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Directorate of Fisheries - Institute of Oceanography
Aquaculture Station Matre
A/S Fiskekultur
Fish and Fish Research

Report for 1971 - 1976.

This report was prepared on the basis of operating reports, construction drawings, research reports from scientists associated with the research group for aquaculture at the Institute of Oceanography of the Directorate of Fisheries, as well as research notes.

Manuscript and Presentation: Oscar Ingebrigtsen
Photography: Jan Erik Fosseidengen and O. Ingebrigtsen
Drawings: Leiv Aardal, Øyvind Bjerk and O. Ingebrigtsen
Printing: Boktrykk, Bergen

Contents:

Introduction.

The marine fisheries have traditionally consisted of catches of "wild", naturally spawning populations. This is still essentially the rule but there is to-day also an increasing interest in a more direct control of production in the populations, either by regular breeding of particularly valuable species (edible fish production) or by culture of fry for release and by changing the environmental conditions of "wild"-living populations for subsequent fishing and catching (culture-based fishing). This culture is often termed "aquaculture".

In our country conditions exist for relatively large marine aquaculture operations. The resources are based on favourable natural production conditions along the coast. The access to suitable feed material is an advantage. Taking into account the assumed magnitude of resources these are still little developed. The branch of aquaculture which is presently given most emphasis in development is the breeding of salmon and rainbow trout to large, edible fish.

This industry has to-day an annual production equivalent to a wholesale value of approximately 100 million kroner. It is expected that production will continue to increase and that it will be a basis for a more coordinated engagement in aquaculture. It would be particularly valuable if it would be possible in the future to strengthen by way of culture the natural populations of edible fish species.

The objectives which are here suggested must necessarily be complicated. Both the organisms and the environment have been little explored with a view to intensive cultivation. As a production method the mass breeding of aquatic organisms presents a number of biological and technological challenges. The establishment of a large industry based on aquaculture will therefore require much larger investments in research and development than is the case to-day. One of the first objectives must be the establishment of realistically operating research stations in the districts where the industry is located.

The aquaculture station in Matre was the first one established with the support of the Directorate of Fisheries. It was subsequently decided to establish an aquaculture station in Austevoll.

The installation in Matredal was built in stages since 1971 in cooperation with A/S Fiskekultur (Fish Culture). Fish and Fish Research has obtained a number of interesting results and the installation is to-day in possession of a great deal of experience which is of value to fish breeders.

This report contains a summary of the installation to-date.

Board of Directors
Fish and Fish Research

The Background of Fish Breeding in Norway.

Breeding of fish had a late start in our country but the industry has seen a steady development since it first started around 1960. To-day (1976) Norwegian breeders produce 3,400 tons of salmon and rainbow trout and the prognosis for 1977 is 4,500 tons. This is approximately twice the total catch from the natural populations of salmon-type fish in sea and rivers. Breeding is intensive in its conception, i.e. it comprises controlled production in all life stages of fish, including artificial fertilization and hatching as well as direct feeding in specially constructed installations. Most of these are located along the west coast between Stavanger and Trondheim but a number of installations have also been built in Northern Norway.

The authorities began to participate directly in the development of the industry in the early 1970s. As examples can be mentioned the "Law concerning Measures against Diseases in Fresh Water Fish" of December 6, 1968, the "Interim Law concerning Construction, Equipping, Establishment and Expansion of Installations for Hatching of Roe and Breeding of Fish" of June 8, 1973 and the appointment of the Lysø Committee (1972) as well as the recommendations of 1973 and 1977,

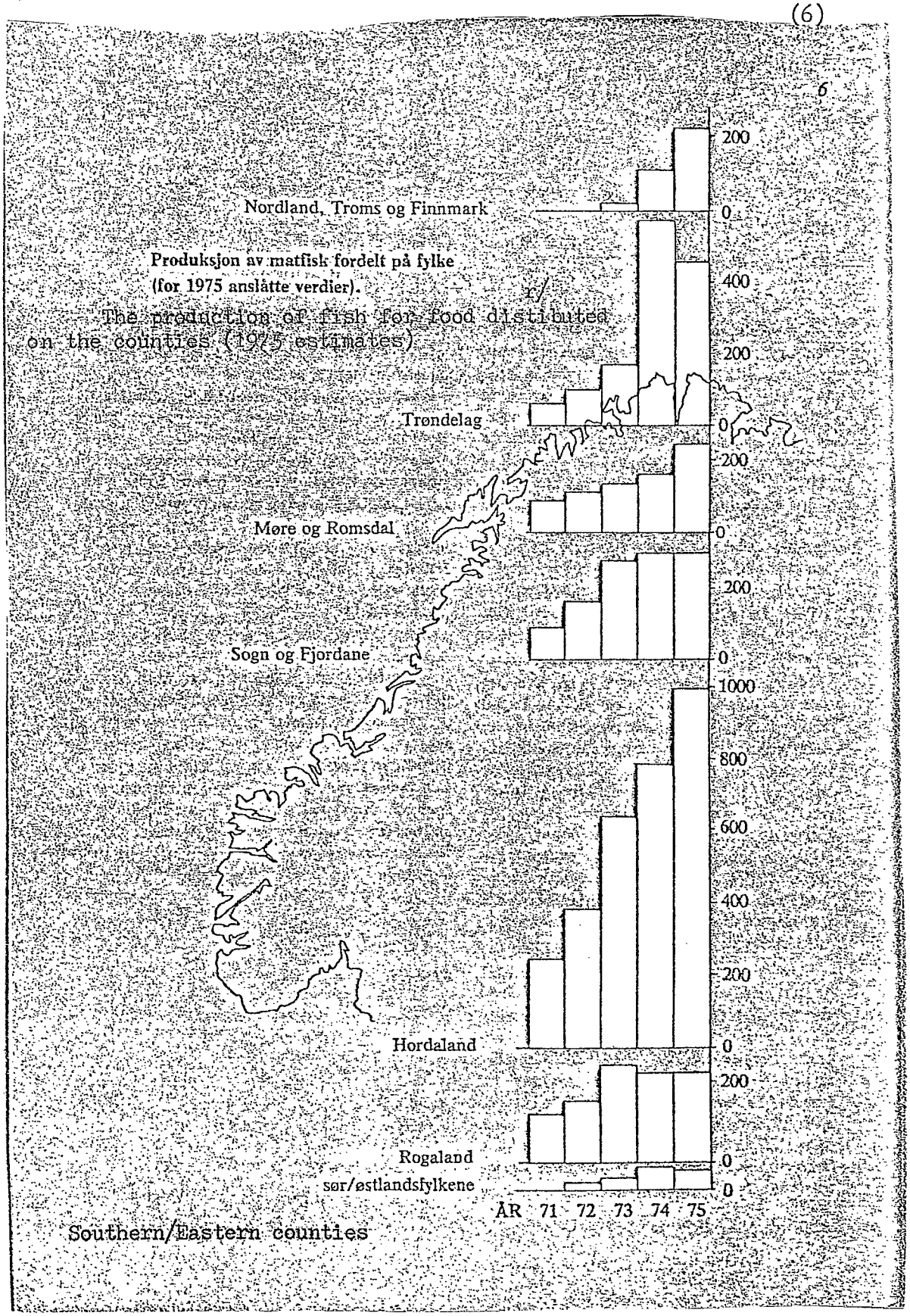
The industry is organized in a national trade association and work is presently in progress on the matter of authorized wholesale trading.

Both the operators and authorities are giving much emphasis to the structure and profitability of the industry. It is no secret that the industry has had a number of difficult problems associated with both production, health and sales. These problems have not been completely solved in any of these fields and they never will be entirely solved in a field such as fish breeding. The objective is, however, to strengthen the industry technically and economically so that a stable production can be achieved. This has in part been successful and it can be said with certainty that the industry is to-day operating on a better foundation than ever before.

The breeding of fish requires professional knowledge in several areas. Many operators have gained valuable production experience so that operation is profitable. There are, however, a number of installations with problems of a sporadic or more permanent nature which require assistance and guidance. In addition there are the newcomers who are starting up and who often lack essential knowledge.

None who is familiar with the industry can be said to be certain that operations have assumed their final structure. Aquaculture, defined as organized production of aquatic plants and animals for sale or recreation, is to-day in intensive development in several countries. Of special interest in our case are the new possiblities which have become available for various combinations of breeding and release of certain fish species in the sea.

The purpose of the Matre project was to assist development of Norwegian fish breeding. In the late 1960s the breeding industry was weak, it lacked Norwegian manufactured roe and hatched fish for stocking, and there was much uncertainty concerning the selection of production methods. There was a need for research stations to guide the industry and to train operators.

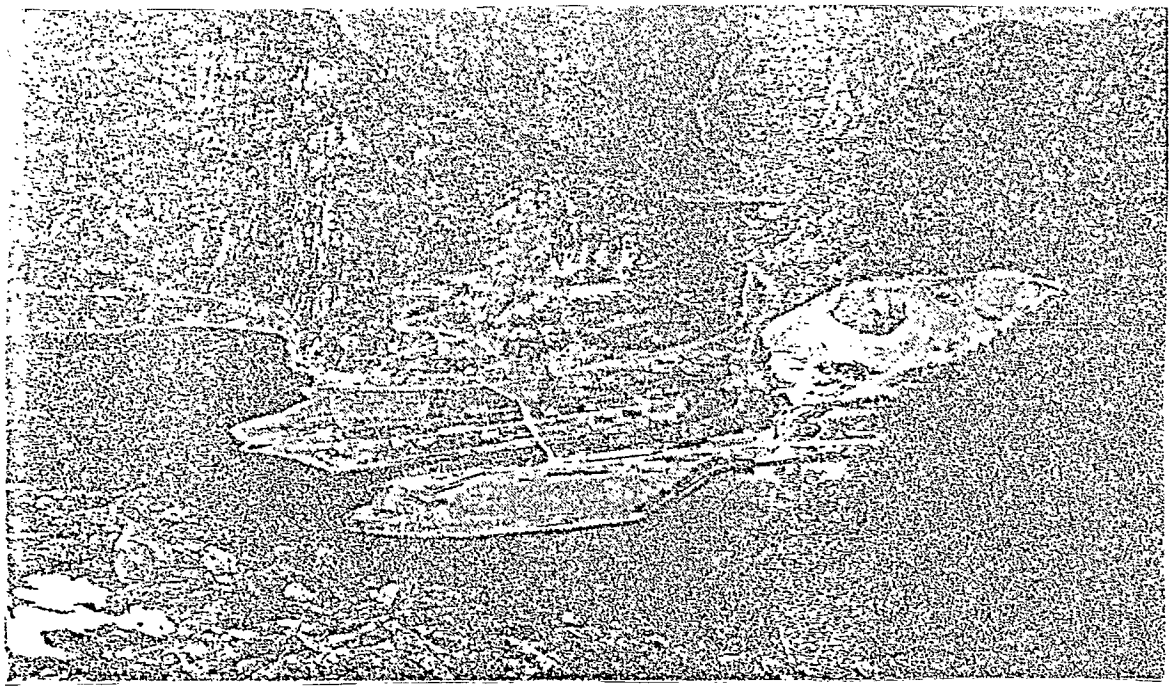


Produksjon av matfisk fordelt på fylke (for 1975 anslåtte verdier).

r/

The production of fish for food distributed on the counties (1975 estimates).

Southern/Eastern counties



Matre in the Masfjord is characterized by high mountains and much precipitation. The most important industries are power production and sand quarries.

It was obvious that the industry itself was economically unable to construct and operate a research station. The modest extent of operations and their somewhat undefined association with the fisheries administration was the reason why there was no immediate plan to establish a research station. The interest in the industry was, however, increasing greatly, particularly after salmon had been found to be a very suitable breeding fish, and successful breeding tests with this species in floating bags and enclosures were carried out.

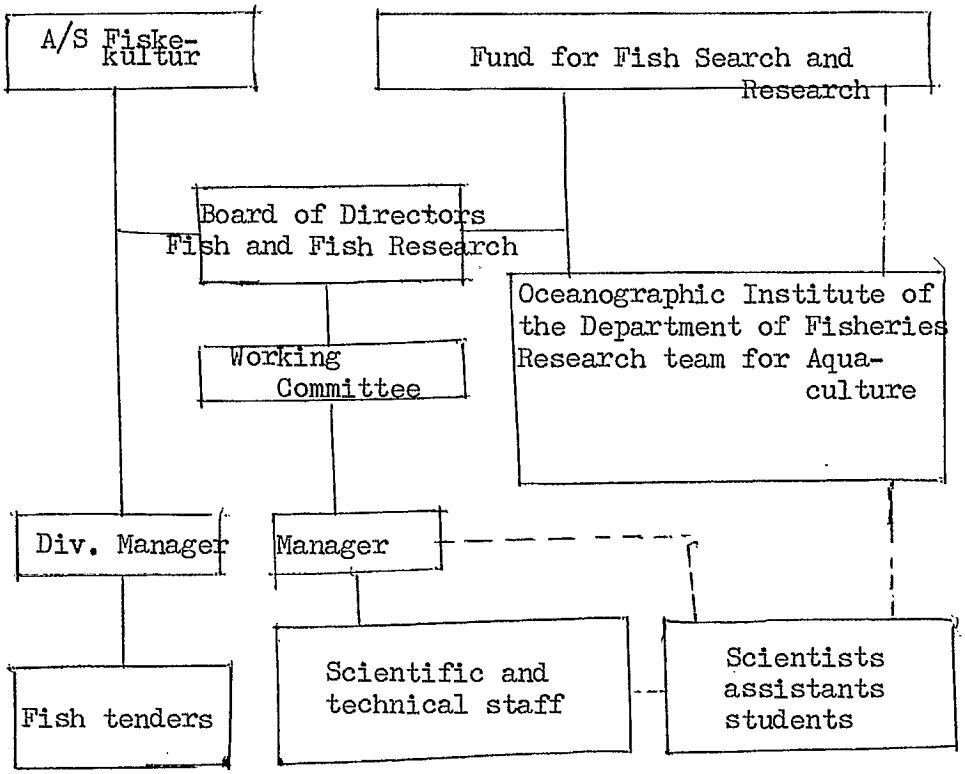
As a result the Directorate of Fisheries and its institutes were requested to take an interest in the development of the industry. Both the then Fisheries Director Klaus Sunnanå and Director Gunnar Saetersdal at the Oceanographic Institute were positively disposed toward the idea and contributed greatly to the establishment of the Matre station.

Funds approved by the research fund of the Fishing Industry (now Fund for Fish Search and Fish Research) made it possible to begin

construction of the research station. Fisheries Director Knut Vartdal who took over from Sunnanå as fund manager, showed the same interest in the development of aquaculture. He supported the participation of the research fund and officiated at the opening of the station on February 18, 1976.

The Fund for Fish Search and Research owns to-day the research division of the station and continues to approve funds for individual research projects. The Fund's strong participation in Matre is also in part a result of the positive attitude of the Norwegian Fishermen's Union to the project.

Matre was selected for various reasons. The most important was the availability of cooling water from Matre Power Station. The location also appeared well suited for breeding of hatchery fish for stocking in the brackish water outside the power station. For research purposes it was also of great importance that there were good possibilities for cooperation with an experienced fish breeder and that there was an assurance of a qualified person to take over the manager's job.



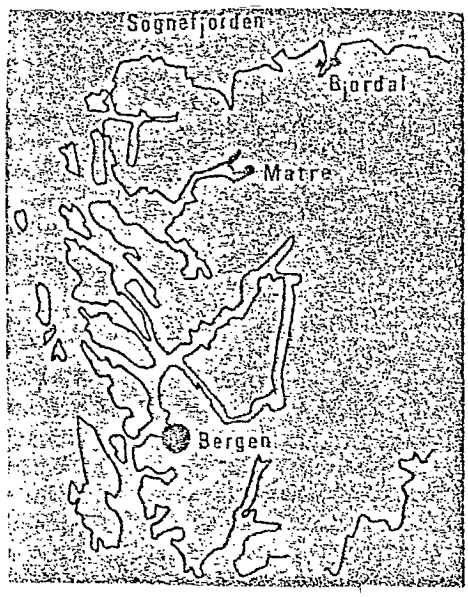
It would of course have been difficult to establish a station in Matre if the Municipal Power Company of the Bergen Peninsula (BKK) had not accepted the project. As a significant power development in the area the company has obligations with regard to the stocking with fish as compensation for losses in lakes and water courses. Production of fish for stocking in Matre would simplify these problems for the company. Cooperation with BKK has always been good, both at the managerial and local level. Matre Power Station has also given useful assistance on several occasions during the construction phase.

Another consideration was that a fish installation would provide jobs in a thinly populated area and would strengthen the local environment. A/S Fiskekultur thus obtained security for a construction loan from the municipality of Masfjord.

Cooperative Project:
Fish and Fish Research.

Establishment and Startup.

"Fish and Fish Research" is the name of a cooperative project of the Fund for Fish Search and Research and A/S Fiskekultur, Bjordal, for the purpose of supporting development of Norwegian fish breeding by research, production and education. For practical operations with this objective in mind a combined research and production installation for hatching and breeding of fish for stocking was built in Matre, 5198 Matredal, Masfjord (Hordaland) during the years 1971-76.



The map shows the location of Fish and Fish Research in Matre at the bottom of Masfjord, Hordaland.

Fish breeder Erling Osland took the initiative as early as the late sixties to utilize the water resources in Matre. Apart from the cooling water from Matre Power Station the location has also sea-and brackish water without ice problems and a regulated river. The travel time to Bergen is approximately three hours by car and ferry; to Bjordal it is approximately one hour by car during the summer when the road across the mountain is open.

Osland founded A/S Fiskekultur and invited a number of research institutions to cooperate in fish breeding at Matre. Drs. Dag Møller and Gunnar Naevdal at the Oceanographic Institute (FHI) of the Directorate of Fisheries were at that time looking for a suitable field station for genetic investigations on salmon populations. Following a number of discussions an agreement was entered into in the summer of 1971 to cooperate at Matre. Subsequently a rental agreement was signed with BKK concerning water and building site. The work on the station was started the same fall following the appointment of Cand. Real (Graduate in Science) Oscar Ingebrigtsen as manager.

Organization and Management.

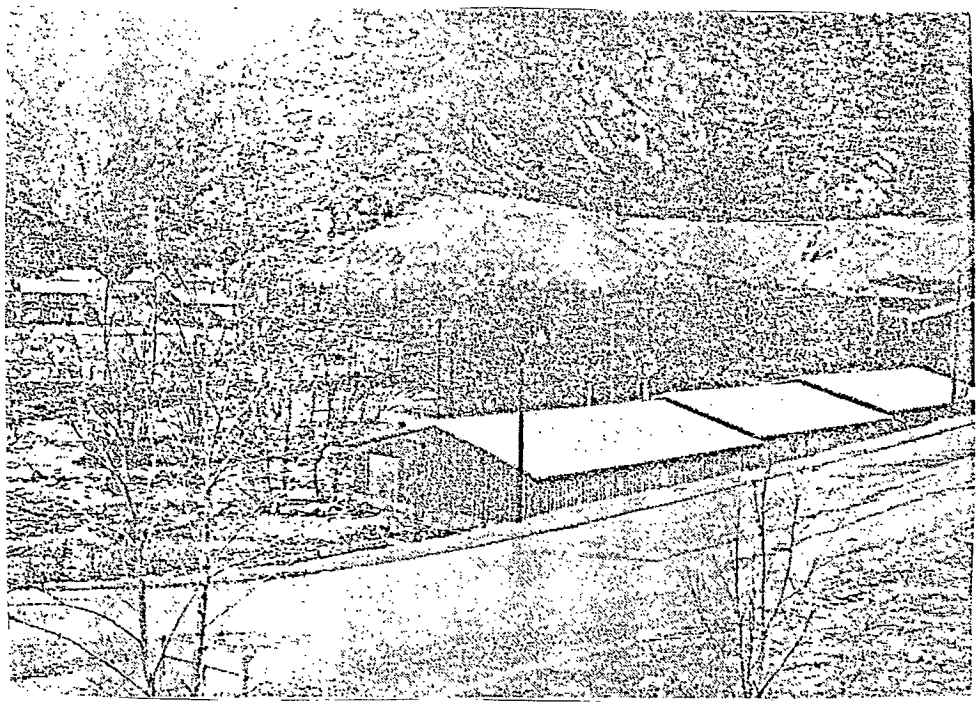
The cooperative agreement between the parties regulates the utilization of the resources in the location so that these can be used equally by both partners. This concerns particularly water and operating site. The development of the components of the installation has taken place in partnership and partly in separate construction operations. The water supply installation was built in partnership while most buildings were constructed with fund capital. A rent is paid where A/S Fiskekultur uses space in buildings constructed by the fund. The property rights to physical assets are recorded in the section concerning the installation. Operation of the station takes place within the framework of two operationally and economically separate units. The research division is operated by FHI under the name "Oceanographic Institute - Aquaculture Station Matre - of the Directorate of Fisheries". Work has been carried out in population genetics (breeding), feeding/nutrition (mostly under the direction of the Vitamin Institute of the Directorate of Fisheries) as well as environmental studies. The production department is a commercial undertaking and the most important job of A/S Fiskekultur is supply of roe and fish for the purpose of further breeding and stocking. The departments cooperate in individual projects, e.g. breeding fish, transportation etc.

The manager of the aquaculture station has been employed by FHI since January 1, 1976. The production department has its own

production manager. As representative of the Board of Directors it is, however, the manager's job to ensure that the cooperative agreement is complied with in practice.

Capital for research operations is supplied by the fund, by Government grants and by sale of surplus fish from the experiments.

The highest authority in Fish and Fish Research is the Board of Directors where the Directorate of Fisheries provides the m/ chairman. Below the Board of Directors there is a working comittee consisting of a representative from each of the cooperating parties. The chairman attends both committee and board meetings.



The operating area of the station is located between the Matre River and Matre Bay. The site consists essentially of fill from the large sand-pit in the background.

Klaus Sunnanå, Director of Fisheries, was the first chairman. In 1976 the Board of Directors consisted of the following:

Arne Brekke, Fish Breeder, A/S Fiskekultur.

Dag Møller, Research Scientist, FHI. His substitute was Professor Olaf R. Braekken of the Vitamin Institute.

Erling Osland, Fish Breeder, A/S Fiskekultur.

Hallstein Rasmussen, Assistant Director, Directorate of Fisheries. Substitute: Frithjof Amundsen, Directorate of Fisheries.

Gunnar Saetersdal, Director, FHI. Deputy: Gunnar Aase, Deprtment Head, FHI. a/

Svein Vik-Mo, Chief Assistant, A/S Fiskekultur.

Hallstein Rasmussen is chairman of the Board of Directors.

Gunnar Naevdal, Scientist, is permanent secretary.

The Municipal Power Company of the Bergen Peninsula has the right to attend meetings of the Board of Directors.

Staff.

In 1976 the staff at Fish and Fish Research was as follows:

Elin Bakke, Fish Tender (part-time)

Øyvind Gjernes, Technical Assistant.

Ola Halynjo, Fish Tender Foreman.

Heidi Haugsvaer, Office Assistant (part-time)

Oscar Ingebrigtsen, Manager.

Reidar Kvamsdal, Repairman (acting construction foreman)

Peter Mallinson, Trainee (½ year)

Susan Merill, Trainee (½ year)

Håkon Trodal, Fish Tender.

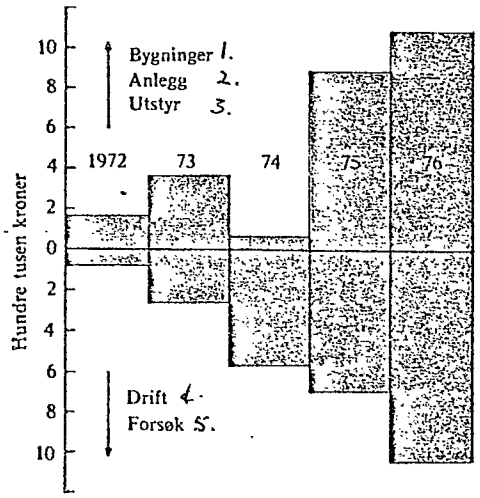
Ottar Trodal, Fish Tender (½ year)

Anna Østerbø, Janitor (part-time)

Ole Dag Østhus, Scientific Assistant.

Top: Hallstein Rasmussen, Assistant Director of Fisheries, has been chairman of the board in Fish and Fish Research since 1973.
Middle: Dag Møller, Oceanographer, is head of the aquaculture group at the Oceanographic Institute.
Bottom: Erling Øsland, Fish Breeder, was the first who wanted to utilize the discharge water from Matre Power Station for fish breeding.

Cost of development and operations by the research department at Fish and Fish Research. A/S Fiskekultur has also invested approximately ½ million Norwegian kroner in joint installations and own equipment.
1. Buildings; 2. Installations;
3. Equipment; 4. Operation;
5. Research



Development, Installations and Equipment of the Operation.

Starting Base and Development.

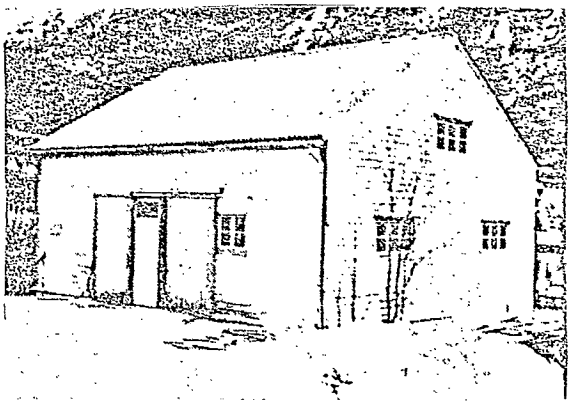
Much thought has been given to the makeup of the installations at Matredal. This was so because consultants did not exist in this area except for pure construction technology, and also because economic considerations required savings in every field. The working committee (Ingebrigtsen, Møller, Osland) was essentially also the construction committee, later it was reinforced by Gunnar Osland, construction engineer and Reidar Kvamstad, construction superintendent.

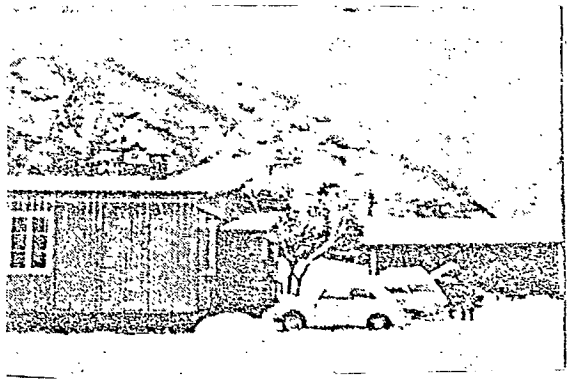
Bjørn Knutsen, engineer, FHI, Øyvind Gjernes, technical assistant, Fish and Fish Research, as well as others associated with the project, have also made important contributions during the development of the installation.

The point of departure was hatching and breeding of fish for stocking based on the possibilities provided by the location. In the light of the situation the development of the installation was considered essential. The procedure used was construction at a standard which would cover requirements for a trial period of 3-4 years and to use experience gained for a possible permanent construction at a later date. For reasons of economy it was decided

to use company staff as much as possible for construction jobs.

In the fall of 1974 it was decided to build a permanent station in Matredal. In the course of its five years of existence the character of construction has therefore changed. New buildings were added and water supplies were improved last year. Some construction jobs will still be outstanding at the end of the year and on their completion the installation will be safer and simpler. Also for the permanent construction jobs it was decided to operate under the direction of company staff as far as possible. Thanks to this arrangement and to an efficient superintendent considerable sums have been saved.





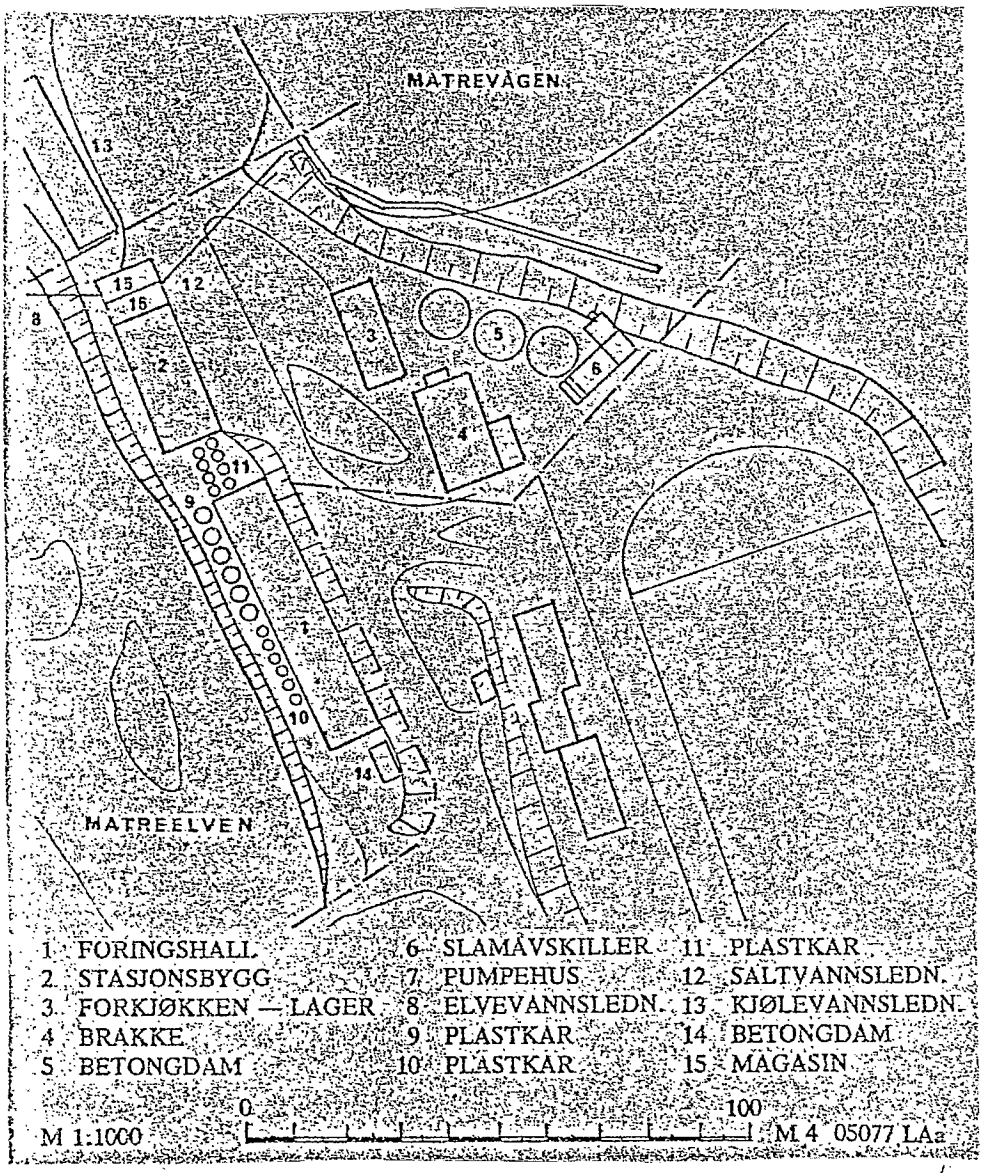
Three older buildings on the rented site made it possible to start operations already during the first fall. The barrack with annex (right) served as living quarters, office, store and workshop while the shed on the sand jetty (left) functioned as hatchery for five years.

Water System.

The water system is based on three supplies, each with its own transportation system.

River Water.

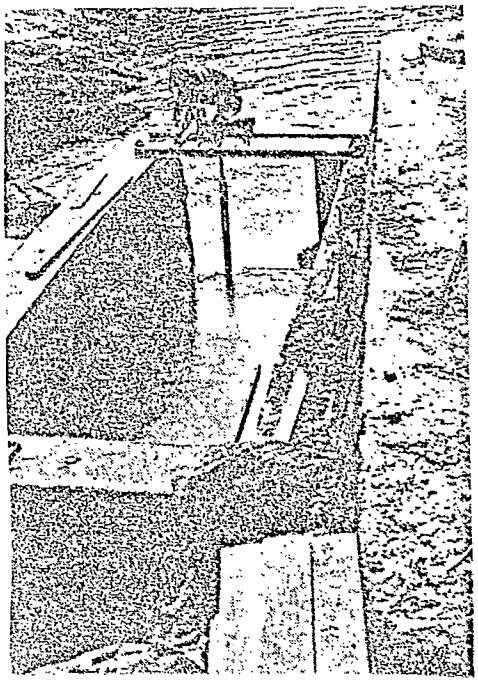
River water is obtained at an intake installation from a 900 meter long gravitation-operated water line originating at the



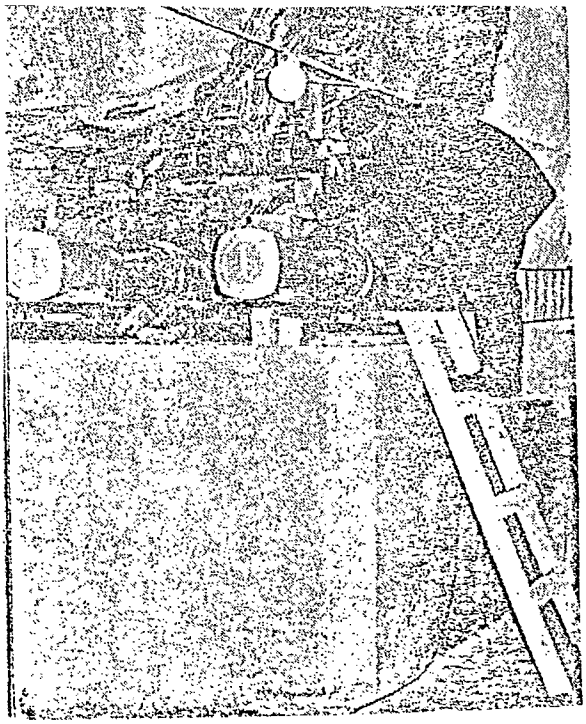
1. Feeding building
2. Station building
3. Pantry - storeroom
4. Barrack
5. Concrete pond
6. Sludge separator
7. Pump station
8. Riverwater pipe

9, 10 and 11 Plasic tubs
12. Salt water pipe
13. Cooling water pipe
14. Concrete pond
15. Storage

Kvernhus Falls on the Matre River. The line is a 300 meter (?) long cast iron pipe, buried in the ground with a smooth drop along the north bank of the river. At its lowest point it crosses the river and rises to the tank installation at the station building. The intake pond measures 2x6x2 meters and is constructed in cement with aluminum gratings forming a horizontal intake surface for the water. The line has a capacity of 10 cubic meters per minute. The drop between the intake and the water reservoir is 11 meters.



The intake reservoir for river water is solidly anchored to the bedrock at the Kvernhus Falls. The construction design envisages minimum maintenance when cleaning the gratings.



The pump installation and the suction well for the cooling water supply from Matre Power Station to the fish plant.

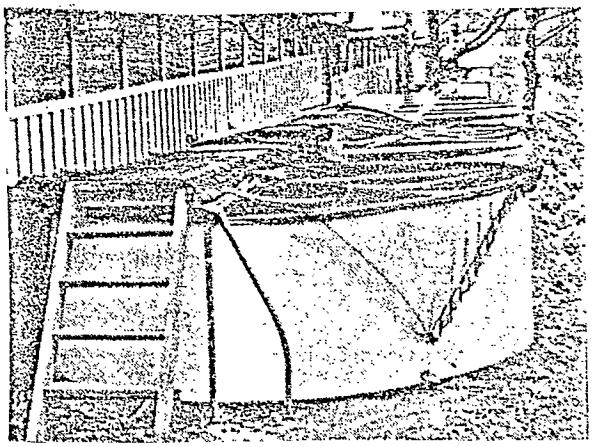
Cooling Water.

The cooling water line was originally a 550 meter plastic pipe with 150 mm (i.d.?), attached to the wall of the discharge tunnel of the power station and following the bottom of Matre Bay to the fish installation. This line presented maintenance problems and had too little capacity. In the fall of 1976 a new cooling water

line was therefore constructed. It has an i.d. of 200 mm and was laid through the transportation tunnel of the power station and from there in a ditch along federal highway 14 to the fish installation. The reconstruction included a pumping basin and installation of 2 pumps (one as a spare) inside the power station. The cooling water is pumped directly to the water reservoir prior to distribution inside the installation. As a result the supply of cooling water increased from 1,000 to 3,000 liters/minute.

The Sea Water Line.

The sea water line consists of a 150 mm (i.d.?) plastic pipe both at the suction and pressure ends. So far 2 pumps have been connected to the line in a pump building but there is room for additional ones. Sea water is pumped like the other water supplies to a special water reservoir. At the end of the sea water line a large suction screen of perforated aluminum is located, measuring 1x1x2 meters. The intake depth is 10 meters. There have been problems with mussel larvae at the intake end of the sea water line. The intake will be lowered to 15 meters or deeper to avoid the larvae.

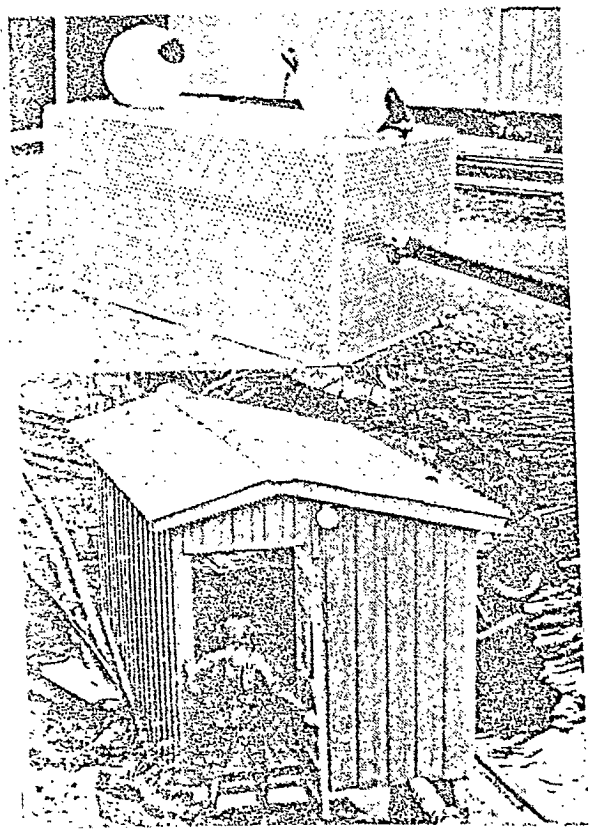


The rented site along the river is utilized to the maximum extent.

The Feeding Hall.

The feeding hall was the first new building that was erected. It was completed in the spring of 1973 when the feeding tubs had stood in the open for one year. It is constructed on three levels conforming with the site. The building is constructed of pressure impregnated wood on a concrete foundation. It is not insulated. The roof is built of asbestos cement and the floor is covered with gravel. There are no interior pillars which, together with the rough floor, provides good possibilities

for a flexible layout. The hall is equipped with three different types of plastic tubs with water supplies and discharge, arranged in longitudinal and cross rows. The tubs are equipped with automatic feeders and lids.



The following tubs have been installed:

74 circular tubs of 1.8 m^2 each
40 rectangular tubs of 2 m^2 each
6 circular tubs of 7.5 m^2 each (outdoors)
6 circular tubs of 3.0 m^2 each (outdoors)

Production Department:

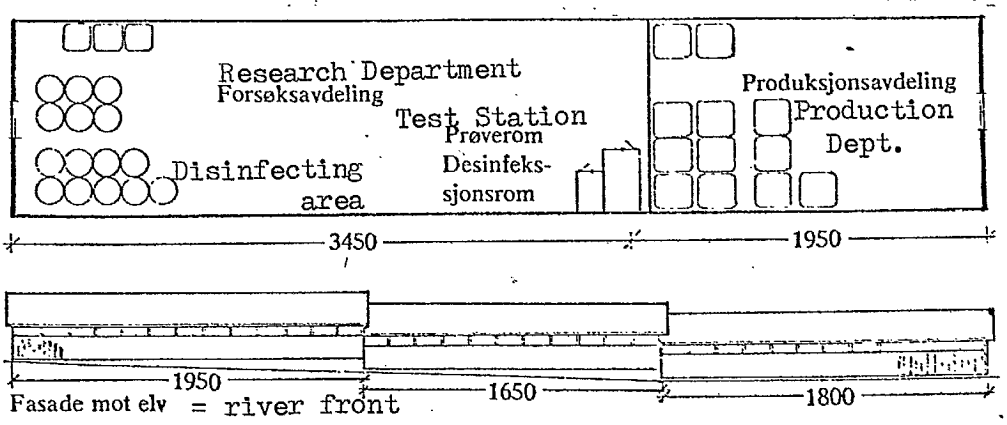
28 rectangular tubs of 4.0 m^2 each
5 rectangular tubs of 2.0 m^2 each (outdoors)

The building is financed by the research department which uses 2/3 of the area.

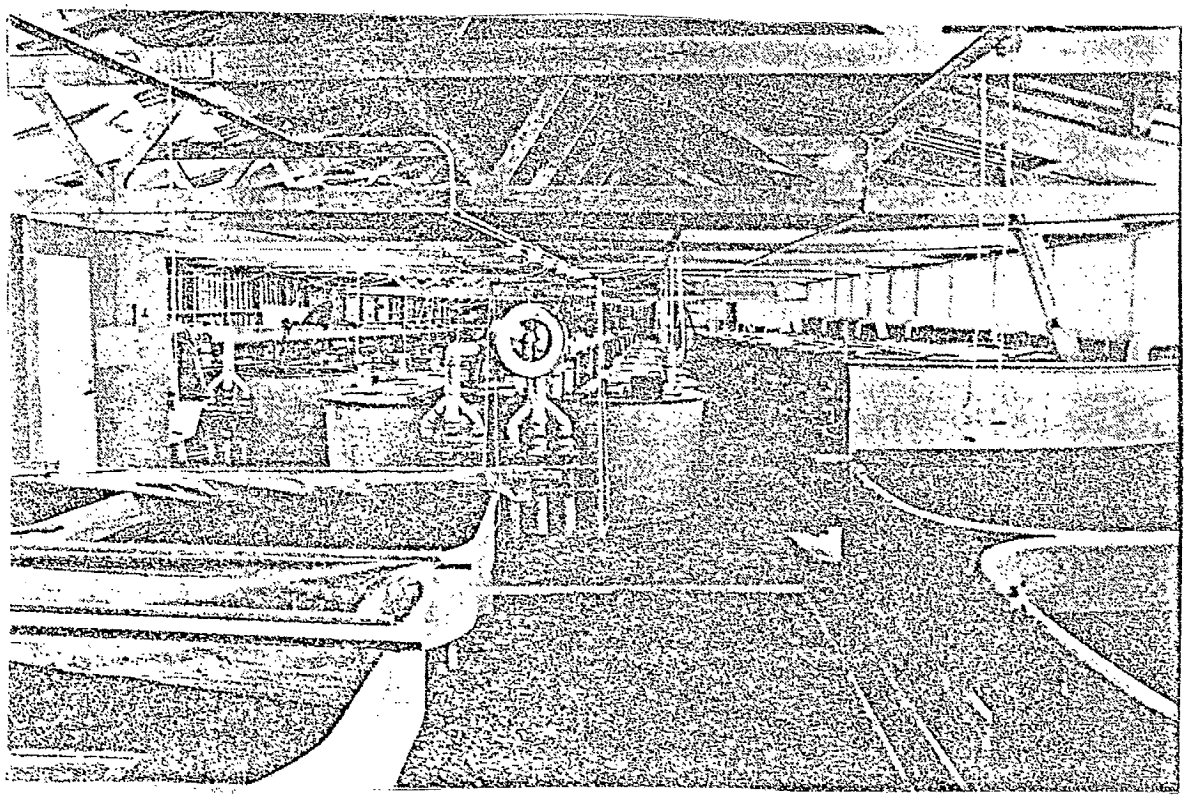
Top half: The sea water line has a large screen at its end.
Bottom half: The sea water pump station is located on the slope to Matre Bay.

The Floating Pond Installation.

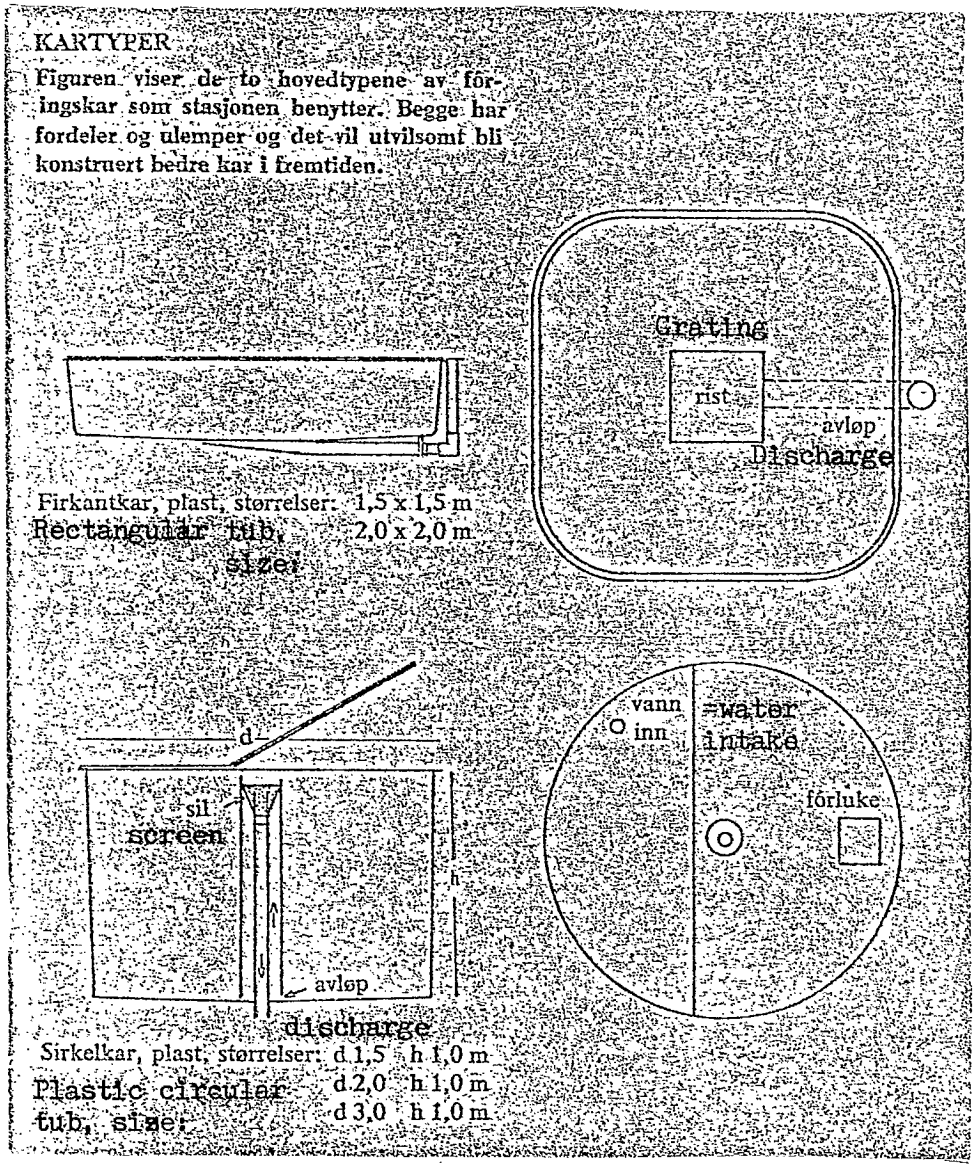
This installation consists of a series of dock sections of impregnated timber which are coupled together and are kept afloat by hollow plastic pontoons. It contains 40 apertures measuring 3x3 meters^2 (?). The seine bags used to contain the fish are



The Feeding Hall is built on three levels following the contours of the site with the front facing the Matre River.

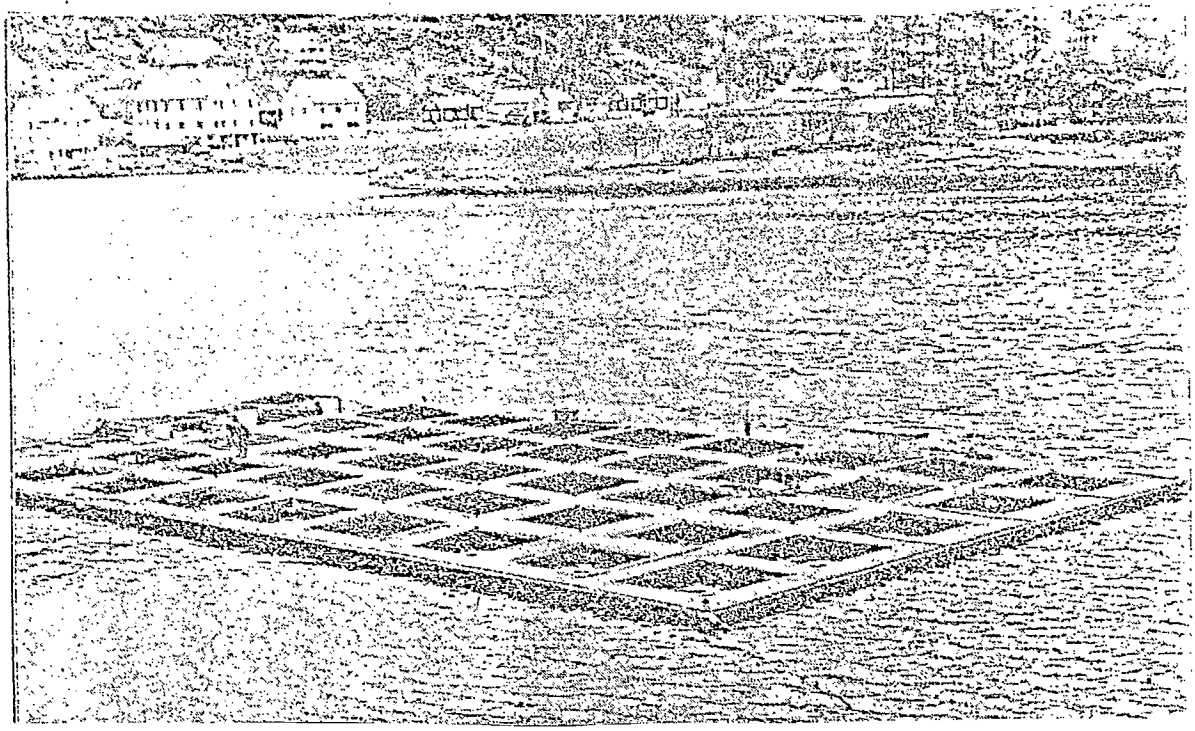


The Feeding Hall is equipped for intial feeding and for feeding of fry to stocking fish.



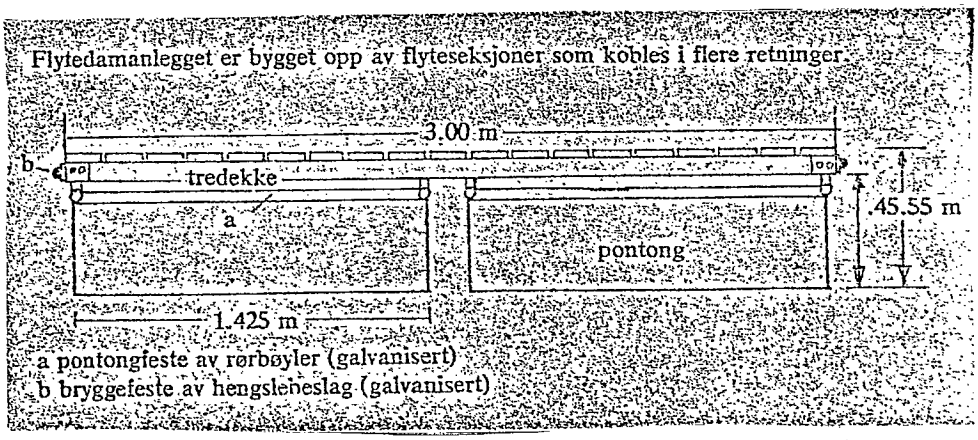
Types of tubs

The figure shows the two principal types of feeding tubs used at the station. Both have advantages and disadvantages and undoubtedly better tubs will be designed in the future.



The floating pond installation viewed from Matre Island.

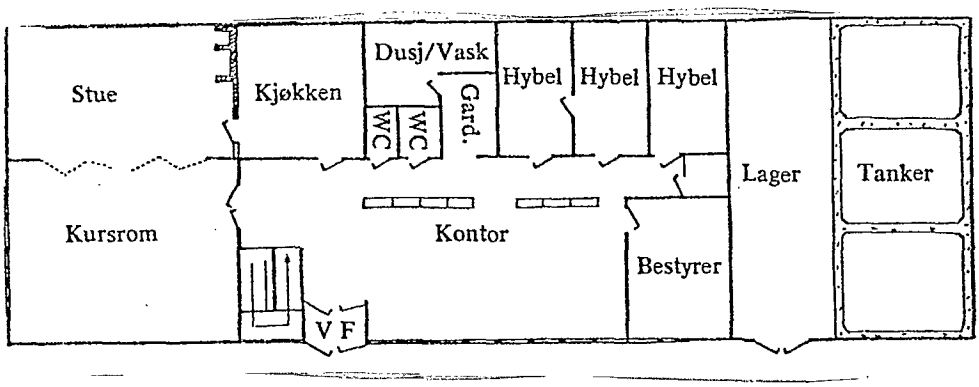
2meters deep and are of varying mesh size. The floating pond installation was positioned at Matre Island in August 1973. The location has water of varying current intensity and strongly increasing salinity from the surface downward due to the operating water from the power station and the Matre River.



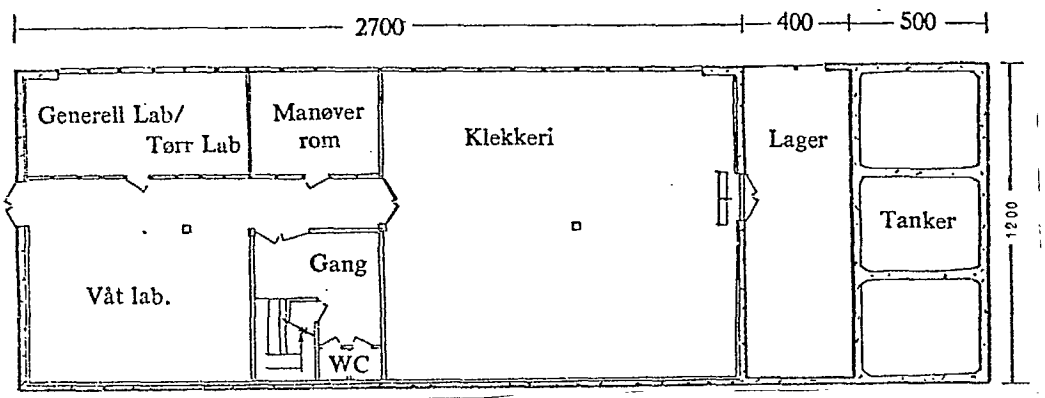
The floating pond installation is constructed of floating sections which are coupled together in several directions.

The Barrack.

An older construction barrack is rented from BKK. It was renovated during the trial period and has served as billet, office and storage since the start. After completion of the station building A/S Fiskekultur has retained its office in the barrack and is also using it as a billet.



Legend: Stue = living room; Kursrom = lecture room; Kjøkken = kitchen; Dusj/vask = shower/wash room; Hybel = apartment; Lager = storage; Tanker = tanks; Kontor = office; Bestyrer = manager; VF = entrance hall



Legend: Generell lab/ tørr lab = general laboratory/dry laboratory Våt lab = wet laboratory; Manøver rom = control room; Gang = hall; Klekkeri = hatching; Lager = storage; Tanker = tanks.

The station building incorporates a number of functions in the operation of the installation.

The Station Building, the Water Tank Installation and the Connecting Building.

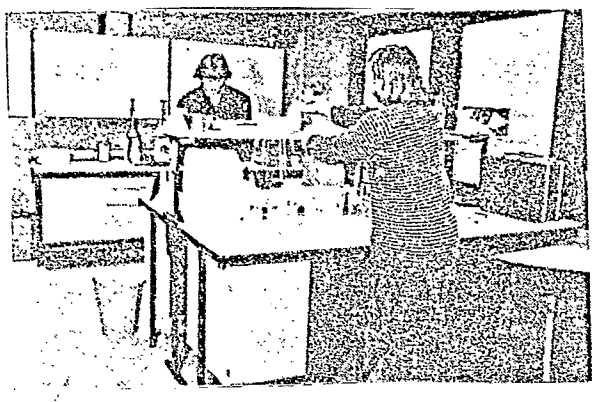
The station building with the water tank installation and the connecting building have already been mentioned a number of times. This building complex was completed in February 1976. The station building consists of two levels, each measuring 324 sq. meters. The lower level and the floor of of the upper level are built of concrete. There are three supporting concrete pillars. Throughout the floor on the lower level heat cables have been inserted. A ventilating installation had been planned but a trial period without it showed that there were no condensation problems. To permit a flexible water supply generous pipe trenches were installed along all outer walls to accommodate the principal water pipes.

The Hatchery.

The hatchery was installed in an old storage shed with difficult working conditions during the trial period. In the fall of 1975 the new hatchery in the station building was started up. It has an area of 150 sq. meters and covers almost half of the lower level area. The shelves have long hatching channels[a] on two levels, mounted permanently. There is also row with 20 hatching cylinders (A/S Fiskekultur). An important detail is the wash basin for the cleaning of all loose inventory and equipment. All hatching channels are equipped with both cold and warm water. The space in the hatchery is equally divided between the departments.

Laboratories.

The lower level contains a dry laboratory for microscopy, water analyses, simple feed analyses etc. There is also a large wet laboratory equipped with aquaria for studies of small fish. Automatic controls for water temperature and salinity have been installed.



The dry laboratory.

Guard and Control Room.

One room is equipped as a combined guard-and control room. Control switches and fuses are located here. A supervision and warning system with a control panel in this room for the water installations will be purchased.

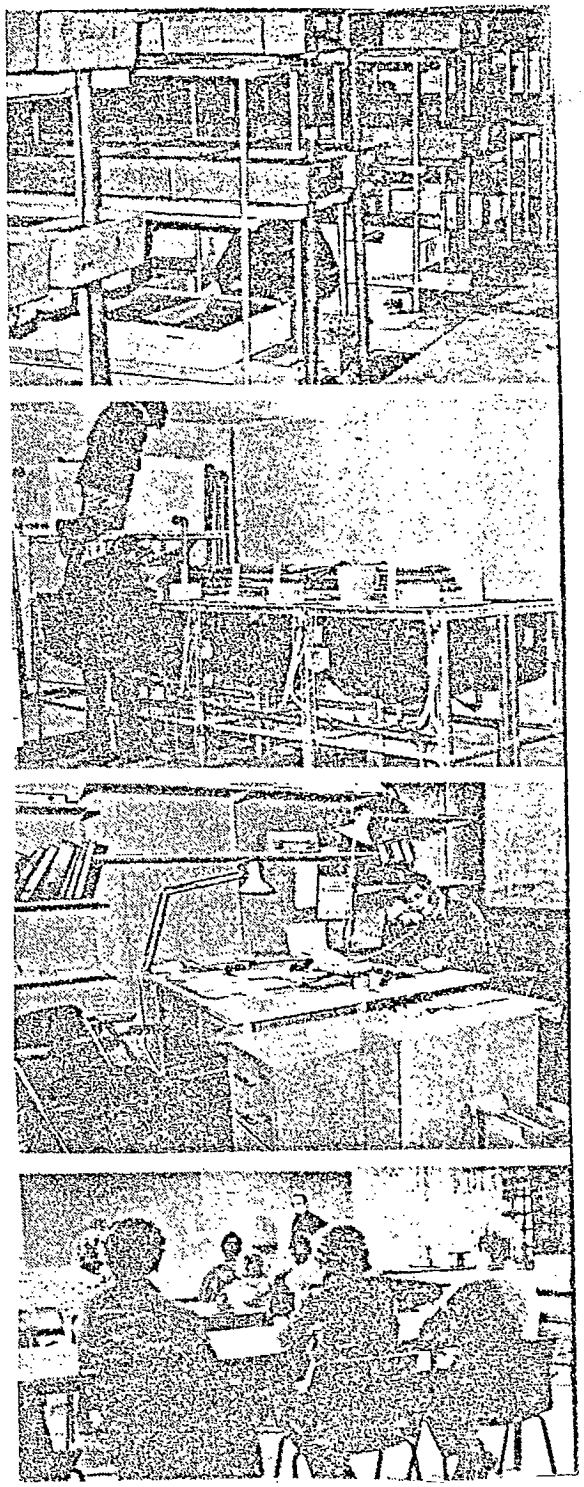
Upper Level.

The upper level in the station building is constructed with pressure-impregnated wood and an asbestos cement roof. Normal good building standards were used in the layout. It contains four open offices, one enclosed office, three apartments, a lecture hall, a living room with fireplace, a kitchen/lunch-room, an archive, a washroom, two W.C. and a vestibule.

The rooms accommodate all normal station and social functions, both for the permanent staff and for visitors.

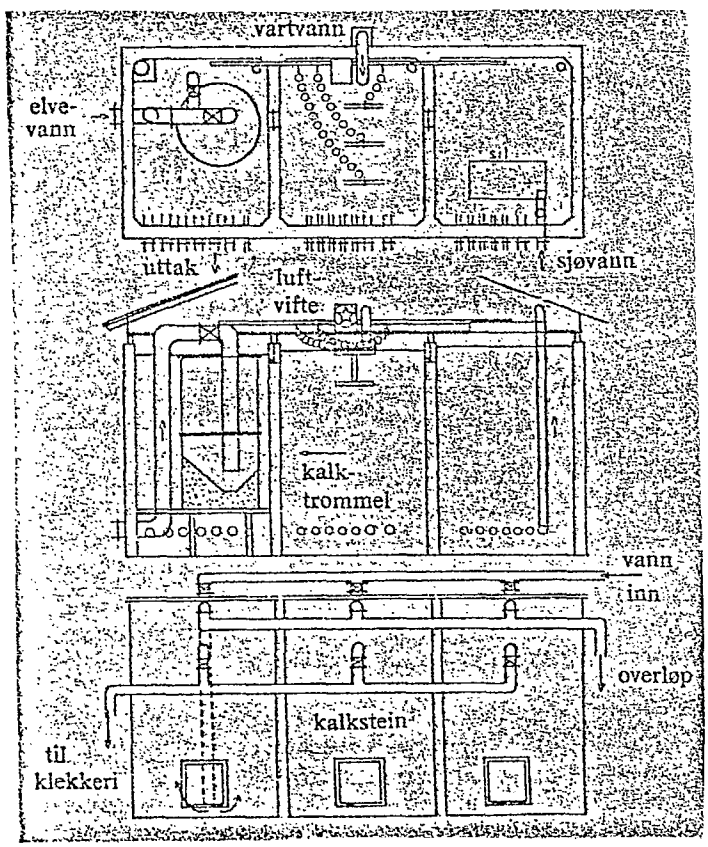
The Watertank Installation.

The watertank installation is covered with a gable roof which extends over the connecting building where it adjoins the station building. The installation consists of three



From top: Hatchery, wet laboratory, guard room, lecture hall.

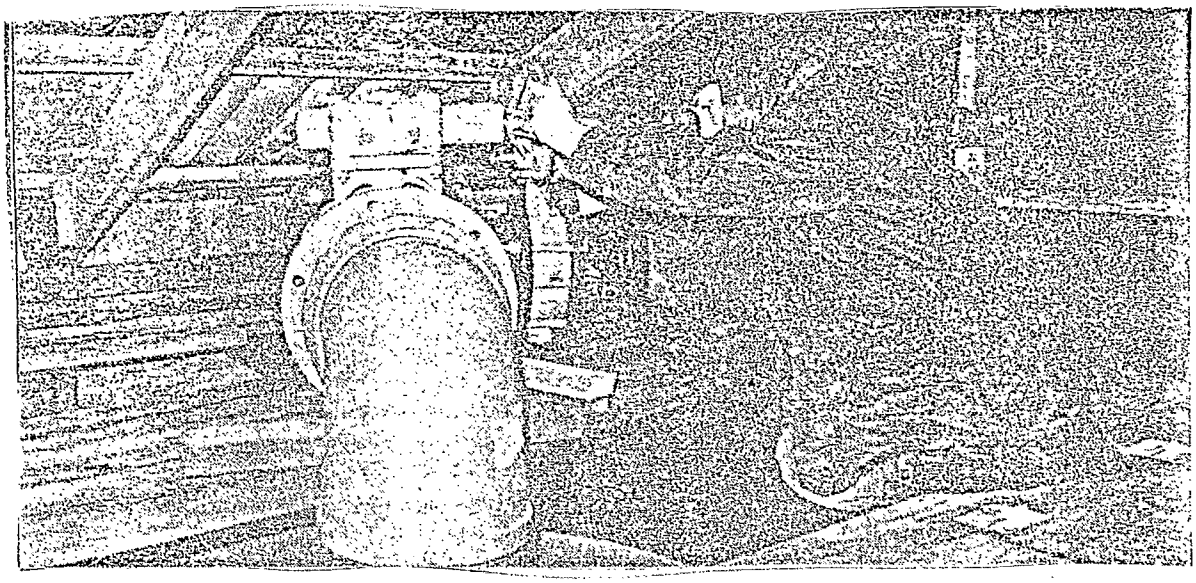
chambers, the interior measurements of which are 3.5 x 4.5 x 5.5 meters, i.e. approximately 80 cubic meters each. The thickness of the outer walls is 40 cm; the separating walls are 30 cm thick. All are constructed in reinforced concrete. The interiors of the tanks are plastic impregnated. Each tank is equipped with an overflow pipe which determines the water level in the tank. The pipe can be removed if it is intended to empty the tank entirely. There is a large emergency overflow which can accommodate the water from all tanks. Between the tanks there is a cavity with a butterfly valve in the separating walls.



The figure shows the water reservoir in top view (top), and section view (middle) and the lime filter for the hatchery water (bottom).

Legend:
Vartvann = reserve water
Elvevann = river water
Uttak = discharge
Sjøvann = sea water
Vifte = fan
Kalk trommel = lime drum
Vann inn = water intake
Overløp = overflow
Kalkstein = limestone
Til klekkeri = to hatchery

Several methods were tried for both lime treatment and water aeration until a satisfactory solution was found. The aeration method which is here indicated (direct bubbling in the water reservoir) has since been replaced by a so-called Inka aerator (see text).



Control of river intake at top of water reservoir.

In normal operations the water is 5 cm higher in the sea water than in the cooling water tank, and the level in the cooling water tank is 5 cm above that of the river water tank. If the water level drops in one of the first two tanks (pump operation) then the pressure diffe-rence affecting the butterfly valves will supply water from the adjoining tank. The drain[§] from the water tanks (21 in all) are located 1 meter above the tank bottom to avoid withdrawal of any bottom sludge. The valves are located on the outside of the tanks in the bottom room of the connecting building, with direct access from the hatchery. All distribution pipes from the water tank installation to the plant are hard PVC.

Aeration of the cooling water takes place at the top of the water tank installation. A cooling tower with perforated aluminum plates was used earlier but it was unsatisfactory. A Swedish aeration equipment (Inka Aerator) is now installed, based on air which is blown by[a] compressed airfan through perforated aluminum plates over which water passes.

Because of the acid fresh water in the area it is necessary to treat it with lime. In the case of the river water this takes

place in a large container where water and "shell sand" are blended with the help of water pressure. In the case of the cooling water this is done by adding feed(?)lime with lime equipment of Danish design. Water for the hatchery passes also through an additional lime filter.

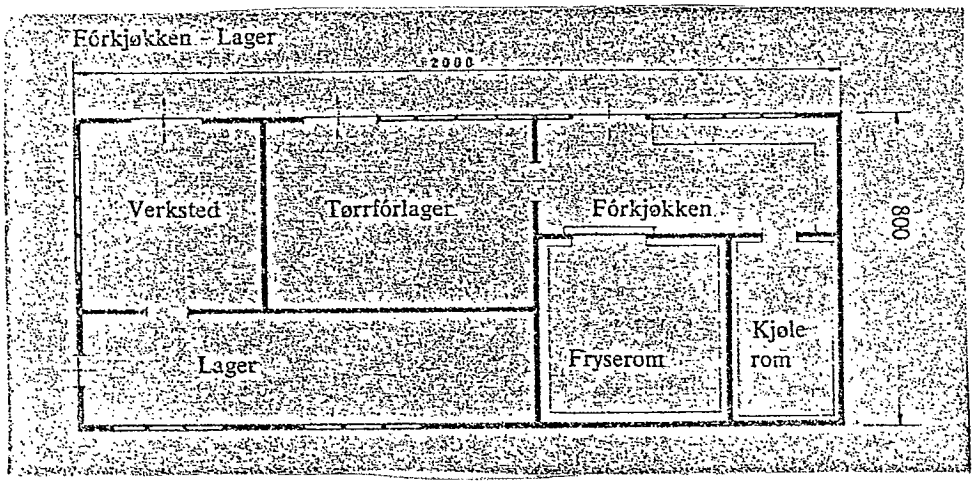
The aeration equipment for the cooling water (checking of the bubble installation).

The Connecting Building.

The connecting building is constructed of pressure-impregnated wood. It is divided into three floor levels. Control valves and lime filters for the hatchery are on the bottom level. The middle level serves as storeroom for materials and merchandise. The top level provides access to the water tank installation and serves also as storage room amd work area. The station building itself belongs to the research department while the water tank installation and connecting building are for common use.

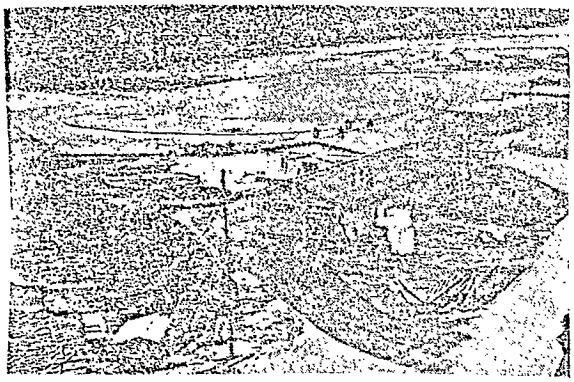
The Feed Kitchen Building.

This building was completed in September 1976. It contains feed kitchen, freezer room, refrigerated room, dry feed storage, workshop, garage and storeroom. It is built on one level and measures 160 sq. meters. It is constructed of pressure-impregnated wood. The feed kitchen is equipped with a scale, a mill and a small feed blender. The workshop is used for various maintenance jobs and for repair of equipment. It is also expected that some new equipment and testing facilities can be made here. This building belongs to the research department.



The feed kitchen building was the last one erected. Wet feed will be used in some feeding tests and for breeding fish.

Legend: Førkjøkken = feed kitchen; Lager = storage; Verksted = workshop; Tørrforlager = dry feed storage; Førkjøkken = feed kichen; Lager = storage; Fryserom = freezer; Kjølerom = refrigerator.



The feed kitchen building is centrally located on the plant site.

The dry feed store room in the same building.

The Stocking Fish Installation.

The outside stocking fish installation belongs to the production department. Three circular concrete ponds (silo form) and a combined control and sedimentation pond have been built. The circular ponds measure 10 meters in diameter and are one meter deep at the periphery, dropping to 1.80 meters in the centre. Vertical discharge screens have been installed. Both fresh and sea water supplies to the ponds

Stocking fish in open ponds must be protected from birds. Fishing nets are here placed over beams.

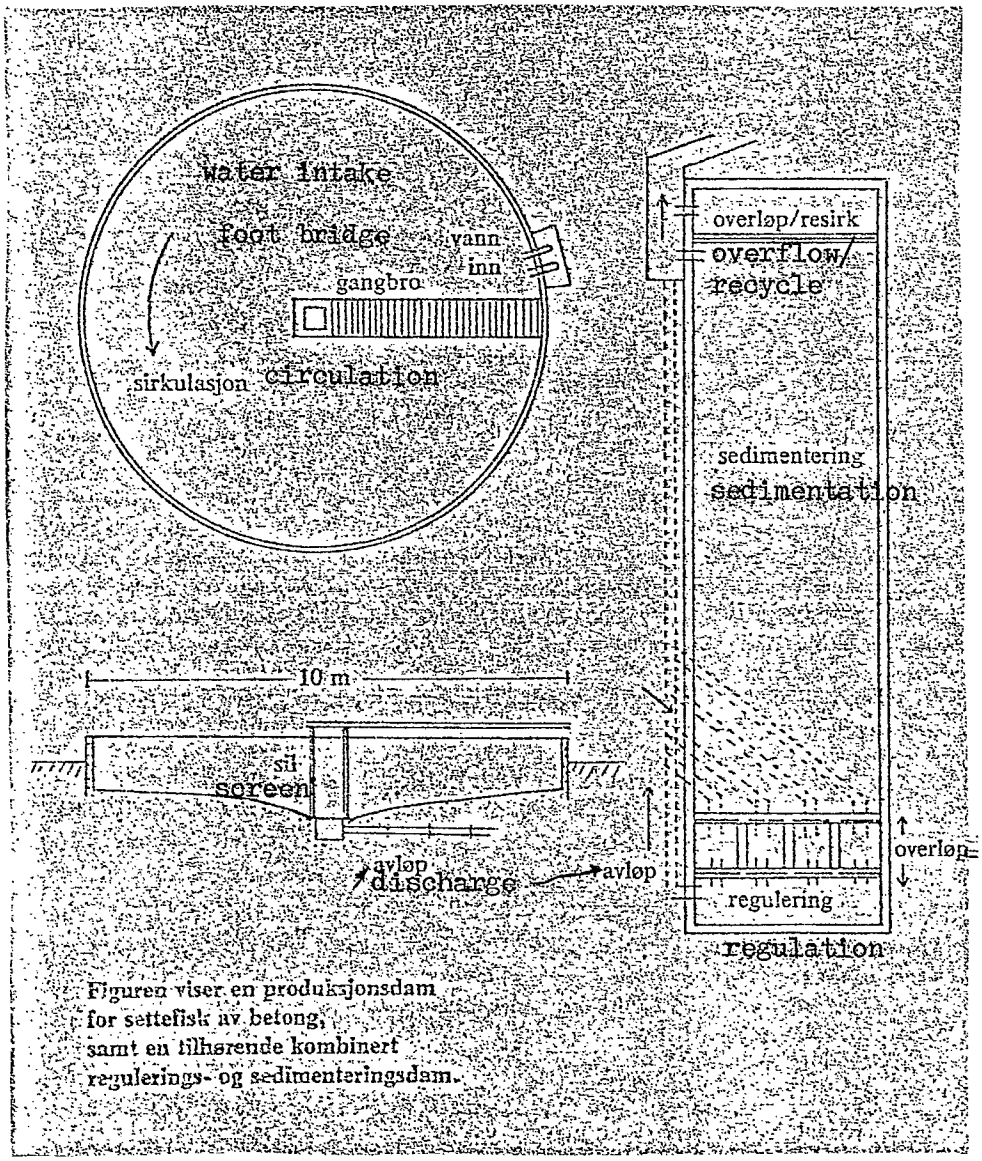
are available. The sedimentation pond is part of a future plan involving a recycling operation.

Among the still remaining construction jobs a discharge line to the sea, a boat dock for serving the floating dock installation, descending and ascending channels for fish and a minor regulation of the Fosse Lake can be mentioned. Only the channels for fish migration have so far been financed.

Organization of Operations.

Regular Work Program.

In five years of operation a fairly regular operating pattern has been established, both on a year-round basis and for the normal working day. The guideline in this work has always been to utilize the natural resources of the location and the physical potential of the installation as well as possible. A particularly important but difficult task has been to institute safety routines in everyday operations to avoid fish fatalities. Ole Dag Østhus, Scientific Assistant, has been particularly engaged in this work.



The figure shows a concrete production pond for stocking fish and an associated combined regulating and sedimentation pond.

With regard to the establishment of a year-round routine the water resources and their use are of paramount importance. The stability of the quantity and quality of water is a basic condition for the operating programs of the hatchery and the stocking fish installation.

Even if the water resources in Matre are generally good, since river water, warm discharge water and seawater are accessible close to the fish installation, it has nevertheless been necessary to improve the quality of all fresh water. Like most rivers in Western Norway the Matre River is acid (pH approx. 5.2). Another problem is the heating of the cooling water in the power station which results in excessive gas saturation in this water. These conditions require continuous water treatment with operational control.

Warm Water.

Because of the large quantities of roe with which the station has operated, a significant portion of the warm water has been used in the hatchery. Little warm water has therefore been available for fry and stocking fish production. Fish and Fish Research has thus been unable to produce significant amounts of year-old smolt the percentage of which has been as follows:

1973 5.0% (mixed)
1974 4.2% (groups)
1975 30.9% (groups)
1976 6.6% (groups)

The high percentage in 1975 is due to the fact that the winter temperature in the stocking fish installation was maintained at a higher than normal level (less roe).

With the increased amount of cooling water available from the spring of 1977 it is expected that the percentage of year-old smolt in the installation will increase.

Production Pattern.

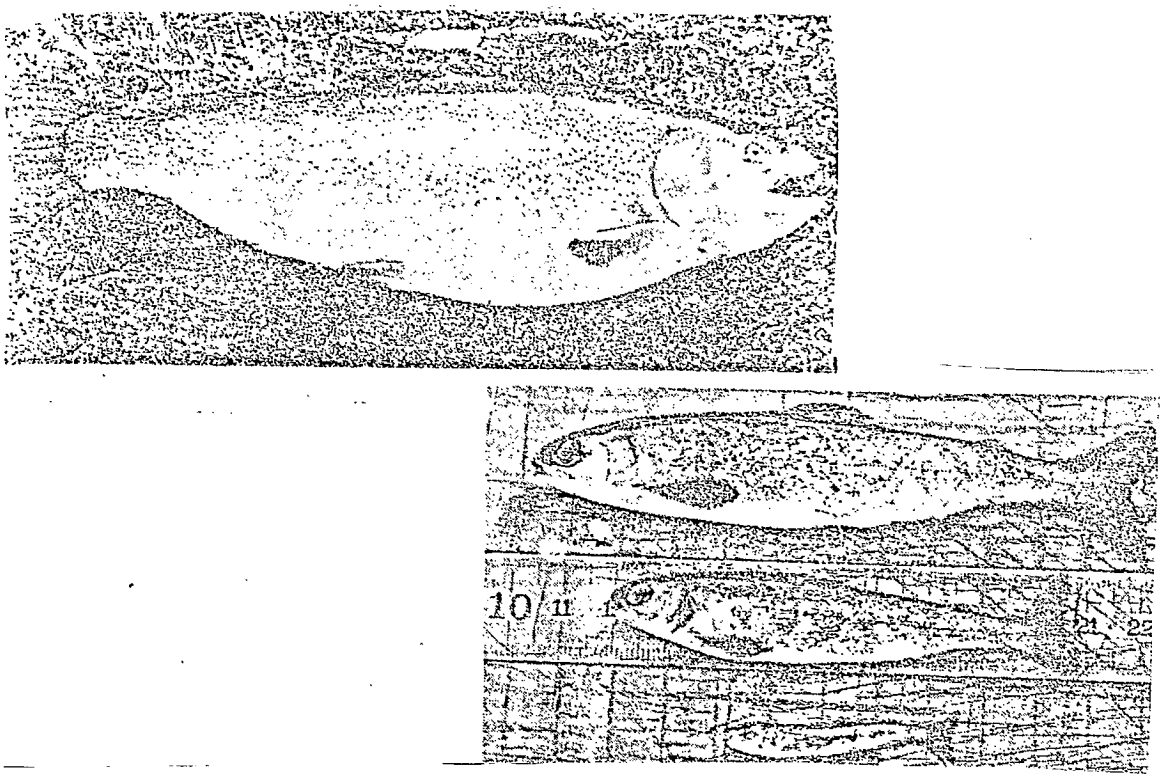
Salmon roe is placed in the hatchery during the period November-January. Hatching takes place during the period

February-April (5-7°C) and feeding is normally started in April-May.

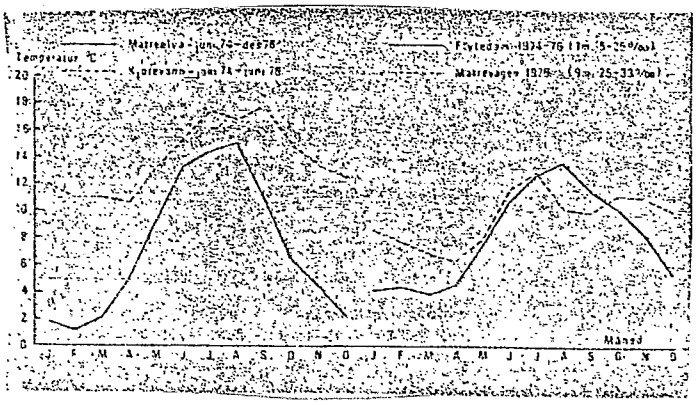
During the summer the fry is fed in small rectangular plastic tubs and in August it is transferred to circular tubs with an area of 1.8 sq. meters. The fish remain here for one year and those which do not smoltify are transferred to the floating pond for the last winter. Two year old smolt are 15-17 cm long and weigh 35-40 grams on the average.

For rainbow trout the annual production rythm has been as follows:

The roe is drawn (?) in January-April; it is hatched in February-May and feeding of the fry is started in circular tanks in March-May. Feeding is continued until December of the same year and at a weight of 30-50 grams the fish are transferred to the floating pond installation in the sea. The one year old fish weighs approx. 100 grams.



Large rainbow trout (top) and salmon in various stocking fish stages (bottom).



The water temperature is one of the most important factors in fish breeding. For roe and stocking fish of salmon fresh water is most important. The Matre River is regulated and has a temperature of over 10°C for four months of the year. With the help of cooling water from Matre Power Station production can take place also during the winter.

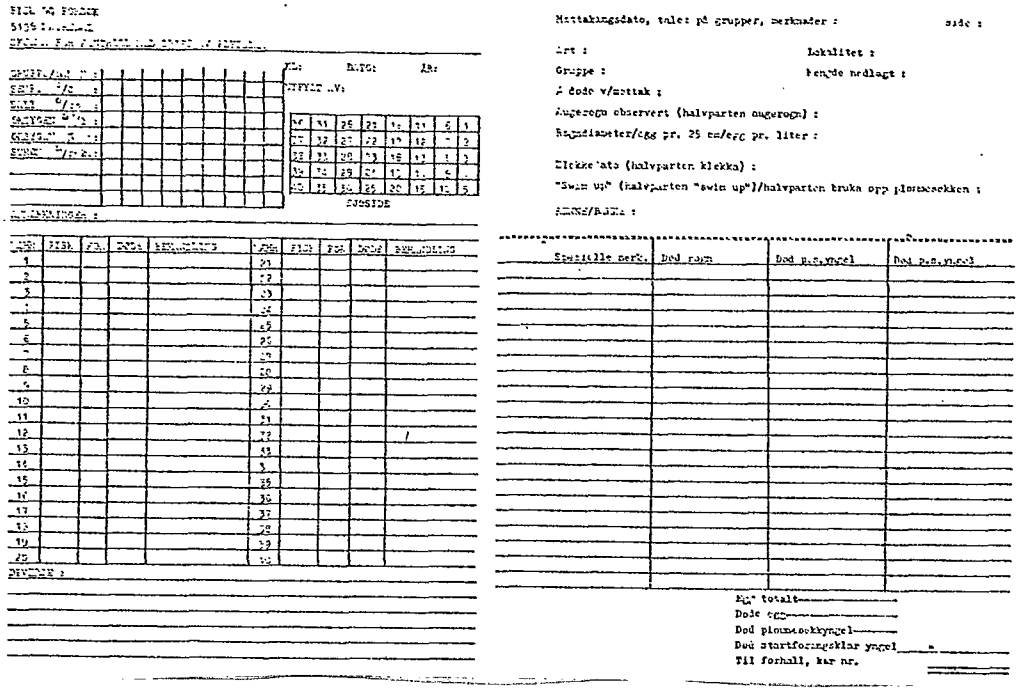
Legend: Temperatur = temperature; Elva = river; Juni = June;
Desember = December; Kjølevann = cooling water;
Flytedam = floating dock; Matrevågen = Matre Bay

Work Routines.

Even if operating conditions have at times been difficult because of the water situation, there has been enough fish to work with. As part of the research work of the station regular daily routines for the fish tenders have been worked out with a view to ensuring good fish management and uniform treatment over an extended period. In this way it is possible to measure the effect of the work of the tenders and to observe the development of the various generations of fish.

In practice a detailed recording system with daily forms has been introduced for the various sections of the plant. The form contains a survey of the tubs and information on cleaning, fish deaths, water measurements etc. The routine tender work takes place preferably in the morning.

Information from the daily forms is transferred to the monthly summaries. In addition to the forms work instruction has been



Mottakingsdato, talet på grupper, merknader :

Art :

Gruppe :

Døde v/mottak :

Augerogn observert (halvparten augerogn) :

Rogndiameter/egg pr. 25 cm/egg pr. liter :

Klekte'ato (halvparten klekka) :

"Swim up" (halvparten "swim up")/halvparten bruka opp plommesekken :

Spesielle merk. | Død rogn | Død p.s.yngel | Død p.s.yngel

Egg totalt
Døde egg
Død plommesekkyngel
Død startforingsklar yngel
Til forhall, kar nr.

Two examples of forms used in operations.

Legend: Top part of (1) is illegible; Gruppe = group; Temp: °C=temp.°C; Salt 0/00 = Salt 0/00; Oksygen = oxygen; Strøm = current; Anmerkninger = comments; (2): ?; Fisk = fish; For = feed; Døde = deaths; Behandling = treatment; (3) Mottakingsdato = date of receipt; Talet på grupper = number of groups; Merknader = notations, Side = page; Art = species; Gruppe = group; Døde ved mottak = dead on arrival; Augerogn observert = rosefish(?)roe observed; Halvparten augerogn = half rosefish roe; Rogndiameter/egg pr. 25 cm/egg pr. liter = roe diameter/egg per 25 cm egg per liter; "Swim up" = swim up; (Halvparten "swim up")/halvparten bruka opp plommesekken = (half swim up)/ half used up yoke bag; (?) Spesielle merk. = special comments; Død rogn = dead roe; Død p.s. yngel = dead yoke bag stock; (4) Egg totalt = total of eggs; Døde egg = dead eggs; Døde plommesekk yngel = dead yoke bag stock; Død startforingsklar yngel = dead stock ready for feeding; Til forhall, kar nr. = ready for shifting (?), tub no .

prepared for the various positions, as well as health regulations and special instructions for particular operations.

The work assignments at the station are of three types:
- Scientific and administrative work.
- Technical and maintenance work.
- Tender work.

The hatchery and the stocking fish installation are in many ways particularly vulnerable to accidents of various kind. There can be' failures in the water supply, blocking of screens etc. A watch arrangement has therefore been introduced at the research station so that the installation is manned from 08.00 hrs until 20.00 hrs on a year-round basis. The guard duty is shared by the fish tenders. During the night an alarm system is operating which will later be replaced by a telephone alarm.

Production Results.

Each year between 3 and 8 million eggs of rainbow trout, salmon, char, trout and humpback salmon have been laid (1973, 1975). The mortality in the roe stage was 30-50%. 1-3 million "øyerog" = augerogn = rosefish roe? or eye roe? have been sold annually by the production department.

In the yoke bag stage the mortality has been higher than expected. The reason was usually oversaturation with gas in the water, pH variations and other water conditions. Fish mortality has decreased in its later life stages. During the period when seawater was used to regulate water acidity, sporadic attacks of vibriosis occurred, a disease caused by the bacteria Vibrio anguillarum. Particularly fry and small stocking fish have been difficult to cure with medicines. To avoid this disease it was therefore decided to treat all fresh water with lime (pp 25-26).

Initial feeding was most successful in the small rectangular plastic tubs (see illustration on page 18). Initial feeding of rainbow trout was successfully carried out in the deep circular tubs but a special technique is needed to do this with salmon fry. As the fish grow up, the round tubs become more advantageous, they have better self-cleaning capability and the fish distribute themselves slowly in the entire water column. The population in the

starting phase has been 6-8000 fry per square meter tub area but there have been appreciable deviations due to the size of test groups, space conditions etc.

Apart from special tests dry feed has been exclusively used for all fry and stocking fish produced at the station. With regard to the choice of particle size, feeding frequency etc. reference is made to special experiments which are mentioned later. Feeding has taken place during the period 08.00 hrs - 20.00 hrs with one feeding per hour as a general rule. At low water temperatures the feeding was stopped for several hours during the day. Under such conditions it was found expedient to reduce the current velocity of the water in the tubs to preserve the fish.

Artificial light has been used in the feeding hall between 07.30 a.m. and 20.30 p.m. During the summer half year the light in the hall follows the daylight rythm because of uncovered windows and skylights in the ceiling.

The capacity of the station with regard to stocking fish production has been greatest in the research department. A large portion of this fish has been used for continued feeding as part of the breeding operation but some of the surplus fish was also delivered to breeders. The production department has mostly produced fry for sale, both salmon and rainbow trout. Work is now in progress to increase the production of stocking fish and smolt in the installation. Emphasis will be placed on species/hybrids which give the best results in the breeding tests.

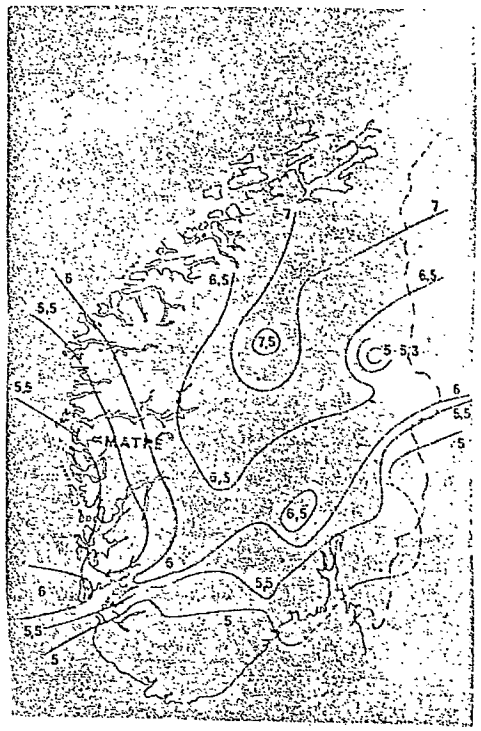
Organization of Research Work.

Discussion of Projects.

Use of the Research Station.

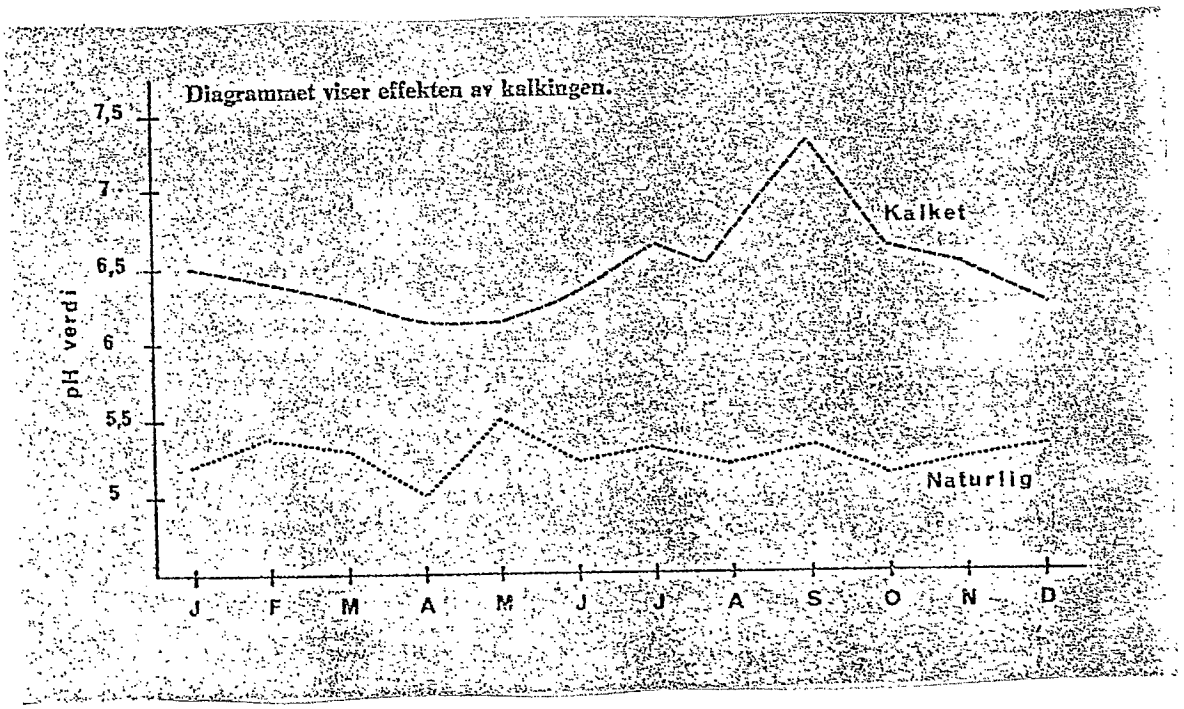
The board of directors of Fish and Fish Research sets the guidelines for the utilization of the station. Scientists associated with the research group for aqua culture at the FHI are the principal users of the station. These submit their project proposals to the board for consideration. Also other institutions can apply for research space.

The research department was in part established for systematic breeding work and most of the research activities have been in this sector. During the last years feeding tests have, however, obtained increased space. Now after completion of the station technique and methods will also become an important field of research.

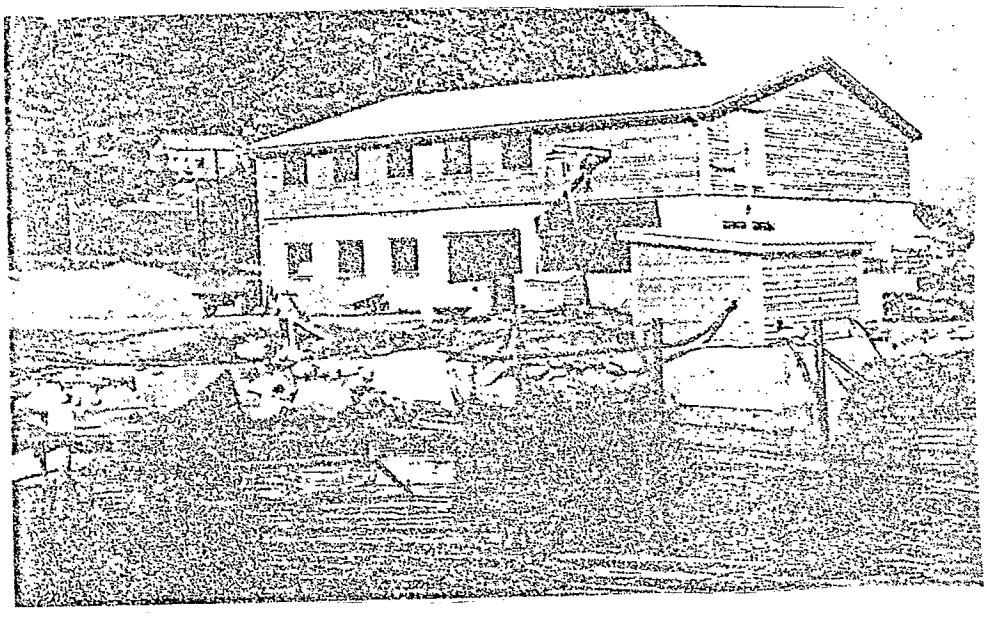


The research station is located in an area with high precipitation and low water pH. All fresh water must therefore be neutralized with lime before use. The ... map was prepared for the project "the effect of acid precipitation on forest and fish" (SNSF).

Altogether approximately 20 different tests/investigations have been carried out at the station. Some have extended over more than a year and one has been in progress during the entire time. Results have been published in articles and reports (see the list of publications at the end of the report). The most important projects will be discussed in the following.



Effect of lime treatment. Legend: Kalket = treated with lime
Naturlig = "natural" control



"Eros Laks" (Salmon) in Bjordal has fed breeding fish of rainbow trout for genetics tests since 1972.

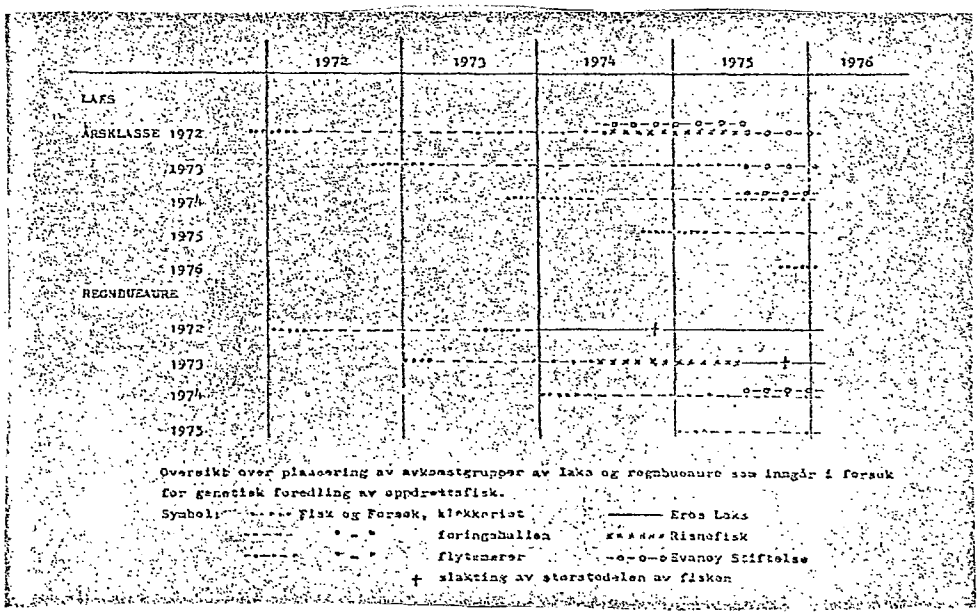
Population-genetics Experiments.

Tests for genetic improvement of breeding fish were started in the fall of 1971 at the Oceanographic Institute of the Directorate of Fisheries. During the first years the tests were financed by the research fund of the fishing industry but since 1975 a significant part of the operating expenses were covered by the Norwegian Fish Research Council (NFFR).

The tests had two objectives:

a) to investigate the importance of heredity with regard to the optimum economic properties of fish,

b) to produce better breeding material than is used to-day in Norwegian fish breeding.



Oversikt over plassering av avkomstgrupper av laks og regnbueaure som inngår i forsøk for genetisk foredling av oppdrettsfisk.

Symboler: ..... fisk og forsøk, klekkeriet
_____ Eros Laks
- - - - foringshallen
xxxxxx Risnefisk
-.-.-.- flytemærer
-o-o-o Svanøy Stiftelse
+ slakting av størstedelen av fisken

Legend: Laks = salmon; Regnbueørret = rainbowtrout; Årsklasse = age group.

Summary of placement of groups of progeny of salmon and rainbow trout used in the tests for genetic improvement of breeding fish.

Symbols:..... Fish and Fish Research, hatchery

------ " " " " ,feeding hall

-.-.-. " " " " floating dock

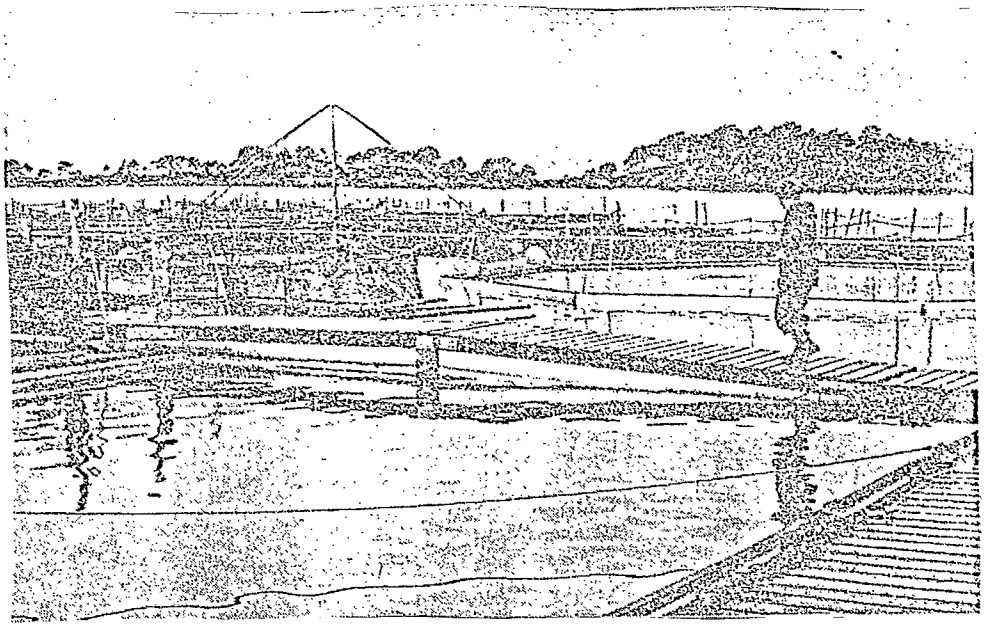
_____ Eros Laks (salmon)

xxxxxx Risne fish

-o-o-o Svanøy Foundation

\+ most fish killed

To begin with it was attempted to determine the variation in important production properties (particularly growth rate and age at sexual maturity) and to examine to what degree variations are controlled by hereditary factors. This will be the basis for the actual breeding work, i.e. selection of breeding fish or strains with the best production characteristics.



The fish installation at the Svanøy Foundation have had experimental fish "boarding" since 1974.

Work has been done in these tests with both salmon and rainbow trout, on a small scale also with other species of salmon fish and species hybrids. (See the special section on humpback salmon and char). In each age group there were normally approx. 50 groups of siblings of salmon and approx. 20 groups of siblings of rainbow trout. The length of the first two age groups was measured every six months. The later age groups were normally measured only once a year. Smoltification (?) and if possible sexual maturity were recorded at the same time. When selecting and killing breeding fish, and when measuring large fish, the weight is also recorded.

Rainbow trout was normally taken by Fish and Fish Research to a sea installation when one year old; salmon was taken soon after

smoltification. The first two age groups contained significant numbers of year old smolt. These were separated and transferred to the sea installation together with the two year old smolt.

Since the Oceanographic Institute has so far no research installation in the sea, it was necessary to rent space in commercial fish installations. There has been cooperation with the Svanøy Foundation, Svanøybukt, Eros Laks, Bjordal, and Risnefisk in Brekke.

The groups have been tagged by "freeze"(?) tagging and combinations of clipping of fins. Apparatus for freeze tagging has been lent by the Fish Research Station at Sunndalsøra. External Carlin tags have been used for smolt (1972 age group). Various types of American Floy tags have been tried for fish of 15 cm or more length. Breeding fish which was particularly valuable has been tagged with ordinary cod tags (Lea tags).

Salmon.

There is much variation between salmon groups, both with regard to growth and sexual maturity. The percentage for sexual maturity of fish in the sea during the second year varies from 0 to 100; only groups numbering few fish show 100% sexual maturity. The variations between groups from the same location are moderate, apart from salmon originating from the breeding installation at Eros Laks. These groups vary greatly both in growth rate and sexual maturity but it has to be considered that these groups originate from fish caught in the sea and which thus came from different rivers.

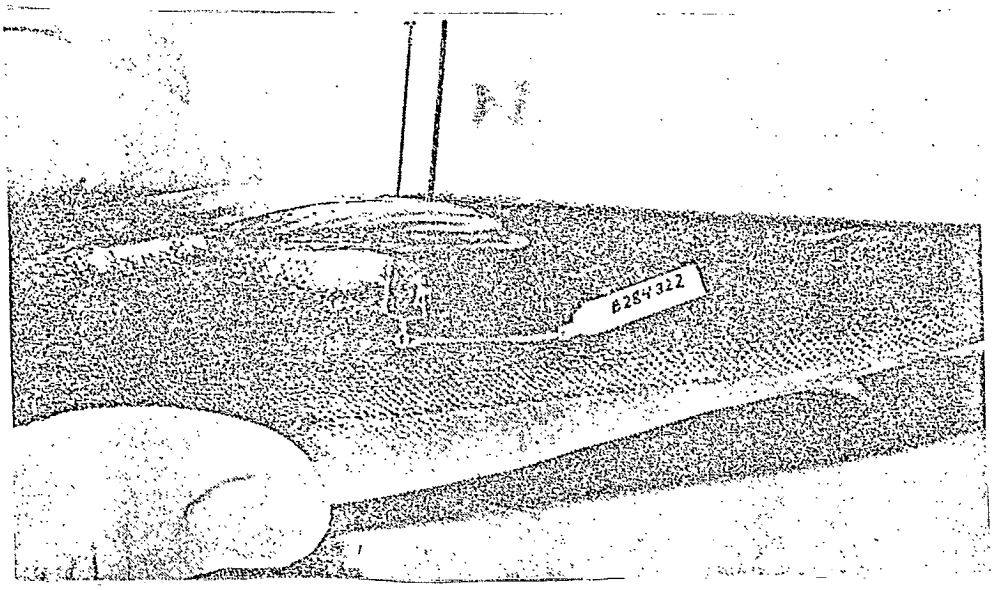
In groups originating from rivers with typical large salmon e.g. Alta-, Lærdal-, Etne Rivers, Gaula, Vosso and Opo there are few or no sexually mature fish but in groups from typical "tert" (young salmon) rivers, such as Lonevåg River, sexual maturity is very frequent.

Generally speaking sexual maturity appears to have had some effect on growth since sexually immature fish are on the average somewhat larger than the mature ones in most groups where there is a relatively large number of both types. The difference is, however,

Summary of growth and sexual maturity for groups of salmon hatched in the spring of 1972.

Gr nr	Opphav	30 måneder		36 måneder		42 måneder				
						kjønnsmodne		umodne		
		gj.sn. lengde	antall	gj.sn. lengde	antall	gj.sn. lengde	antall	gj.sn. lengde	antall	% kjønns-modning
01	Målselv	35,2	101	45,9	97	56,9	15	55,5	66	29,8
04	"	33,5	107	44,5	95	53,9	8	55,6	77	17,9
05	Lakselv	31,3	13	40,5	9	45,3	1	49,6	18	22,2
06	"	31,2	6	—	—	—	0	53,1	8	0
09	Altaelva	29,8	2	—	—	—	0	66,5	2	0
10	"	—	—	—	—	—	0	62,7	7	0
15	Lonevåg	—	—	—	—	45,6	16	—	—	100
17	"	—	—	—	—	48,8	8	—	—	100
18	"	—	—	—	—	46,4	7	—	—	100
19	"	36,0	34	46,7	31	51,4	34	58,0	2	94,4
21	Lærdal	34,9	37	45,8	53	52,3	1	55,8	55	6,8
22	"	36,4	104	47,5	108	—	0	58,0	113	0
23	"	36,1	66	47,3	67	53,0	3	57,6	73	4,0
24	Rauma	37,4	79	51,3	76	57,6	66	60,7	7	90,4
27	"	33,3	9	—	—	54,2	9	43,0	1	90,0
28	Etneelva	34,6	101	44,1	100	59,0	1	57,5	100	1,0
30	"	32,8	104	42,2	100	50,8	4	53,9	97	4,0
31	"	33,5	102	42,4	99	54,2	6	53,7	93	6,1
32	Tengselva	35,2	46	46,7	49	53,8	9	55,4	50	15,3
33	"	35,9	34	46,6	37	55,4	14	55,9	27	34,2
34	"	36,3	69	48,1	65	57,2	21	56,7	45	31,8
37	Gaula	31,6	108	40,6	100	52,5	2	53,0	88	2,2
38	"	32,3	114	42,2	100	52,0	1	54,1	89	1,1
39	"	32,2	104	40,9	100	52,5	2	52,0	99	2,0
40	Opo	34,0	101	43,1	104	—	0	55,2	99	0
41	"	34,1	51	43,4	46	—	0	58,5	51	0
43	Eio	33,2	100	42,6	100	54,8	12	55,1	86	12,2
46	Vosso	31,2	102	39,5	103	—	0	52,6	77	0
47	"	32,0	98	41,4	90	50,0	6	53,5	75	7,4
49	"	30,3	103	41,1	116	46,0	1	55,9	101	1,0
50	"	31,3	100	41,7	98	55,8	5	56,2	83	5,7
52	Eros Laks	36,9	100	47,4	100	57,0	1	57,9	87	1,1
55	" "	29,3	114	39,3	80	52,7	17	51,8	66	20,5
57	" "	36,6	85	47,7	84	—	0	58,7	70	0
58	" "	40,4	4	—	—	59,2	6	62,6	7	46,2
59	" "	28,8	110	39,2	100	51,0	1	52,3	91	1,1
60	" "	30,4	46	40,0	48	55,3	6	54,0	47	11,3
61	" "	27,4	64	38,8	52	55,8	5	52,4	49	9,3
62	" "	31,9	110	41,5	100	57,8	9	55,3	85	9,6
63	Skellåfteelv,	28,4	103	39,0	99	46,6	39	49,7	48	44,8
64	Sverige	27,1	106	35,3	100	44,5	40	47,0	36	52,6
65	" "	28,2	95	38,0	80	48,0	37	50,9	41	47,4
66	" "	26,8	100	37,6	55	48,0	21	50,1	28	42,9
67	Maria Pond,	33,4	15	41,8	8	50,0	1	55,0	19	5,0
68	Canada	40,0	96	49,1	96	57,0	1	58,4	12	7,7
69	" "	40,1	14	47,2	13	50,3	3	56,4	23	11,5
72	MacDonald	28,6	30	41,0	19	56,1	15	56,3	8	65,2
73	River, Canada	32,6	20	40,7	22	53,8	6	54,3	12	33,3

Origin	30 months		36 months		42 months				
	average length	no	average length	no	sexually mature		immature		% sexually mature
					ave. length	no	ave. len.	no	



Fish tagged by Carlin tag.

not great and in some groups the reverse seems to be the case. A small but statistically significant negative correlation ($r = -0.49$) was established between average length after $1\frac{1}{2}$ year in the sea and percent sexual maturity. This is explained by the effect of sexual maturity on growth since no correlation ($r = 0.05$) was found between average length after one year in the sea (spring) and sexual maturity in the coming fall.

Average growth in the early stages gives little indication of a group's growth characteristics in later stages. For registration in close proximity the relationship is clear; growth after 6 months in the sea, when the age of the fish is 30 months, appears to be a useful measure of the growth characteristics of the group in the sea phase.

For the 1974 and 1975 age groups the variation in smoltification after one year was remarkable. Under conditions in the feeding hall, where conditions are as uniform as possible, the smolt percentage varied between groups in the spring of 1975 from approx. 1% to 69%. Smoltification is closely associated with growth and the full importance of these variations will become apparent only when growth data for the age group are analyzed.

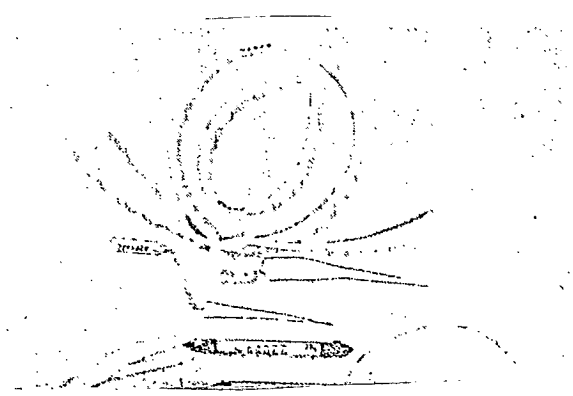
Rainbow Trout.

For the definition of age at sexual maturity the percentage of mature fish in their second and third year was used; the few which were sexually mature in their first year were disregarded, as were fish which were possibly not mature before their fourth year.

In November of the second year of life of the fish there is practically no difference in size between fish in the maturing stage (this applies essentially only to males) and fish which is still immature. The sexually mature fish grow, however, little during the winter and, when measuring in the spring, the immature fish were considerably larger than the mature ones.

With regard to the sexual maturity in the third year of the life of the fish, the maturing fish were considerably larger in the fall than immature fish; this applied to most groups in both age groups.

The percentage of fish which became mature in their second and third year showed large variations from group to group. These data are used to calculate heredity (that part of the phenotypical variation which is controlled by independently functioning genes) for this character. The calculation methods are based on the fact that independently functioning genes will produce a large measure of likeness between relatives. By comparing the variation in the material one can therefore find a measure of the effect of independent genes.



Fish tags used in the genetic investigations:
Top: Lea tags
Middle: Carlin tags
Bottom: Floy tags
Freeze tagging and fin clipping were also used.

Data for growth among groups of siblings of rainbow trout.

Data for vekst hos søskengrupper av regnbueaure.

Gruppe nr.	6 mndr. gj.sn. lengde mm	12 mndr. gj.sn. lengde mm	18 mndr. gj.sn. lengde cm	24 mndr. gj.sn. lengde cm	24 mndr. gj.sn. vekt g	30 mndr. gj.sn. lengde cm	30 mndr. gj.sn. vekt g
1972 årsklassen							
01	97.5	170.6	27.25	37.22		50.60	1 470
03	121.7	201.2	30.93				
05	111.8	188.2	28.35	37.79		47.98	1 300
06	115.9	195.0	29.37	37.59		49.16	
07	107.2	181.4	27.30	35.92		47.90	1 370
08	116.0	201.0	29.73	36.76		47.61	1 250
09	117.2	197.8	29.58	36.42		47.53	1 200
12	102.5	169.3	25.46	34.73		46.30	1 120
13	107.4	167.3	28.95	36.10		49.55	1 620
14	103.3	162.3	28.56	36.13		50.02	1 580
15	104.8	179.3	31.29	38.30		50.99	2 040
16	100.0	164.6	29.80	37.37		50.98	2 050
17	112.2	168.1	29.69	37.44		50.52	1 900
18	108.6	170.3	30.32	38.88		53.97	1 920
19	127.9	195.9	33.44	40.09		52.02	2 020
20	116.3	202.0	32.09	36.10		51.71	2 324
21	-	172.3	32.40	38.13		50.12	1 640
1973 årsklassen							
22	124.7	192.2	36.51	43.12	1 144	53.84	2 222
23	111.3	164.5	33.50	38.09	877	48.75	1 722
24	109.8	184.4	34.00	40.70	985	52.52	2 279
25	119.8	197.1	33.84	40.20	882	51.79	2 005
26	111.0	162.2	34.01	39.81	933	51.13	1 884
27	113.6	176.7	35.49	43.74	1 161	51.74	2 011
28	90.6	137.6	30.01	35.19	629	46.30	1 357
29	98.9	150.8	33.92	40.30	1 052	51.40	2 012
30	138.3	195.4	35.73	39.86	950	50.41	1 954
31	141.1	209.7	35.99	42.70	1 224	53.02	2 318
32	134.4	188.5	34.57	40.97	1 024	51.66	2 039
33	137.5	208.1	34.88	41.88	1 013	52.73	2 151
34	117.1	182.2	34.87	41.35	974	52.26	2 036
35	115.9	171.0	35.82	43.30	1 203	54.96	2 414
36	135.9	190.6	34.63	42.02	1 064	52.97	2 100
37	126.5	186.1	33.11	39.42	915	50.73	2 014

Group no	6 months average length mm	12 months average length mm	18 months average length mm	24 months average length mm	24 months average weight g	30 months average length mm	30 months average weight g
1972 age group							

The results were not unambiguous but they show on the whole that heredity is limited with regard to the relative number of sexually mature individuals in their second year but considerable higher values (0.2-0.4) were found with regard to sexual maturity in the third year of the fish. Since the environment was the same for all groups among the age groups, the conclusion must be drawn that non-additive heredity (genes functioning in unison) is of significant importance with regard to the earliest sexual maturity in rainbow trout. Additive heredity is, however, also a factor since variations in sexual maturity in the third year of the fish appear to be in part affected by independent genes.

With regard to growth large variations were found between groups. Here also additive heredity appears to play a significant role in the control of the observed variations.

The large variations observed between sibling groups of both salmon and rainbow trout show that the breeding material used in Norwegian fish breeding to-day is very non-uniform. While the calculations are not unambiguous,it appears that independently functioning genes play a significant role both in growth and age at first sexual maturity. The surest way to check results is to carry out a selection and compare the progeny of selected parents with progeny of blended breeding fish material. Such tests were initiated in 1975 and continued in 1976.

Experiments with Humpback Salmon.

Fish and Fish Research has worked with humpback salmon since the fall of 1973 with a view to establishing whether this salmon species can be used in Norwegian "serving"-fish breeding, based on seawater installations. This matter has often been discussed since there is a large international market for "serving"-fish (fish weighing 200-300 g).

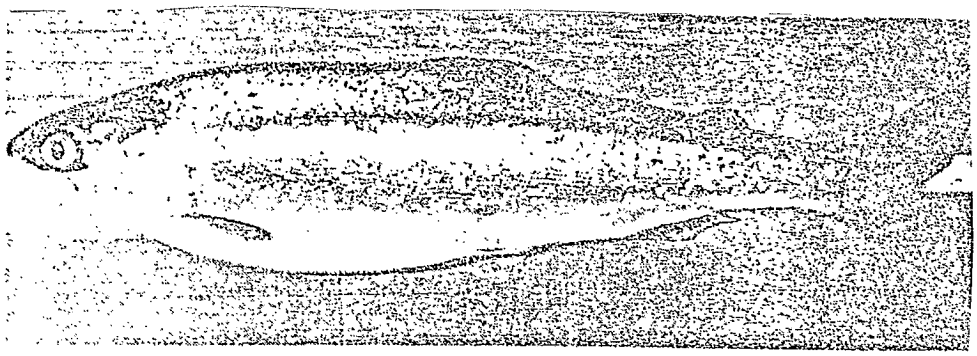
Tests at the station have shown that technically and biologically the humpback salmon is not a difficult breeding fish to work with under our conditions. It produces large roe which hatches well and is easy to feed. Its ability to tolerate salt water as a small stocking fish (approx. 4 cm long) makes it possible to transfer it early to the sea-water installations and spend most of its production time there. This fish has an attractive appearance, its meat turns red with pigment feeding and has a good taste when killed at the right time. The greatest

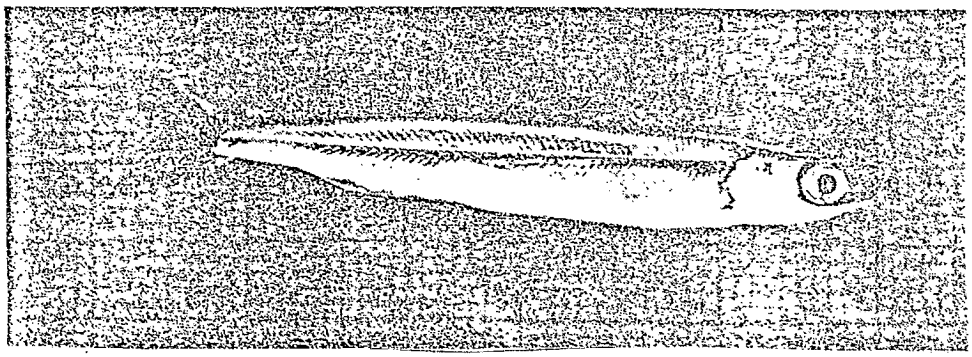
disadvantage is that it "is a smolt throughout its entire life", i.e. it has loose skin (?) ("rips") and is easily damaged by handling.

From a consignment of "eye"(?) roe from Finnmark obtained in 1973, the station has developed two generations of humpback salmon for research work. In the spring of 1976 60,000 stocking fish were produced. 40,000 of these were distributed to three breeding installations for practical testing.

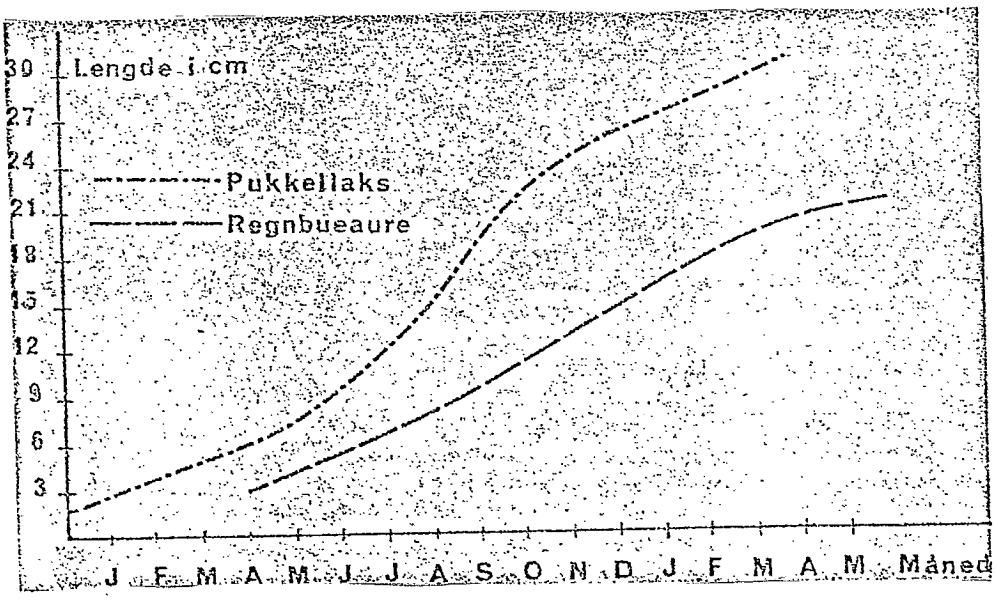
19,000 were used for stocking in two locations: Søgne River and Matre Bay.

Stocking in Søgne River was carried out in cooperation with the Directorate for Game and Fresh Water Fish.





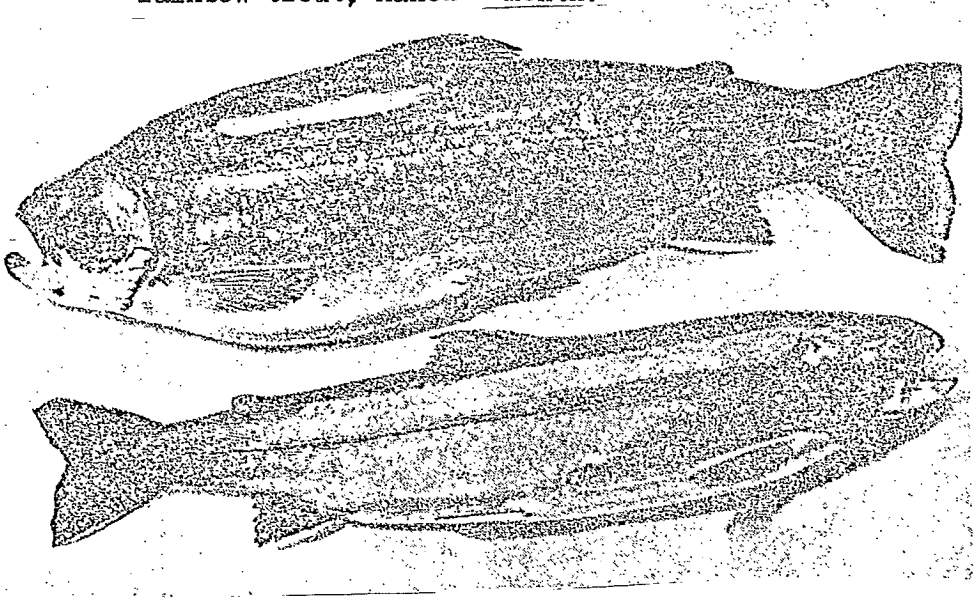
Top: "Serving" (or portion) humpback salmon.
Bottom: Fry of humpback salmon.



Growth of Humpback Salmon compared with Rainbow Trout bred at Fish and Fish Research.

The curves do not show everything with regard to the growth capability of these species since breeding conditions, particularly water temperature, were different. The result shows nevertheless how these fish species utilize the existing growth environment at the station.

Legend: Lengde i cm = length in cm; -.-.-.= humpback salmon; --- = rainbow trout; Måned = month.



Char produced by breeding becomes a fine dinner fish. The picture shows char in spawning condition (top: male), (bottom: female).

Experiments with Char.

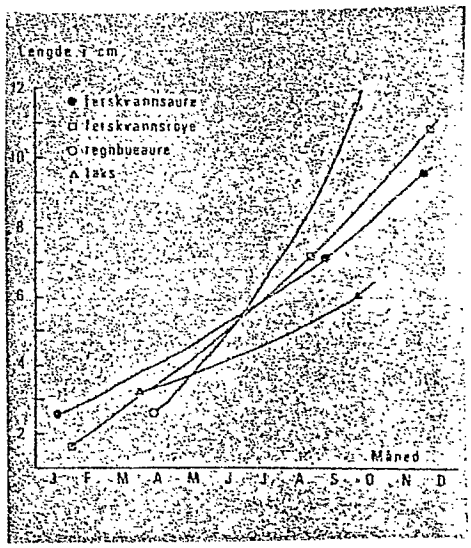
Char is another salmon species (Salvelinus alpinus) which has been investigated at the station. Since 1972 tests have been made with regard to growth and seawater tolerance of both seawater-and freshwater char.

The tests have shown that char grows rapidly under breeding conditions. In the stocking fish stage the growth rate is roughly equal to that of rainbow trout. Char is easy to breed in the stocking fish stage; it eats well, tolerates a high fish density and is not readily susceptible to wear of the fins. Stocking fish of char which is transferred to seawater in the spring and which assumes a natural daily rythm, has managed well during the first summer but has lost weight and shown increased mortality from August/September and throughout the winter. All sexually mature char, and also immature char from some locations in Western Norway, has had development problems in seawater with 16 hours regulated length of day, throughout the year. Immature sea char from Northern Norway and some char populations from Western Norway tolerated and prospered in the same environment.

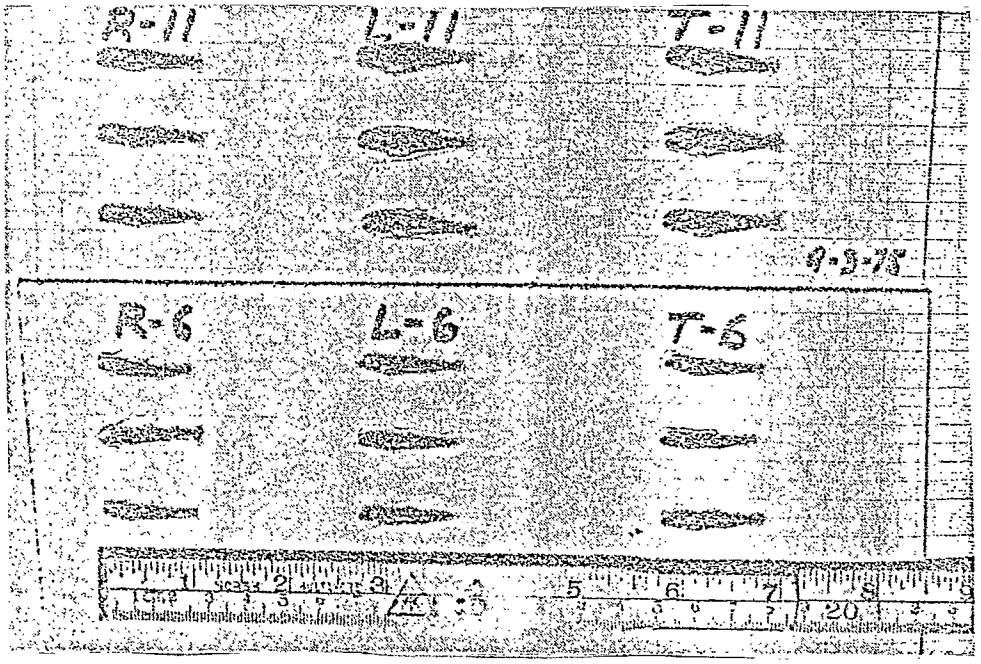
An environment in brackish water produced good growth and no survival problems. Sea char grew also well in fresh water at low temeratures.

10-20% of the sea char population were sexually mature after $1\frac{1}{2}$ year (all males) while female fish became sexually mature one year later. The ability to show good growth in dense populations was remarkable. Fish densities of up to 30 kg/m^2 in round tubs and up to 18 kg/m^2 in floating docks showed no reduction in growth.

Legend: ● freshwater trout
□ " char
o rainbow trout
♣ salmon



First year growth in freshwater char compared with trout, rainbow trout and salmon in breeding tests at Fish and Fish Research.



Growth of fry of sea trout at 10°C (top) and 6°C (bottom) water temperature; fed on dry feed (right), beef liver (middle) and red copepod (Calamus finnmarchensis) (left).

Initial Feeding of Fry.

The period at the time of hatching and the first feed intake by the fry is a critical phase in nature and during breeding. Particularly at the time of initial feeding it is possible so/ to control both fry and environment by various manipulations that survival and growth are at an optimum.

The station has carried out a number of small tests to examine some of the problems associated with initial feeding. Fry of salmon, trout and humpback salmon were used in the experiments. It was confirmed that water temperature is extremely important ing/ for the results of the first food intake. Initial feed for both salmon and trout should take place at water temperatures over 10°C. First feeding of humpback salmon can be carried out with good results at a temperature of 8°C. The reaction of fry to various modifications was also tested. It has been stated that red copepod is a good starting feed for fish fry and that trout initially cannot be effectively fed on commercial starting feed (dry feed).

Comparative tests have clearly shown that red copepod alone is not suitable as starting feed for salmon and trout, presumably because of the high content of poorly digestible fatty substances (waxes). Dry feed was, however, found to be clearly superior as starting feed for fry of both salmon and trout but beef liver gave also good results. Taking into account both labour and price, dry feed was clearly the best fry feed. Other tests showed the importance of supplying fry at all times with feed of the right particle size. Both excessively large and excessively small particles result in reduced growth and increased spoilage.

Effect of Feeding Frequency.

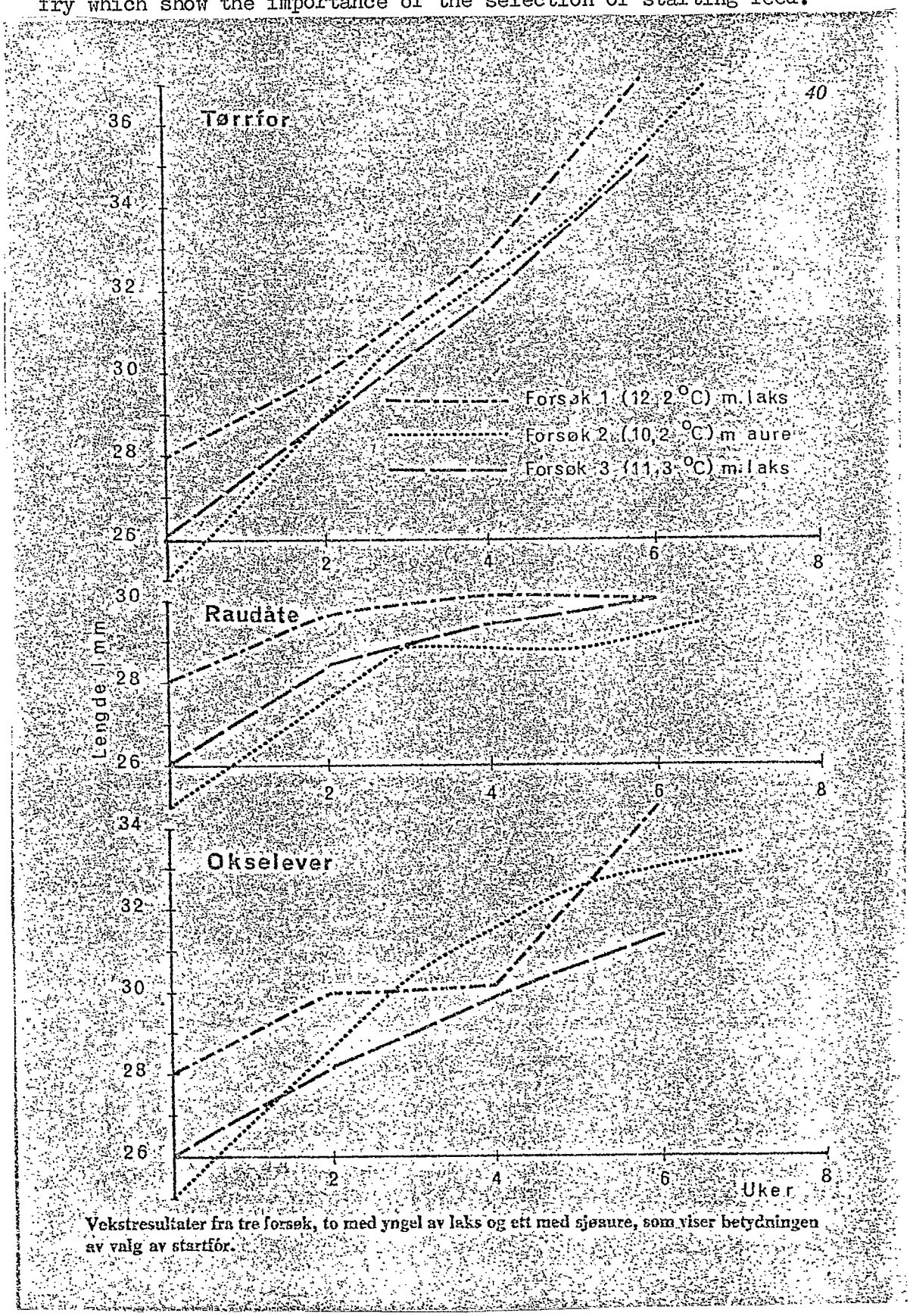
A type of experiment which can benefit many breeders are practical tests in the field of feeding technique. The Vitamin Institute of the Directorate of Fisheries has initiated tests at the research department to study the importance of feeding the fish more or less frequently, both on a daily and weekly basis.

With rainbow trout at the initial size of 3.5 grams fed with dry feed, it was found that the best growth was obtained when feeding all weekdays and four times daily (appetite feeding). Fewer feedings per day produced reduced growth while more than 4 feedings gave no improvement in growth. When feeding was omitted on one weekday, growth dropped, regardless of the number of feedings per day. When feeding was omitted on two consecutive weekdays (free weekends) then growth dropped even more in relation to the groups which were fed every day. All groups were fed during daylight hours between 08.30 a.m. and 19.30 p.m. Feeding was done by hand and with great precision.

**** Tests have been initiated with large rainbow trout fed on wet feed in seawater to study the effect of varying feed frequency under such conditions. On the basis of this type of test it will be possible to arrive at a more precise feeding program for fish in various growth conditions and stages.

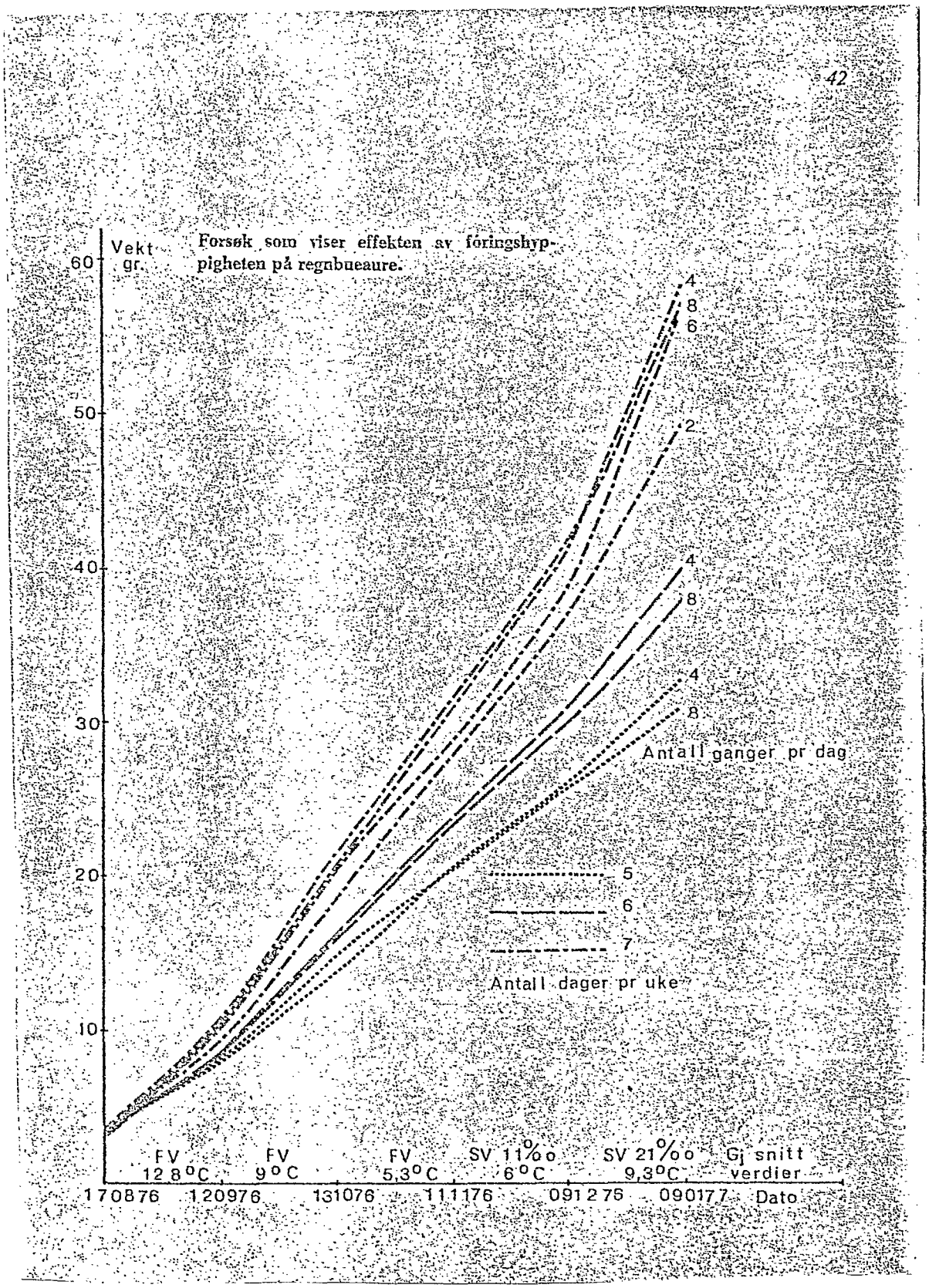
**** The feed factor, i.e. the kg feed needed per kg growth, increased with the number of feeding per day, essentially an effect of the degree of spoilage associated with the number of feeds.

Growth results from 3 tests: 2 with salmon fry and one with sea trout fry which show the importance of the selection of starting feed.



Vekstresultater fra tre forsøk, to med yngel av laks og ett med sjøaure, som viser betydningen av valg av startfôr.

Tests showing effect of feeding frequency on rainbow trout.



Other Experiments.

In addition to above mentioned projects smaller, short-term tests have been carried out since the beginning. These tests had largely practical purposes.

1. The ability of the eggs to tolerate mechanical effect[5] in various development stages. These tests are of great importance to work in the hatchery; they were carried out during the winter 1971-72 (O. Helland-Hansen, Ingebrigtsen).

2. Effect of Density and Sorting according to Size on the Growth of Salmon and Rainbow Trout.

Optimum density in floating dock and feeding tubs is of appreciable importance to good fish growth and optimum utilization of station capacity. Tests of this type have therefore been carried out as methodical experiments to obtain better knowledge of the capacity of the various production units. In connection with breeding tests the effecto of density as a source of error in such tests was also investigated (Møller, Naevdal).

3. Uncontrolled spoilage from stocking fish tubs and floating docks have been and are a serious problem for fish breeders and for station operation. Experiments and observations to analyze the reasons for such spoilage have been carried out.(Østhus et alia).

4. The Salt Tolerance of the Salmon Fish at varying Age and Size.

Because of the low pH in the freshwater at the station it is of great importance that stocking fish is transferred to brackish water as early as possible. Tests of this kind have therefore been carried out as methodical experiments for the utilization of the capacity of the station (Østhus, Ingebrigtsen).

5. Vaccination against Vibrosis.

Vibrosis is a serious disease in breeding fish. A vaccine has now been developed against this disease and is being tested at the station.

6. Behaviour Tests with Smolt.

The transition of salmon from stocking fish (pairs) to smolt is a complicated physiological and biochemical process which is not fully understood. The smoltification affects among others the behaviour of the fish, and tests to analyze behaviour changes in connection with smoltification are in progress (S. Knutsson, T. Grav).

7. Overgrowth problems.

Overgrowth on the docks and installations for fish breeding is a great problem, and cleaning of nets is a significant expense item for fish breeders. Fish and Fish Research has participated in testing of new types of impregnating substances.

8. Vitamins for Breeding Fish.

Tests with various vitamin additives in feed for breeding fish (rainbow trout) were carried out in the fall of 1973. The various vitamin additives showed little effect on the ability of progeny to survive (Ingebrigtsen, F. Utne).

9. Acid Conservation of Wet Feed.

The tests showed that conservation of wet feed with acetic acid (as an alternative to freezing) produced a satisfactory feed.

10. Pigmentation.

Tests with various types of colouring materials for the pigmentation of fish meat were carried out in 1972-73 and resumed in 1976 as a thesis in the major subject of a student at the Norwegian Fisheries University (S. Ugletveit, Torrisen).

11. Pigmentation with Red Oil (Shrimp Oil).

Tests with this form of pigmentation for fish meat were carried out with satisfactory results (Ingebrigtsen, Utne).

12. Comparative Investigations of various Types of Herring Meal in Dry Feed.

These tests were carried out in 1975 as a cooperative project of Fish and Fish Research, the Vitamin Institute and Nordsildmel (Northern Herring Meal) (Ugletveit, Utne, Ingebrigtsen).

13. Vitamin Addition to Fish Meal.

Tests with various vitamin additives in fish feed has cooperated with the Vitamin Institute (E. Lied, Utne).

14. Practical Stocking Tests with Fish.

The project was started in 1976 on the basis of a grant from the Fund for Fish Search and Research. The objective for this project is to maintain and increase the population of salmon in the sea by stocking. The work is carried out in cooperation with the Directorate for Game and Fresh Water Fish.

In 1976 the objective was to produce fish for stocking, to procure and install equipment for such operations and to carry out the first the firststockings. Altogether 22,000 fish: 18,000 humpback salmon and 4,000 smolt were released. Half of the humpback salmon was turned over to consultant Senstad in the Directorate for Game and Fresh Water Fish for release in the Søgne River. The remaining fish was released in the Matre Fjord. Tests dealing with the behaviour pattern of smolt with migration in simulated installations were initiated.

In 1977 a combined channel for downward and upward migration with associated ponds will be built. A series of test will attempt to analyze the importance of strain, "smoltaler"(?), smolt size, tagging of re-catches among others. The effect of stocking on the natural emigration of fish from the Matre River will also be measured.

15. The Vitamin Requirement of Rainbow Trout.

With funds from the Norwegian Fisheries Research Council tests have been initiated to analyze the vitamin requirement of rainbow trout bred in seawater. Observations indicate that excessive amounts of vitamins are added to some feed mixes (Utne et alia).

16. Other Tests.

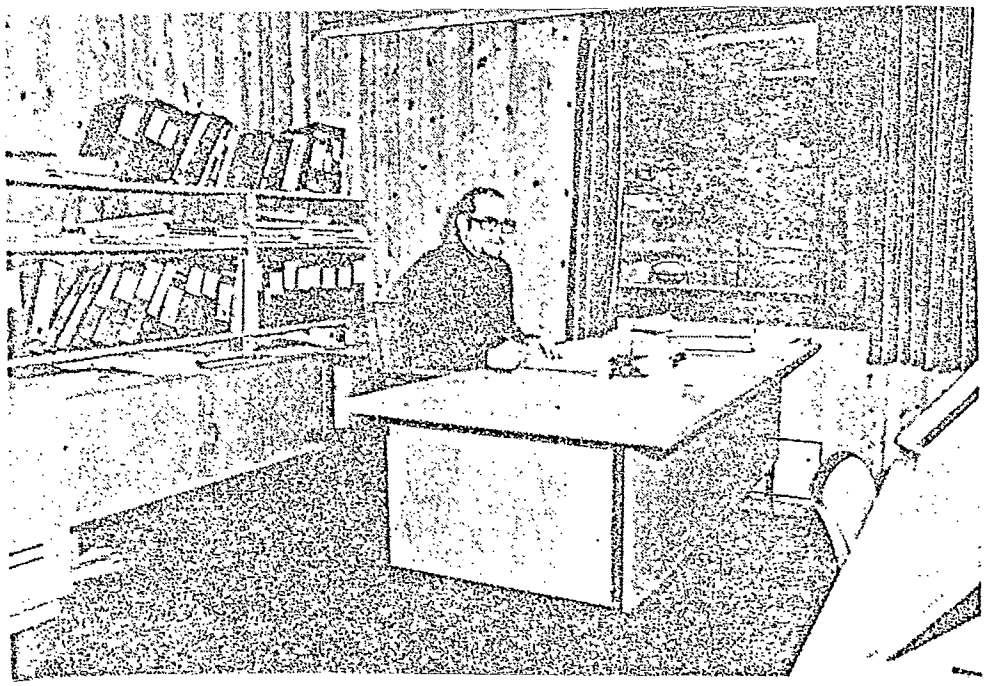
Tests dealing with arsenic in fish feed and experiments with unsaturated fatty acids can be mentioned (Braekken, Ingebrigtsen, Ugletveit).

17. Delivery of Materials outside the Station.

Fish and Fish Research has each year delivered material for tests at the Oceanographic and Vitamin Institutes. Among others physiological /ecological tests in connection with smolt production are mentioned as well as temperature/growth tests, behaviour tests, vitamin tests, metabolism tests and feed tests (protein diets).

Training and Education.

The paragraph dealing with objectives in the agreement of cooperation mentioned earlier states that the station shall provide trade instruction and guidance in the field of fish breeding. From the beginning enquiries have been directed to the station with requests for assistance and advice. As early as November 1972 the station was used for a course in fish breeding arranged by the research group for aqua culture. Other courses were arranged in May 1973 and March 1974. The manager has also lectured in other locations. Following an increase in staff in 1975 an internal station course with lectures and seminars was arranged in the spring of 1976. This course will continue in 1977. During the entire time the station has also accepted trainees for shorter and longer periods. In recent times the trainees have also received theoretical instruction in the course arranged at the station. The station considers the education of trainees an important feature for the industry and would like to expand this part of its activities in cooperation with the trade organization of this industry.



A large part of the manager's time is used to maintain contact with the industry, both by telephone, by publications and by courses.

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