes the muddy water. The salmon that gather at the river mouth shun these muddy waters and wait for them to settle, then they go upstream. However if it takes too long to settle the water, sometimes they move to other rivers.

p.43

The investigation of the Tokoro river designated by the Economy Planning Agency was done after the investigation of the Ishikari River and the entire picture of its chemical contamination was given as follows; in April and May the river rises when the snow thaws and the degree of its water-pollution is low. June, July and August are the drought season of this river so the density of impurities increases and with the many

unfavourable conditions, such as the shortage of oxygen, the river becomes a minimum habitable condition for the fish. In October, the sugar refineries and starch factories begin production and by the end of October the water condition becomes worse. The BOD value at the mouth of the river (under the Tokoro bridge) was 4.44 ppm (Oct. 22, 1959), 6.01 ppm (Nov. 23, 1959), 16.8 ppm (Dec. 26, 1959) and 17.00 ppm (Jan. 26, 1960). Recently the water has been more contaminated especially at the end of January, which is the end of the sugar refining season. The BOD value is extremely high (In 1955 the Fisheries Agency suggested that the standard BOD value of the water suitable for the marine products industry should be less than 5 ppm. Nowadays, the hatcheries are asking for a BOD value of less than 3 ppm for the salmon and trout upstreaming). At present the sewage refining equipment of these factories is not effective and if it is not improved the marine products industry in the Tokoro river will be ruined. The number of captured salmon parent fish has been decreasing since the opening of the pulp factory in 1953. There were 22,489 in 1950, 16,236 in 1952, and suddenly they decreased to 9,370 in 1955. It was 6,010 in 1956 and 8,670 in 1960 (recaptured rate for the past five years is 0.135%). In 1960, salmon were captured in the neighbouring river of Abashiri and Yuubetsu, 70,590 and 49,799 respectively (recaptured rate for the past five years is 0.497% and 0.313% respectively). In the Yuubetsu River, 42,364 were captured in 1950 then they increased gradually and 32,119 were captured in 1957 and 49,755 in 1960. The situation is similar in the Abashiri River where 6,613 were captured in 1950, 33,061 in 1959 and 70,590 in 1960. The BOD values at the mouth of these rivers between 1958 and 1960 was 2.40 ppm to 3.56 ppm for the Yuubetsu and 0.58 ppm to 3.95 ppm for the Abashiri. It is clear that the mouth of these rivers are not

contaminated.

### 3) The Shubuto River

The numbers of parent salmon captured in the Shubuto river began to decrease in 1942 (a gold mine opened in 1941). There were 1,271 captured in 1942, 199 in 1947 and then there was a sharp decrease in 1948 with only 41 being captured. The reason was investigated and it was found that the white muddy rain water from the slag deposits in the mine (at that time it was abandoned) flowed into the Shubuto River and caused contamination. The spawning ground of the ayu (fish) were the shores of the river before the opening of the gold mine but now no ayu are living on the shore of the river where the Rurukomanai River (a tributary of the Shubuto River) pours into the Shubuto River. Recently the catch of the ayu is less than one third of what it was before. As for the upstreaming salmon, they usually instinctively go upstream immediately after the rise of the river. Contrary to this, in the Shubuto River they go upstream when the water level is normal. The fisherman's union observed that if the water of the Hisato Bay becomes muddy, the fish disappear from the bay. These facts clearly show that the water pollution is caused by the slag particles.

In 1947 the water quality of the Rurukomanai River was investigated both at the river rise time and at the normal time. Normally, the water of this river is clear (the normal water flux of this river is  $0.18 \text{ m}^3/\text{sec}$ ). The drain of the slag deposition enters the river near its source. In the river rise time the water flux increases to  $1.08 \text{ m}^3/\text{sec}$  and its colour changes to dark milk-white by the inflow of the slag particles). The content of the chemical component is small and it does not differ much with other rivers. However, in the river rise time

the colour changed to dark milk-white and the total solid material was 1,797 \* ppm, which is ten times larger than the normal value.

It is foreseen that the trouble of the water pollution in Hokkaido will increase because of the opening of the beet sugar refinery. This is expected on the Tokachi River System as well. The development of the mines such as lead, copper, zinc, manganese and sulfur will cause pollution (development of sulfur mines are expected west of Tomakomai). Mercury comes as sulfide. If gold or silver mines were opened sodium cyanide would be used for the smelting and an enormous amount of fish would be killed. If copper, zinc or lead are mixed with water it also is serious for the fish. If coal mines are developed in the Kushiro district, then the rivers Tokachi and Akan will become blackened and the colloidal particles will increase in the rivers and these disturb the upstreaming salmon and trout and if these are in great quantities the fish may choke. Some other examples of physical damages already exist.

p.45

The hydroelectric power stations are usually built in the heart of mountains and in some district the decrease of the water level in the river will cause troubles. While in the Hitaka district they will be built near the sea coast (in fact the Horoman dam is already built near the sea), in Hokkaido this kind of dam is one of the largest handicaps for the downstreaming fry. Sometimes the fry are sidetracked into irrigation ditches where they will be killed. The water volume of the rivers in Hokkaido is decreasing because of the increasing demand for irrigation water. In the Chitose River, the normal water flux is 400 units, but the

---

\* It could be 17.97 ppm.

demand of the irrigation water is over 200 units and the damage to the fry by this sidetracking of water is enormous. The influence of the lumbering industry also causes large damage locally. The so-called teppoo-nagashi\* carries lots of sand and mud away. In the case of the Ishikari River the teppoo-nagashi is done at the most upper part of the river (Oobako near Kamikawa) give influence not only to the city of Asahigawa area but also to the Takigawa area. This causes havoc in the spawning grounds and this handicap cannot be ignored. The gravel collection for building ruins the spawning ground and decreases the ground area. It will be necessary to secure the spawning ground by preparing special rivers or special regions for the spawning of the fish. The collection of the gravel must be limited. In the rivers which have factories near its basin, the river contamination increases as the scale of the factories increase.

If we consider all the handicaps mentioned above, the future of the water quality protection in Hokkaido is in a pessimistic condition. Strict supervision of the water quality of the rivers in Hokkaido must be carried out to prevent the natural and artificial handicaps. Unlike Honshu, there is peat in Hokkaido and the humic-acid penetrates from the peat bog into the rivers and promotes the colloidal action of the fine particles in the water. Therefore, the rivers near the peat districts are always muddy. If these rivers are contaminated by the artificial contamination from the upper part of the river then the lower part of the river is damaged by both artificial and natural contamination and perhaps the

---

\* A small dam is built in the upper part of the river and timbers are stored in the pool and suddenly the dam is opened and transports the timbers for a long distance.

natural cleaning action of the river cannot keep the river clean.

#### 4) The coast

When the salmon and trout fry arrive at the coast, they normally stay there for about five months from March to July, then they move far off the coast to the ocean. At that time they are 10 to 12 cm in length. While they move around on the coast, they form a dense school and when caught they are mixed with the other coastal fish. This damages the reproduction and supply of the fish enormously.

The coastal fishing mainly is done with large and small stationary poundnets, the drag nets and boat towing nets. The main object of the fishing is the herring, sardine, kounago, hokke, mackerel and chika as well as cuttle fish and grey mullet, etc. An enormous amount of salmon and trout fry are caught with them. In 1951 the mixed catching of the salmon fry was investigated at the coasts of Ishikari, Hitaka, Soya and Watarishima in Hokkaido. The total number of fry caught was estimated to be more than one million three hundred thousand and it is more pronounced on the coast of Ishikari. The results are shown in Table 13. p.46

This was also investigated in 1952 at the Funka Bay coast and it was estimated that about 1,800,000 salmon fry were caught with the small size fish such as sardine, kounago, isada, hokke and pollack. This is about 25% of the total fry released in the Funka Bay area. The results are shown in Table 14.

The length of these mixed caught fry is more than 7.6 cm in average and the range of the mixed catch area is over 2.5 km from the coast with the catching period as long as three months from May to June.

In 1953, the mixed catching was investigated in Hokkaido, covering

Table 13. The results of the mixed caught sake fry investigation.  
(1951)

District	Investi- gation	Mixed caught fry	Fishing implement	Remarks
Ishikari	June 5 to June 27	1,014,630	small stationary pound net, set net	especially on the Ishikari coast
Hitaka	May 1 to June 30	39,974	stationary pound net for summer her- ring, small station- ary pound net for herring, drag-net	especially small station- ary pound net for herring
Sooya	May 20 to July 20	248,083	<u>Tamasuji Gyomoo,</u> <u>Sirauo-gill-net,</u> set net	especially <u>Tamasuji,</u> <u>Gyomoo</u>
Oshima	May 28 to June 30	25,880	<u>Tamasuji Gyomoo,</u> drift-net, drag-net.	especially <u>Tamasuji,</u> <u>Gyomoo</u>

Table 14. The results of the investigation of the mixed caught  
fry obtained at the Funka Bay in Hokkaido (sake). (1952)

District	Investi- gation	Mixed caught fry	Fishing implement	Remarks
Date and Shizukari	May 20 to June 20	300,000	large stationary pound net (34), small stationary pound net (64), drift-net (21) <u>isada</u> (3)	herring, salmon, trout, <u>Kounago,</u> mackerel, <u>chiba.</u>
Oshamanbe and Sumahara	May 15 to June 30	800,000	<u>isada</u> (116) small stationary pound net (136) drag-net (2) drift-net (2)	<u>kounago,</u> <u>isada,</u> sardine, herring
Shikabe and Ofudao	June 10 to July 10	700,000	small stationary pound net (143)	<u>kounago</u>
Total	5.15-7.10	<u>1,800,000</u>		

all the coasts, and the total number of fry caught were estimated as 13,760,000. This investigation was done only for the stationary pound net method, therefore, the actual number must be far greater than this result.

### VII. The Migration

All species of salmon in the North Pacific Ocean are born in the fresh water of rivers and lakes and grow in the ocean far from the effect of these rivers and lakes. There they reach maturity in a year or so and when spawning time comes, they leave the ocean to go to the rivers or lakes where they were born.

This fact is called migration, however, the definition of the migration region is not definite. Sometimes it means a river basin, tributary streams or specific spawning ground in the tributary streams. At other times it even includes the coastal region.

In this section we deal with the problem of whether salmon have a special character which makes them return to a specific stream or not. To answer this question the fact that every year at almost the same time, each specific region of a river is utilized as a spawning ground and this must be taken into consideration.

This migration character is a tendency which salmon have in general. Even if this character is certified for one specific fish it does not prove that all the fish will come back to the mother river and it has no value as proof of migration. To prove this character one must study the movement character of salmon as a specie.

Many investigations have been done to demonstrate scientifically whether a school of salmon migrates to its mother river or not. These

investigations are mainly concerned with the following articles in the next paragraph and recently, experiments have been done about biological study and homing abilities of the fish.

Many investigations have been done in the past to determine the actual circumstances of the migration, these are (1) tagged experiments, (2) character of species, (3) homing ability of fish. Strong evidences exist about the migration of salmon to their mother rivers.

#### (1) Tagged Operation

To investigate the migration, tagged schools of fry were released into the water and they were recaptured when they returned to the river after they had matured in the sea.

Tagged operations have been done actively in many countries of the world and many investigations have been reported. Kelez (1937), Foerster (1934 - 1936), Barnaly (1944), Rich and Holmes (1927) and Snyder (1921~1924) studied those Atlantic salmon, sockeye salmon, silver salmon and king salmon. (These salmon live for some time in the fresh rivers and lakes.) Rich and Holmes investigated the king salmon between 1916 and 1927 in the Columbia River and obtained a recapturing rate of 0.002% to 0.45%. Snyder obtained almost equivalent values in his investigation in the Sacramento River between 1921 and 1924.

p.48

Foerster observed Sockeye salmon in the Cultus Lake and reported that he released 91,6000 tagged ones and recaptured 804 of them (recapturing rate 0.88%) between 1929 and 1930. In his experiment an apparatus to count all the tagged and untagged downstreaming fish accurately was used and then they were released into the river again. The age of these fish was accurately investigated at the time of releasing and recapturing.

He observed that the total number of fish returned to Cultus Lake was 3940 and the rate of recaptured fish compared to the total released fish was 2.49%.

Foerester continued his experiment in 1928 and 1931 and obtained the following results:

tagged fish	91600	~	365800
recaptured	804	~	12803
rate	0.88%	~	3.5%

It should be noted that a large percentage of the fish that were recaptured was in Cultus Lake.

Barnaly investigated sockeye salmon in the Karluk River, Alaska between 1926 and 1933. Five thousand and fifty thousand were released and 107 and 1549 were recaptured respectively. (The recapturing rate was 2.14 and 3.09% respectively). Almost all the recaptured fish were obtained in the Karluk River. He also reported that if the tagged fish were included in the total investigated schools of fish in the same rate as those obtained in the river (2.14 and 3.09%), then the total number of the recaptured tagged ones would be increased, therefore the recaptured rate (2.14 and 3.09%) would be increased to 15.4 and 23.6%. He also reported that the older the fish was when it was released, the recapturing rate increased as well. The results in 1926 and 1931 were as follows:

released age:	2 years	3 years	4 years	5 years
recaptured rate:	7.6%	19.5%	24.3%	40.8 - 58.3%

Kelez investigated silver salmon in Friday Creek in 1934. He reported that the recapturing rate for the tagged fry (47.5 mm in length) was only 0.027% (26,150 released, 7 recaptured), on the other hand, the recapturing rate for tagged ones 101.6 mm in length, was 1.76% (the same number released and 460 recaptured). These results suggest that the recapturing rate increases as the size of fish is increased at the releasing time.

Davidson (1934), Pritchard (1934) and others reported that 8,700 to 124,000 karafu=masu (O. gorbuscha) were released and recapturing rate at the mother rivers was from 0.028 to 2.73%. The recapturing rate of these fish was much lower than sockeye salmon and suggests that recapturing rates are lower because they spend less time in the fresh water.

Pritchard (1944) investigated Karafu-masu in Morrison creek. In this experiment 101,194 were released and 868 were recaptured of which 865 were recaptured in the mother river and 3 were recaptured in the other rivers. In Japan sake (O. kata) (the most important salmon) has mainly been the one investigated. Many experiments have been done in the rivers in the northern part of Japan and sake migration has been exemplified. Sake were investigated in the Chitose River in Hokkaido between 1896 and 1902 and 48 were recaptured by 1905 and during this period a recapture rate of 0.017% to 0.018% was obtained.

The fact that mainly these gill-less or adipose-fin-less salmon were captured during this experiment indicates that the salmon released from this river returned again.

After that, tagged operation was carried out in the Aisaka River in Aomori Prefecture, the Miomote River and the Hayade River in Niigata

Prefecture and the Abashiri River in Hokkaido, between 1927 and 1943. The results are shown in Table 15. \*

The 6.38% recapture rate obtained in the Miomote River in 1927 is a very high rate for sake. This value is the recapture rate for the fourth year after they were released and this is not the sum of each spawning year, therefore the migration of more tagged ones can be expected. In some cases no reports are given about the recaptured number. It is not known if there was migration or if recapture tests were not practiced. In Abashiri River, a double tagged method was used for the migration experiments in the years between 1941 to 1943. Then by 1947, all the rivers in Hokkaido District were equipped to catch these double tagged fish. The age of the recaptured salmon was investigated and they were classified according to their spawning year; results were considered accurate. p.50

Since 1951, tagged operations have been done for Sake, Karafu-tomasa and Sakurama in a nationwide scale, the results were summarized separately in each spawning year. The recapturing rate was high in the rivers such as Tokoro, Shibetsu and Tokachi. In the Tokoro River, many salmon were recaptured both in the mother river and its coast. This indicates high probability of migration to the mother river.

The results of these investigations depends on the effort made recapturing the fish, some fish were possibly missed. This fact must be taken into consideration in the estimation of the migration results. The results of the tagged experiment is shown in Table 16.

---

\* Table 15 is attached at the end of this booklet.

Table 16. Tagged experiment for sake in Hokkaido (1951-1960)

Year	River	Fry Re- leased	Recaptured Fish			Recap- turing Rate	Remarks
			Coast	River	Total		
1951	Tokoro	27,600	26	46	72	0.26%	including the ones re-captured in N. Pacific(1)*
1951	Chitose	31,800	5	15	20	0.06	
1951	Shireuchi	37,000	14	14	28	0.07	
1952	Iwaobetsu	30,000	3	4	7	0.02	
1953	Chitose	803,480	58	35	93	0.01	
1954	Chokanbetsu	63,000	5	18	23	0.04	
1954	Tokoro	500,000	2,259	333	2,592	0.52	" *
1955	Chitose	637,000	29	47	76	0.01	
1958	Chibetsu	513,000	510	732	1,242	0.24	
1960	Tokachi	788,000	149	112	261	--	up to Sept. 1963 unfinished

\* These remarks are not explained in the paper.

The same type of investigation has been done in the Prefectures of Aomori, Niigata, Yamagata, Toyama, Ibaragi, Iwate, and Hyogo and recapturing rates obtained were nearly the same values obtained in Hokkaido.

Karافتo-masu and sakura-masu have been investigated in Hokkaido and Toyama Prefecture, etc. The results are shown in Table 15. However, the results for karافتo-masu in Toyama Prefecture and sakura-masu in Hokkaido are not shown.

Table 17. The results of the tagged experiment for karafuto-masu and sakura-masu.

Year	Fish	River	Re- leased	Recap- tured	Recap- turing Rate	Remarks
1952	karafuto-masu	Yuurapp	42,335*	27*	0.06%*	in the river only
1952	"	Yuubetsu	113,195	15	0.01	in the river only
1953	"	Kurobe	10,000	?	--	
1954	"	Yuurapp	99,089	22	0.02	in the river only
1955	sakura-masu	Teshio	51,560	?	--	

\* According to this table, the recaptured rate of sakura-masu in the river is 0.06%. While about 4,500 sakura-masu were captured on the coast. If we assume that tagged ones are mixed the 4,500 captured on the coast at the same rate (0.06%) as in the river, then the total recaptured tagged sakura-masu will be increased and the recaptured rate will be larger than 0.6%.

In these investigations, the migration is estimated by the recapture rates, however, these values indicate the minimum rate. Therefore, the actual number of migrated fish may be larger than that reported.

The largest number of salmon were recaptured in Tokoro River and most of them were recaptured in a small region facing the Sea of Okhotsk, including the coast of the Tokoro River. Three hundred and thirty-three salmon were recaptured in the river in this region and more than 98% of them were recaptured in the Tokoro River, where they were released. These facts also indicate the migration character of the salmon toward their mother river where they were originally spawned.

Recently the circumstances of the rivers in the northern part of Japan have been aggravated by the development of industry and the growth

of salmon is damaged by these situations. This has an important effect on the migration of tagged fish. In studying migration, the following conditions must be considered; handicapped region, number of surviving fry, number of upstreaming parent fish, etc.

(2) The character of salmon as species

The results obtained from the investigation of tagged operation on the coast and open sea indicate that salmon in the Far East can be classified into two large groups, summer and autumn salmon. They are distinguished from each other by their body size, their organs, number of spawns, scales, age construction, migration season, etc. These investigations revealed that a specific school of salmon grows in the rivers in a specific region. The following conclusions are reasonably clear; the salmon in the North Pacific Ocean can be classified into two groups, one comes from Asia and the other from North America. In these two groups some mature in the northern part of the North Pacific Ocean and the others in the Southern part of the North Pacific. Autumn salmon can be classified into two groups, one migrates to the coast of Japan and the other migrates to the rivers in Okhotsk, Amur and Sakhalin region. Their migration route and migration region differ.

Each creature has its measurable characteristics, which are generally deviated from the mean value among these groups. The one which is most adapted to its environment, develops well, and consequently the number of creatures that have these characteristics increase in number.

p.52

Each school of fish in one specific river, or in one specific tributary stream, or in one specific spawning ground, have different

characteristics and some measurable characteristics are formed.

Many investigations have been done concerning the classification of fish with its measurable body characteristics. Such experiments have been done for all kinds of salmon in the North Pacific Ocean. The ratio of the body, numbers of gill arch, gill-ray bones, the fine-rays, the spinal bones, and the pylorus appendix were measured and the number of lateral line scales, eggs and pattern of scales were analyzed.

Chamberlain (1907), Rich (1939), McGryer (1923), Parker (1933), Townsend (1944) and Pritchard (1945), et al. investigated the body length, the number of spinal column bones and gill filaments, etc. of the Alaska salmon. They classified the difference of the salmon species and the change of these characteristics over a long period of time.

The characteristics, such as the number of eggs of masunosuke (King salmon) and the number of pylorus appendices of karafuto-masu (O. gorbuscha) also differ from river to river.

The different characteristics of the school of benisake (Sockeye) and masunosuke in the different rivers and spawning grounds are also classified by the scale pattern analysis. In Japan, Hirano and Nakagawa (1938), Kubo and Kobayashi (1953), Kubo and Yamahira (1953), Sano and Kubo (1946) and Koboyashi (1961) et al. investigated these salmon characteristics.

The number of spinal bones were investigated in the Ishikari River and the differences found between the main stream and the tributary streams were classified (the salmon in the main stream have more eggs). The same tendency was observed in the number of the lateral line scales. Moreover, the salmon in the Shirenai River, in Hokkaido, has the largest number

of the lateral line scales and spinal bones. This river is known for its salmon, this being the largest upstreaming salmon in Hokkaido. The difference in the number of eggs was observed between the upstreaming salmon in the Hokkaido rivers and in the South Kuril Islands. This number was larger in Hokkaido. p.53

The number of the gill arches, the fin coefficient and the other measured values of the body parts, were also found different between rivers in Hokkaido and it therefore suggests that the salmon have different characteristics in the different regions and in the different rivers.

The autumnal (Hokkaido school) and summer salmon were also classified by the analysis of scale pattern. Some differences were also observed from river to river in Hokkaido. The scale of Sakura-masu also differs between districts and the effect of local environments and heredity, were observed.

The ecological study mentioned above has been making remarkable progress in classifying the characteristics of salmon. The growing region of a salmon, captured in the open sea can be estimated from its ecological characteristics. It suggests the possibility of pointing out the spawning region or even mother river of fish by studying more precisely the characteristics of the captured fish.

Many investigations, such as upstreaming time, age construction, ratio of male to female, and kinds of parasites the salmon have, are now under study and the difference in the large schools of fish and the different river groups, were also observed.

### (3) Homing ability of fish

The tagged operation and the investigation of the characteristics

of salmon schools revealed their migration habit.

Each school of salmon always uses specific region and the direction and region of migration are known characteristics among each school. What urges the fish on such movement or how the fish detects the direction of its spawning ground and arrives at its specific coast and river, are important subjects that are still left unclarified.

Craigie (1926) and Hasler (1954) suggested the importance of the organ of smell for the migration of fish. They also suggested that fish migrate to their spawning ground by the guide of the specific smell of the river where they were originally spawned. They investigated killifish and observed that the fish memorized some specific smell for more than 15 weeks, and always headed to that smell. However, the fish from which they cut the smell organs were unable to detect the smell and they did not choose any specific direction.

Dence (1956) investigated one kind of sucker which lived in a lake and migrated to a specific spawning ground in a specific season. He observed one male that lost his organ of smell by natural accident and it stayed at the spawning ground two to three weeks after the other fish left.

Brett (1957) reported that one kind of secretion from a mammal skin repulses salmon fry with its smell, a density of  $1$  to  $8 \times 10^{10}$  is enough to drive them away. One can estimate the degree the smell organ develops in the fry in their downstreaming stage.

p.54

There is an experiment on salmon parent fish. Salmon were caught in one tributary stream and were then released in the lower part of the main stream of the same river and most of them returned to the same tributary stream. However the ones that had their nostrils blocked with

cotton could not distinguish between the main and tributary streams and many of them upstreamed the main stream. The organ of smell is an important factor for them to make their way to the spawning ground.

The salmon's organ of smell is well developed and it is almost clear that they are guided by the smell in the river. However, it is not revealed how salmon can find their mother river in the ocean far from the effect of the river. The sense of smell mentioned above may be of no use after they have spent 4 to 5 years in the ocean.

As it is well known that in bees and migratory birds that they have an internal clock, the same may be true of fish. Hasler investigated one kind of perch (each school of perch has its own spawning ground like salmon) and found that they head in a fixed direction, which has an important relation with the sun, and this condition is disturbed on a cloudy day. Artificial irradiation will also disturb this characteristic.

Salmon are also known to keep their direction with the help of the sun and it has been gradually clarified that salmon also have an inside clock like bees and migratory birds. The salmon matured in the ocean and were stimulated to make their way to the spawning ground by their natural changes for the preparation of spawning, such as development of reproduction function and fat accumulations.

They find a specific smell from the mother river as they come near the coast and finally return to the specific spawning ground.

The study of their behaviour, after they left the ocean, until they find the specific smell of their mother river may be of great help for the understanding of their migration character, although many problems are still left in the relation between the inside clock and the sun.

### VIII. The results of the artificial propagation

#### 1) Hokkaido

The artificial propagation in Hokkaido is operated as follows: parent fish are caught at more than 70 catching farms in the 59 rivers and fry are incubated at the 60 hatcheries and are released into 48 rivers.

The total catch of parent fish for the last 5 years was about 300 to 430 thousand (363,499 average). 270 to 460 million eggs were collected ( 370 million average) from these fish and about 80 to 90% of the eggs were incubated to fry and were released into rivers. In an ordinary year the variation of the total number of Karafuto-masu is somewhat larger than sake and 15,000 to 51,500 parent fish are caught and 3,780,000 to 28,500,000 eggs are collected. The results are shown in Table 18\*.

The incubation record for sakura-masu (O. masou) is somewhat worse than Sake, however 80% of the eggs were incubated to fry. The upstreaming season of sakura-masu starts early in the year so among the upstreaming sakura-masu only the latter term schools need artificial incubation. 3.3 to 7.7 million eggs (an average of 5.41 million) are collected from three to six thousand (4,712 average) parent fish every year and about 80% of the eggs are developed to fry and released into rivers.

Hime-masu (fish) are artificially propagated in Shikotsu Lake only. Nowadays 5 to 7 million eggs are collected from 37 thousand parent fish and some of the eggs are transported to other parts of Hokkaido and other districts. One to two million fry are released in Shikotsu Lake. This lake holds an important position as the supplier of hime-masu eggs. One to two million eggs are transported from this lake each year.

---

Table 18 is attached at the end of this booklet.

## 2) North-Eastern prefectures

The artificial propagation of sake is operated in Hokkaido and in the North-Eastern prefectures. In 1962 and 1963, 178,962 parent fish (156,000 to 202,000 on the average) were caught in 52 rivers and 146,475,500 eggs (138,440,000 to 154,500,000) were collected. 129,451,500 fry (119,421,000 to 139,482,000) were bred in 80 hatcheries and released into rivers. The results are shown in Table 19.

Table 19. The results of artificial propagation of sake (O.keta) in the North-Eastern prefectures in 1962 and 1963.

Year	Parent fish caught	Eggs collected	Eggs incubated	Fry released	Remarks
1962	202,255	154,504,000	142,893,000	139,482,000	
1963	155,668	138,447,000	122,915,000	119,421,000	
mean	178,962	146,475,500	132,904,000	129,451,500	

### Ending

This booklet dealt with the method of artificial propagation of salmon and trout in Japan, especially in the Hokkaido district. Among the techniques used, many problems are still left for further improvement. It would be of great benefit to the marine products industry if these problems were solved.

Except for some very limited regions in Japan, it may be difficult to keep rivers, where salmon and trout upstream, in their primitive situation, like in the rivers of Kamchatka, Siberia and Alaska. The increase of water pollution and development of manufacturing industry accelerates to worsen the situation.

Nowadays, the rivers in Japan are standing on the brink of ruin because the water pollution caused by the development of the manufacturing industry. However both the manufacturing industry and marine products industry must co-exist. Therefore, it is urgent for the people who are engaged in the propagation of fish to take measures demanded by the circumstances.

The authors desire to do their best for the reproduction of salmon and trout resources with the support and help of the people concerned.

(The publishers forbid reproduction of this material.)

(Table 5-1)

Table 5: The Hokkaido salmon catching system in 1962.

Sea division	Branch	Water system	Working office	Fishing farm φ government Δ entrusted	Fish				Organization		
					sake	sakura- masu	karafuto- masu	himo- masu			
Ckhotsk	Kitami	Rusha	Iwaobetsu	Δ Rusha			0		Shari 1st Fisherman's Union(F.U.)		
		Iwaobetsu	Iwaobetsu	Δ Iwaobetsu	0	0	0		Utoro F.U.		
		Shari	Shari	φ Shari	0	0	0		Hokkaido		
		Mokoto	Mokoto	Δ Mokoto	0		0		Zoshoku F.U.		
		Abashiri	Abashiri	φ Abashiri	0		0		Hokkaido		
		"	"	Δ Nishi- Abashiri	0				Nishi-Abashiri F.U.		
		Tokoro	Shijoo	φ Tokoro	0		0		Hokkaido		
		Yuubetsu	Yuubetsu	Δ Yuubetsu	0		0		Zoshoku F.U.		
		Shokotsu	Shokotsu	Δ Shokotsu	0	0	0		Monbetsu F.U.		
		Mobetsu	Shokotsu	Δ Mobetsu			0		"		
		Okoppe	Shokotsu	Δ Okoppe	0		0		Zoshoku F.U.		
		Oumu	Horonai	Δ Oumu			0		Oumu F.U.		
		Horonai	Horonai	Δ Horonai	0		0		Oumu F.U.		
		Teshio	Teshio	Otoshibe	Tokushi- betsu	Δ Otoshibe			0		Esashi F.U.
				Furepp	"	Δ Furepp			0		"
Tokushi- betsu	"			φ Tokushibetsu	0	0	0		Hokkaido		
Horobetsu	Utanobori			Δ Kitami- horobetsu	0	0	0		Esashi F.U.		
Tonbetsu	Tonbetsu	Δ Tonbetsu	0		0		Hokkaido				
Total in Ckhotsk sea division	17	11	φ 5 Δ 13 total 18	5 8 13	2 3 5	5 12 17					
Sea of Japan	Teshio	Teshio	Shijoo	Δ Teshio	0				Teshio F.U.		
		"	"	φ Saku	0		0		Hokkaido		
		Chitose	Ishikari	Δ Ishikari	0				Ishikari F.U.		
"	Otoe	Δ φ Otoe	0					Hokkaido Otoe ichimi egg collection Union			

(Table 5-2)

Sea division	Branch	Water system	Working office	Fishing farm		Fish			Organization
				♂ government	♂ entrusted	sake	sakura-masu	karafuto-masu	
Sea of Japan	Chitose	Ishikari "	Shi jo	♂ Nishietsu	0				Hokkaido
			Shikotsu-ko	♂ Shikotsuko				0	"
	Oshima	Shiribetsu Shubuto	Shiribetsu	♂ Nakoma	0	0			Hokkaido
			"	Δ Shubuto	0	0			Shubuto-gawa F.U.
	Ribetsu	Ribetsu	Δ Hiyamizu	0				Sedana F.U.	
	Atsusaburi	Atsusaburi	♂ At-usabri	♂	0			Hokkaido	
Total in Sea of Japan	6	8	♂ 5		4	1	1	1	
			Δ 5		5	1			
			total	10	9	2	1	1	
West of Erimo	Oshima	Shiriuchi Moheji Yuurapp Oshamanbe	Shiriuchi	♂ Shiriuchi	0				Hokkaido
			"	Δ Moheji	0				Moheji F.U.
			Shi jo	♂ Yuurapp	0				Hokkaido
			"	Δ Oshmanbe	0				Oshamanbe F.U.
	Chitose	Zukki Shiraoui Nishikitapp Yuufutsu Mukane Niikapp Shizunai Mitsuishi Motourakawa Horobetsu	Zukki	Δ Zukki	0				Shiraoui F.U.
			Shiraoui	Δ Shiraoui	0				"
			Shi jo	♂ Nishikitapp	0				not working
			Yuufutsu	♂ Yuufutsu	0				Hokkaido
			Shizunai	Δ Mukane	0				Mukane F.U.
			Niikapp	Δ Niikapp	0				Niikapp F.U.
			Shizunai	♂ Shizunai	0				Hokkaido
			"	Δ Mitsuishi	0				Mitsuishi F.U.
			Motourakawa	Δ Motourakawa	0				Ogifushi F.U.
			"	Δ Hitakahorobe- tsu	0				Urakawa F.U.
Total in West of Erimo	14	10	♂ 5		5				
			Δ 9		9				
			total	14	14				

(Table 5-3)

Sea division	Branch	Water system	Working office	Fishing farm β government Δ entrusted	Fish			Organization
					sake	sakura- masu	karafulo- masu	
East of Erimo	Tokachi	Reki fune	Ooki	Δ Reki fune	0			Ookimachi
		Tokachi	Shi jo	Δ Uchinai	0			Zoshoku F.U.
		"	"	Δ Chiyoda	0			Hokkaido
		"	"	Δ Tokatta	0			Zoshoku F.U.
		"	Makubetsu	Δ Toshibetsu	0			"
		"	"	Δ Makubetsu	0			"
		"	Fudauchi	Δ Higashi No. 33	0			"
	"	"	Δ Higashi No. 15	0			"	
		Otobetsu	Shiranuka	Δ Charo	0			Otobetsumachi
		Charo	"	Δ Charo	0			Zoshoku F.U.
		Akan	Akan	Δ Akan	0			Hokkaido
		Kushiro	Tsurui	Δ Yukiuchi	0			Zoshoku F.U.
		"	Kushiro	Δ Hokonuma	0			"
		Bekanbeushi	Oota	Δ Bekanbeushi	0			"
	Total in East of Erimo		7	9	Δ 2 Δ 12 total 14	2 12 14		
Nemuro	Nemuro	Bettooga	Atsutoko	Δ Bettoga	0	0	0	Nemuro Chuubu F.U.
		Fuuren	Hamanaka	Δ Fuuren	0	0	0	Bekkai F.U.
		Nishibetsu	Nijibetsu	Δ 14 Sen	0		0	Hokkaido
		Tokotan	Kenebetsu	Δ Tokotan	0	0	0	Notsuke F.U.
		Shunbetsu	"	Δ Shunbetsu	0	0	0	"
		Touhoro	"	Δ Touhoro	0	0	0	"
		Shibetsu	Itakashi- tsu	Δ Busa	0	0	0	Zoshoku F.U.
		"	Ichani	Δ Shibetsu	0	0	0	Hokkaido
		Ichani	"	Δ Ichani	0			Zoshoku F.U.
		Chuurui	"	Δ Chuurui	0	0	0	"
		Kotanuka	Kunbetsu	Δ Kotanuka	0			Shibetsu F.U.
		Kunbetsu	"	Δ Kunbetsu	0			Zoshoku F.U.
		Sakimui	"	Δ Sakimui	0			Shibetsu F.U.
Motosakimui	"	Δ Motosakimui	0			"		

(Table 5-4)

Sea division	Branch	Water system	Working office	Fishing farm of government Δ entrusted	sake	Fish	karafuto- masu	hime- masu	Organization
						sakura- masu			
Memuro	Memuro	Shokubetsu Harukari- kotan Rausu Sashirui	Kunbetsu Rausu " "	Δ Shokubetsu	0		0		Shokubetsu F.U.
				Δ Harukari- kotan	0		0		Rausu F.U.
				Δ Rausu	0		0		"
				Δ Sashirui	0		0		"
Total in Memuro		17	8	φ 2 Δ 16 total 18	2 15 17	1 7 8	2 11 13		
<hr/>									
<u>Total</u>									
5	6	61	46	φ 19 Δ 55 Total 74	18 49 67	4 11 15	8 23 31	1 1 1	

Otoe catching farm has been changed from φ to Δ.

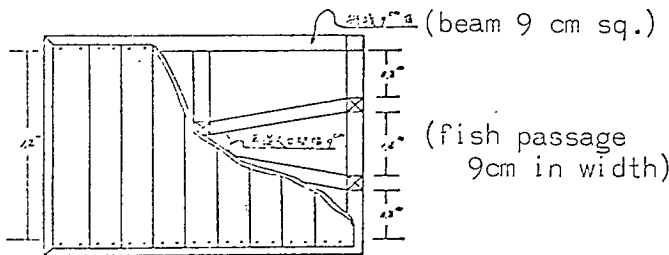
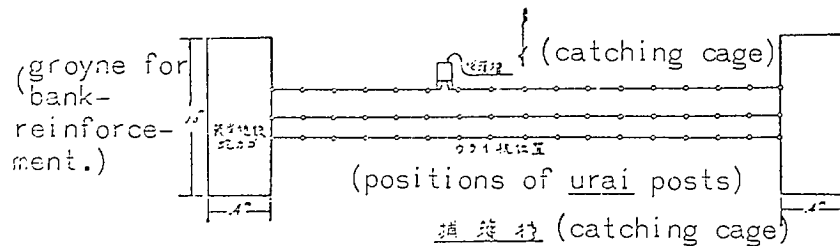
Tokushibetsu catching farm has been changed from Δ to φ.

Shibetsu catching farm is the union of the former 5 Sen catching farm.

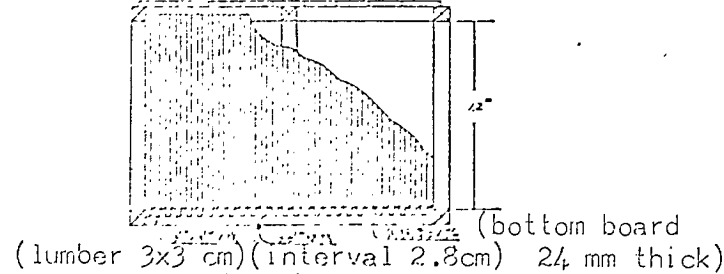
Mishikitapp (government) is omitted.

工事内訳	内訳内容	仕様
その他	各材料 掃除	付ける。 本工事用材は使用前に見本を提出し係員の検査を受け使用する。 本工事落成の際は仮設物は取除き敷地外に搬出し、施設内外および工事区域の残木板並に埋戻しは係員の指示する場所に片付け跡掃除を清浄にする。

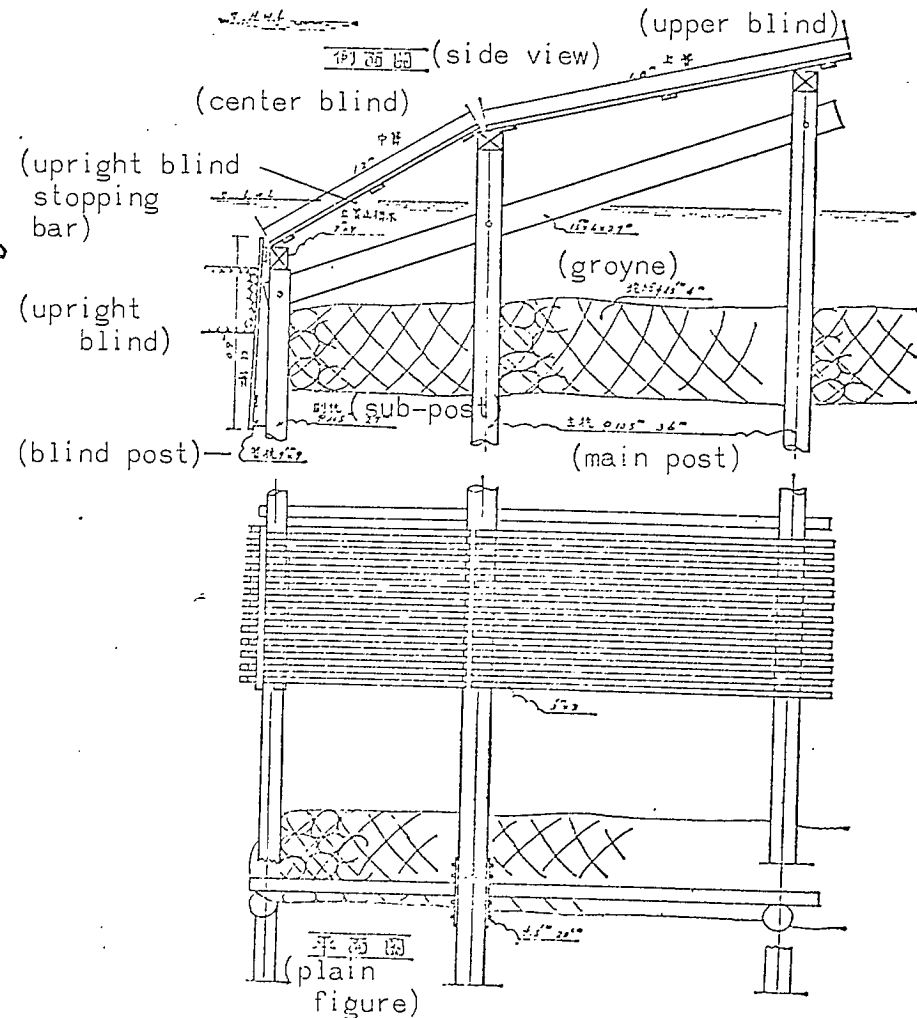
平面図 s-20 (plane figure)



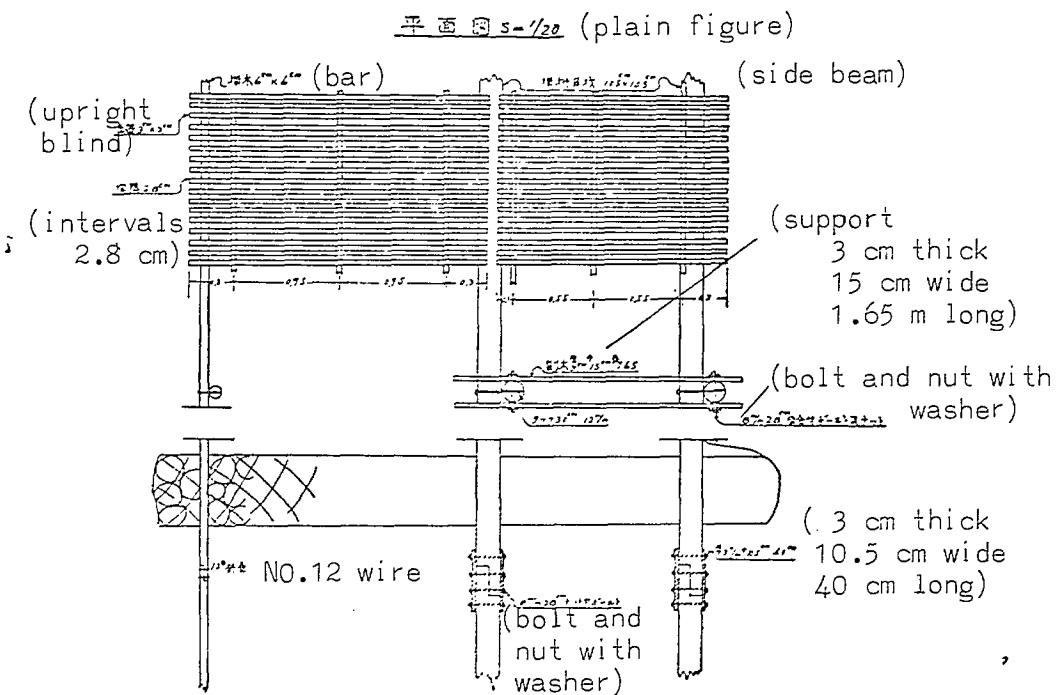
(side view) 側面図 (lid board)



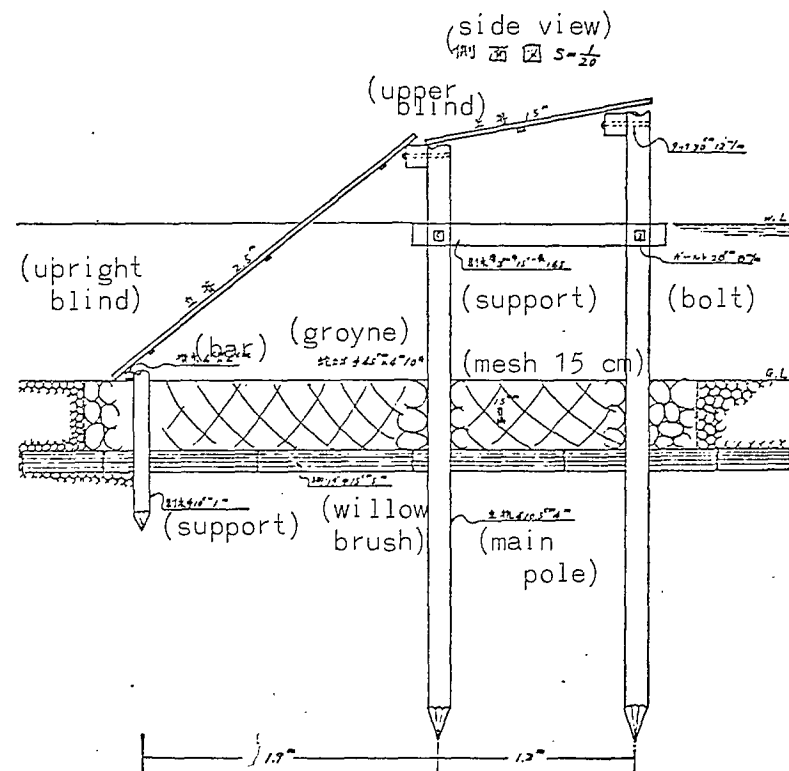
捕獲装置構造  
Fig. 5 Catching works



捕獲装置A: 魚留装置  
Fig. 6 Catcher A: Fish stopper

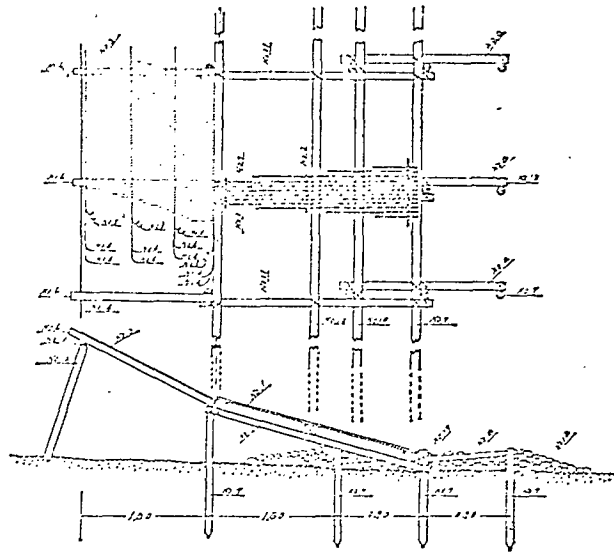


捕獲装置A  
Fig. 7 Catcher A

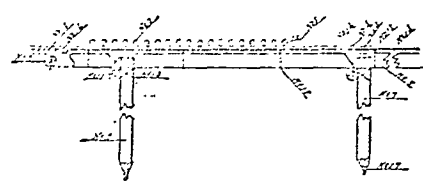


主捕獲装置B (簡略なもの)  
Fig. 8 Main chatcher B  
(simplified catcher).

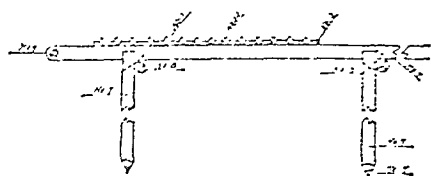
(plain figure and sectional plan)  
 平面及び断面図 s-1/2



上等格子基礎取付の正面図 s-1/2 (front view of the installation of the upper blind foundation)



下等格子基礎取付の正面図 s-1/2 (front view of the installation of the lower blind foundation)



基礎取付の正面図

Fig. 9 Plan of the catcher of the catching farm

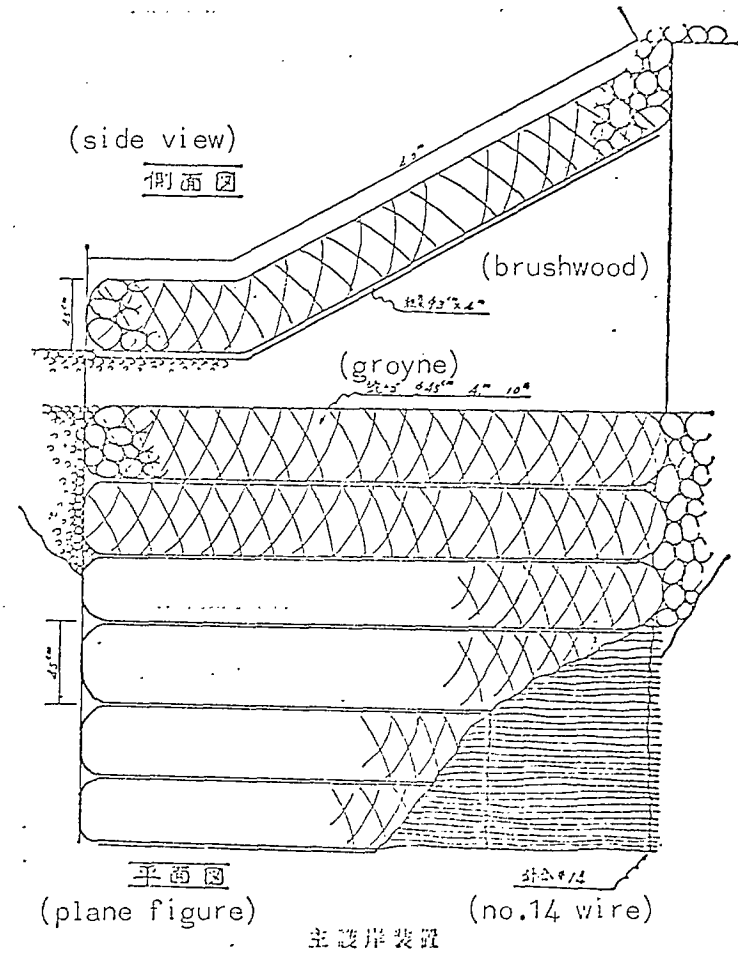


Fig. 10 Main bank-reinforcement

Table 8. The catching farm works

(Table 8-1)

Works	Item	Specification
Foundation	Level off the river-bed	Level off the river-bed to maintain equal water pressure along the whole length of <u>urai</u> .
Bank reinforcement	Cutting and banking	Do not dump the surplus soil from cutting and banking into the river, it should be carried out under the direction of the supervisor. The ground to be used for the groyne should be stamped down to ascertain firm ground
	Bank reinforcement with the groyne	This should be done in conformity with the plan. Choose good quality, hard, and weather-proof packing stones. The size of the stones must be larger than the mesh of the groyne.
<u>Urai</u> fixing works	Foundation of the river-bed	The groyne to be used in <u>urai</u> fixing is similar to the ones used in the bank-reinforcement. Raw willow brushes should be used. The groynes are connected with no.12 wire. When the groynes are fixed under water, they should be fixed not to change both the water level and river course.
	Pole fixing	The oak logs are used as the main poles, their bark should be peeled and the tips are sharpened. The driving depth of the poles are decided by the supervisor. If any difficulty is found out in driving the poles they are reinforced following the indications of the supervisor. The interval of each poles is 1.8 m.
	Stopper for the main pole vibration	Crossbars and main poles are fixed with bolts and nuts.
	Grid supporting beam	Pine is used and its dimension is indicated in the plan.
	Grid	The upper, middle, and upright blinds are built in conformity with the plan. The best quality pine must be used. The grid interval is 3cm each. The grids and grid fixing beams are nailed together and the standard nailing depth is two and a half times of the grid thickness.

(Table 8-2)

Works	Item	Specification
Catching cage works	Construction	This must be constructed following the natural upstreaming instinct of the fish, therefore it should be fixed according the instructions of the officials in charge.
Others	Materials	The materials can be used after their samples are presented and passed the inspection of the officials in charge.
	Cleaning	After the completion of the work, the temporary works must be demounted and removed from the ground. Left over lumbers in and out of the building should be put in order, unnecessary holes must be burried under the instructions of the supervisor. Cleaning must be done completely.

Table 9. The Record of the necessary materials for catching equipment

(Table 9-1)

The Record of the necessary materials for catching equipment							
No.	Materials	Quality and size	Unit	Total amount	Leftover from the previous year	Purchase of the current year	Remarks
1	Pine lumber	2.70 m x 3 cm x 3 cm	hon	2400			25 lumbers per each grid. In case of the 144 m wide river, the total necessary lumber is 2400.
2	Oak lumber	1.80 m x 4.5 cm x 3 cm	"	320			Bars for above mentioned pine grid.
3	Bamboo	2.70 m long	"	3600			23 bamboos per 90 cm. The necessary total number for the 144 m wide river is 3600
4	wire	No.8, unit length 500 m.	maru	2.5			For upper blind binding. Wires are used as a double wire, each 144 m long. 4 double wires are used, therefore the necessary length is 1152 m
5	wire	No.14, unit length 2040 m.	maru	4			This wire was wound around the above mentioned No.8 wire for the upper blind.
6	Oak rod	length 1.8 m. section 7.5 cm	hon	97			Reinforcement for the upper blind, intervals 1.5 m each and 97 was needed for the 144 m wide river.
7	Oak post	"	"	388			These are used to reinforce the foundation poles (4 rows, each row has 97 poles).
8	Oak rod	"	"	97			Foundation beam
9	Oak log	length 3.6 m section 7.5 cm	"	80			Crossbar for fixing lower blind grid and upper blind.
10	Fir log	length 3.6 m section 7.5 cm	"	80			Both the stopper for the move of stones and the bars as the intermediate support for the lower blind.
11	Oak rod	length 2.7 m section 7.5 cm	"	97			Fixed crossbar for the upper blind fixing bar (No.9).

(Table 9-2)

No.	Materials	Quality and size	Unit	Total amount	Remarks
12	Fir rod	length 1.80 to 3.60 m section 6 cm	hon	97	The support when the upper blind is moved upward or downward.
13	Wire	No.8 length 510 m	maru	8	For fixing the foundation pole and crossbeam, 1.20m was necessary for each fixing point; 4038 m were used in total for the 3,365 fixing points.
14	Wire rope	∅ 21 mm.....one ∅ 1.9 mm ...one	maru	2	To move the upper blind up and down.
15	Hook	∅ 12 mm iron	ko	200	These hooks were used to move the upper blind up or down.
16	S shaped hook	∅ 7.5 mm iron	ko	384	For the upper blind. 4 hooks were used for every 1.5 m.
17	Iron tip	0.15 cm iron	ko	388	For driving pole.
18	Stone				To secure the foundations. (These stones were collected at the building spot.)
19	Willow brushwood				To secure the foundation.
20	Nail	length 6 cm	k	36	3 nails were used for each pine made grid. (270 nails per 1kg)

Table 15. Tagged experiment at Niigata and Aomori prefectures,  
and Hokkaido

Year	River	Location of tag	Re- leased	Re- captured	Re- capturing rate	Remarks
1927	Miomote	right gill cover cut	5,000	319	6.38 %	
1928	"	left gill cover cut	10,000	186	1.86	
1934	Hayaide	lower part of the caudal fin cut	5,000	46	0.92	
"	"	pectoral fin cut	3,000	3	0.1	
"	"	gill cover cut	3,000	9	0.3	
1939	Miomote	lower part of the caudal fin cut	15,000	?	-	
"	Hayaide	"	16,000	?	-	
1927	Aisaka	left gill cover cut	10,000	67	0.67	
1939	"	pectoral fin cut	20,000	?	-	
"	"	adipose fin and lower part of caudal fin cut	20,000	?	-	
1940	"	"	19,820	?	-	
1941	Abashiri	left gill cover and adipose fin cut	21,082	163	0.77	summation of the each age of fish
1942	"	right gill cover and adipose fin cut	20,308	198	0.97	"
1943	"	both side gill covers and adipose fin cut	20,157	45	0.22	"

Table 18. The results of the artificial propagation in Hokkaido (1959 to 1963).

Year	Parent fish caught	Eggs collected	Eggs incubated	Fry released	Remarks
<u>sake</u>					
1959	353,499	410,322,990	325,885,650	313,549,090	
1960	305,132	269,207,910	209,516,210	203,412,720	
1961	427,506	455,307,020	375,168,300	359,488,870	
1962	370,988	355,087,100	291,204,380	280,742,700	some were bred and then released.
1963	360,368	361,525,210			"
mean	363,499	370,290,000	300,443,600	289,298,300	
<u>karafuto-masu</u>					
1959	51,474	28,463,670	22,862,840	21,918,300	
1960	15,009	8,240,000	3,776,650	3,718,200	500,000 were transferred.
1961	26,177	3,780,663	1,737,170	1,696,650	1,000,000 were transferred.
1962	49,504	20,059,550	14,865,330	14,703,110	
1963	39,017	22,271,730			
mean	36,236	16,563,000	10,810,500	10,509,100	
<u>sakura-masu</u>					
1959	6,595	7,783,440	6,682,310	6,101,200	
1960	5,074	6,870,180	1,343,120	1,320,100	
1961	3,825	3,827,860	1,817,940	1,805,300	
1962	3,149	3,312,865	2,813,050	2,727,810	
1963	4,915	5,257,850			
mean	4,712	5,410,400	3,164,100	2,988,600	
<u>hime-masu</u>					
1959	12,972	4,305,600	1,515,800	1,190,430	2,190,000 were transferred.
1960	9,333	3,697,200	1,797,000	1,200,000	1,280,000 were transferred.
1961	985	394,200	351,100	349,400	23,000 were transferred.
1962	37,543	7,221,600	2,104,500	2,080,000	
1963	37,006	5,508,900			
mean	19,568	4,225,500	1,442,100	1,205,000	

### Reference

Nothing is indicated about the quoted papers in this booklet.

### Remarks

This booklet is the vol.5 of the series of the Propagation of the Marine Products (Suisan Zooshoky Soosho). In this series of the books the following books are already published.

(1) T. Tamura: The study of the building works of the marine products propagation farm from the view point of the civil engineering.

(2) Y. Saito: The wakame (seaweeds) culture.

(3) T. Kurakake: The improvement of the nori (seaweeds) cultivating ground by civil engineering method.

(4) S. Matsui: The theory and practice of the eel propagation.

(5) T. Mihara, S. Sano and H. Eguchi: Artificial propagation of salmon in Japan.