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# Pollution problems in Norwegian fish farming

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ABSTRACT

The accumulation of organic wastes at the seabed in Norwegian fish farms is a growing problem. The difficulties usually appear after a few years of operation, and involve loss of appetite, damage of fish gills and increasing mortality of the fish. New farms should take particular care in site selection, and if necessary be able to change locality. Pollution may be indicated by periodical smell of hydrogensulfide, development of bubles, accumulation of organic wastes and irritation of fish gills. The accumulation of organic wastes at Austevoll Marine Aquaculture Station and other farms in the area are described. Three common methods to clean the polluted areas are described with particular reference to the use of submersible mixers. A brief describtion is given of some research projects. The pollution problems in Norwegian fish farms are probably more common than earlier expected. The fish farmer should carefully analyze the location of the farm and all routine operations in connection with feeding , cleaning and caretaking of the fish in order to avoid such problems.

## INTRODUCTION

The rapid increase in Norwegian fish farming the last years has created serious pollution problems at a number of farms along the coast. The difficulties appear after a few years of operation and the experienced farmer will observe small changes in behaviour and growth of his stock of fish. The most typical changes are loss of appetite, irritated gills, a decrease in resistance to diseases and increased mortality. The total extent of the problem is not known, but a majority of the fish farmers that has been in activity for some years have been in contact with the problem. The various enviromental problems in connection with fish farming has been discussed by a committee with representatives from all scientific institutions working with aquaculture, representatives from the fish farmers association and govermental agencies (Pedersen 1982). The present paper will give a brief outline of the problem as experienced at a fish farm, discuss possible practical solutions to remove accumulated organic material and mention some of the scientific programs that has been organized.

## HOW TO AVOID POLLUTION PROBLEMS

A fish farm can not be established before licence is given. An application is sent the Directory of Fisheries, and must include a statement from the Governmental agency for pollution control and the Veterinerian Institute. A recommendation is given to the Department of Fisheries, that finally decides whether a licence should be given or not.

Practical experience from fish farms along the Norwegian coast, at a variety of locations, has shown that site selection is extremly important for success in fish farming. The ideal site is difficult to find, but following criteria have shown up to be important.

1. A new location needs a thorough topographical and hydrographical examination in order to avoid siting a farm at places with low interchange of water, and poor replacement of bottom water (within sills, natural enclosures etc).

2. Good current conditions at all depths, including near the bottom. The current should in periods be strong enough to carry away organic particles.

3. The bottom condition should be examined by divers. Sand and gravel indicate good conditions, while sites with mud and silt should be avoided.

4. Depth is probably an important criterion, althought a shallow site can be accepted if the exchange of water is good. In general, the net should be at least 10 m or more above the bottom.

Most Norwegian fish farms has been located at shallow and well protected sites, where the rate of water exchange near the bottom has been insufficient. The best criterion is experience after beeing in operation for two or three years. It should be possible to change site either temporary or permanent if the location creates serious enviromental problems. The present law of concession makes such alteration of sites rather difficult. It will also create ecconomical and practical problems for the fish farmer.

## DETECTION OF A POLLUTION PROBLEM

Most fish farms will sooner or later experience pollution problems. It is therefore important to know when the situation are critical and what type of appropriate measurements that needs to be taken . There is no simple way to measure an incipient pollution. However, following observation should indicate a growing problem.

1. Periodical smell of hydrogensulfide and methan, and especially in summer and autumn.

2. Development of gas bubles at the surface. The intensity of bubbling may develop rapidly. Farmers should take particular precautions in areas with heavy feeding.

3. Routine observation by divers to measure extension and height of mud, organic debris and possible pockets of gas.

4. Routine observations of fish gills.

Early stages of pollution were detected by examining fish gills at Austevoll Marine Aquaculture station in 1981. Small pale swollen areas were found, and the tip of the gill filaments appeared uneven. Severe affected gills turned pale, and in some cases with dark patches. Most filaments were swollen, grown together or even wasted away.

The actual cause of this is still uncertain, but we belive that gas bubbles from polluted areas have damaged the gill filements.

ACCUMULATION OF ORGANIC WASTES AT THE BOTTOM

At the research station fish farming was started in 1978, and pollution problems were experienced during the summer of 1981. The production of salmonids increased substantially in this period, and table 1 gives figures for the amount of fish produced, the type and quantity of feed and the accumulation of organic sediments at the bottom. Table 2 describes further the composition of the feed and fig. 1 shows the location of the station.

It is quite evident from table 1 that the amount of organic wastes produced in 1978 and 1979 had no adverce effect on the environment below the net pens. The amount of dry matter increased four times in 1980, and a small layer of organic wastes was accumulated. A later reduction in dry matter had no effect, and the waste continued to build up.

TABLE 1. Production of salmonids, use of feed and accumulation of organic waste at Austevoll Marine Aquaculture Station in the period 1978 - 1981.

| YEAR | WET FEED (kg) | MOIST PELLET (kg) | DRY PELLET (kg) | DRY WEIGHT TOTAL AMOUNT (kg) | FISH PRODUC. (kg) | ORGANIC WASTE(CM) cm |
|---|---|---|---|---|---|---|
| 1978 | 12 669 | | 3 164 | 7 157 | 3 500 | 0 |
| 1979 | 32 762 | 4 706 | 4 130 | 17 821 | 9 200 | 0 |
| 1980 | | 112 962 | 10 000 | 80 166 | 35 600 | 1-2 |
| 1981 | | 82 131 | 10 057 | 60 793 | 26 800 | 5-10 |
| Sum | 45 413 | 199 799 | 27 351 | 165 937 | 75 100 | |

TABLE 2. Composition of the feed and amount of main components.

| TYPE OF FEED | DRY MATTER (kg) | FAT (kg) | PROTEIN (kg) | CARBO HYDRATES (kg) |
|---|---|---|---|---|
| Dry pellets | 90% | 18% | 41% | 25% |
| Amount fed | 25 846 | 5 169 | 11 774 | 7 179 |
| Moist pellets | 63% | 10% | 32% | 14% |
| Amount fed | 132 167 | 20 979 | 67 132 | 29 370 |
| Wet feed | 34% | 8% | 16% | 5% |
| Amount fed | 16 218 | 3 816 | 7 632 | 2 385 |
| Sum | 174 231 | 29 964 | 86 538 | 38 934 |

Waste of feed is estimated to 20% (34 846 kg) which mean that the fish had eaten about 140 000 kg (dry weight).

By using digestion factors of 90%, 85% and 40% for protein, fat and carbohydrates respectively, the total amount of undigested organic matter were:

Protein : 6923 kg
Fat : 3595 "
Carbohydrates: 18688 "
Dry matter : 29206 "

The total amount of faeces and waste feed was estimated to 64000 kg (dry matter).

Gas bubles (5 - 10 /min) was first detected in June 1981 and the fish soon lost appetite. An airy layer of organic matter (5 cm) had accumulated and four net pens were removed from the area. A second release of gas was detected later in the fall. The bottom layer had now accumulated to 10 cm and increased further during the winter. The consistency changed from airy to a sticky mass. All together fish in three net pens were influenced. Fish with irritated gills were found and mortality increased. The damage on the gills seemed to be dependant on the amount of gasbubbles and the time period it had been affected.

Field studies at other fish farms in the Austevoll area in June 1983 measured a sedimentation rate of 8 - 10 cm for a period of 33 days (table 3). Sedimentation traps were placed on the bottom at various locations below the fish pens.

Table 3. Accumulation of organic wast below fish pens in the Austevoll area, June 1983. Sedimentation was measured in sylinders (10 x 150 cm in size).

| Farm No | Fish stock | Average fish size (kg) | Accumulation (cm) Location of sediment.traps | | |
|---|---|---|---|---|---|
| | | | Center | 1/2 radius | Periph. |
| 1 | 11 000 | 1.4 - 1.8 | 10 | 8.5 | 4.5 |
| 2 | 14 000 | 1.6 | - | 9 | 7 |

The waste material was conserved with chloroform; a further examination will be made later. Samples of gas were collected by for later analysis. They reported that gas bubbles started to divers accumulate in thin layers (2 cm) of organic debris.

## METHODS TO IMPROVE THE ENVIRONMENT.

Various techniques have been tried out to improve the conditions at the bottom of fish farms. The most common methods are:

1. Periodical removal of fish pens.
   The area must be kept unused until the organic wastes have disappeared either in a natural or mechanical way.

2. Make use of a submersible pumps for disposal of sludge and waste material. The wastes may either be transferred to barges for further transport or treatment or pumped out to deeper water.

3. Remove the organic wastes by use of submersible mixers. The mixer will produce a fan shaped water current that distribute the waste material to a large area around the the farm.

The third method was tried out in Austevoll with a submersible mixer of 13.8 kw. The mixer was assembled in a rack that was placed at the bottom. Position of the mixer was regulated by divers. A cleaning operation can affect the fish substantially due to the whirling effect of gas and particles. All net pens had to be towed away before the mixer was used. The system was effective but could be improved by placing the mixer above the bottom. The position and running time in minutes of the submersible mixer at the sea bed, is shown in fig.2 and 3.

A new floating pendulum rack was constructed in cooperation with Flygt Norway* and local contractors. The mixer can now be positioned above the sea bottom at requested depths and angels. An automatic operated electric engine can turn the mixer to a predetermined angle at a set speed but at various time intervals. The mixer can either be run permanently to avoid new settling of sediments or used for cleaning operations. The revised system was tried out for a 3 months period. An accumulated layer of 40 cm was measured before the mixer was connected. When the bottom was inspected three months later the layer had dimished to 10 - 15 cm.

The submersible mixer were able to prevent further accumulation (estimated to 30 cm) and reduce the existing organic layers to a third. The operation costs are estimated to N.kr 20 000 per year of continuous use.

* A subsidiary company of Flygt AB Sweden.

The second method has been used by large fish farms such as Mowi A/S for many years (due to their special enclosed fish farms).

Several private companies has recently spesialized in service functions for fish farmers as diving operations and removal of organic waste by suction pumps. The procedure has shown to be effective but difficult and risky. All fish should be removed from the area before treatment is started.

## SCIENTIFIC PROGRAMS

Several scientific projects has started and others are now organized. The fish farmers association has recently allocated funds to a project called "Healthy fish" which also includes pollution studies at fish farms.

The Institute of Marine Research started in 1982 a project with its maine purpose to study the accumulation and turnover of organic waste at fish farms in the Austevoll area, and the effect on the fish. This study will now be extended to be a part of the "healthy fish" project. This project include epidemiological and bacteriological examinations of various fish farms with particular reference to the Hemmorragic syndrom (Hitra disease) (Agricultural University of Norway and the Veterinary Institute) and toxic plantonic algae and fish diseases (University of Trondheim).

A number of other projects has also been proposed (Pedersen 1982), and can be started if the necessary fundings are allocated.

## SUMMARY AND CONCLUSIONS

Pollution problems seems to be unavoidable in fish farming. The rapid increase in the production of salmonids has created problems that very few were aware of. The total extent of the problems are not known, but seems in particular to depend on location, size of the farm, years of operation, experience and type of feed. New farms should not be established without a thorough examination of the site. A new law of concession probably will take new criteria for site selection into consideration, and eventually give the farmer a chance to change site if necessary or alternate between two localities.

Further studies are necessary to measure and detect an early pollution of fish farms. Several methods has been proposed and a routine examination of fish gills seems promising.

The problem of accumulation of organic waste at the bottom seems to appear after two or three years in operation. A pollution can develop even earlier, depending on exchange of water, size of fish stock and feeding procedure. When an organic layer has been established, further development is fast and may be disasterous.

Several methods to remove the waste material has been discussed. All fish should first be moved to an unpolluted area. The cleaning operation can make use of either submersible pumps or mixers. One main problem is wheter the organic wastes should be removed completely from the locality or dispersed evenly to surrounding areas. The dilution principle is generally accepted by Norwegian authorities because dispersion will usually be satisfactory for disintergration of organic waste.

Fish farms may probably be separated in three main groups. The first group include a few farms without any problem in relation to pollution. The second and possibly the largest number of farms can use submersible pumps or mixers to disperse the waste either continuously or in periods to surrounding areas. The waste is then broken down or spread by natural means. The third and most problematic type of farms are located in high risk areas where organic wastes must be completely removed by mechanical aid to avoid serious contamination problems at the farm itself and nearby areas.

Many future problems can be avoided with careful site selection and continuous monitoring of the farm. Just as important are all routine procedures in connection with feeding, diet composition, cleaning of nets, removal of dead fish and similar tasks. A key word is good husbandry technique.

REFERENCES

Pedersen, A, 1982. Miljøpåvirkning fra fiskeoppdrett. (Environmental effects from fish farming) Prosjktrapport FP 80802 (F.430) NIVA :153 pp.

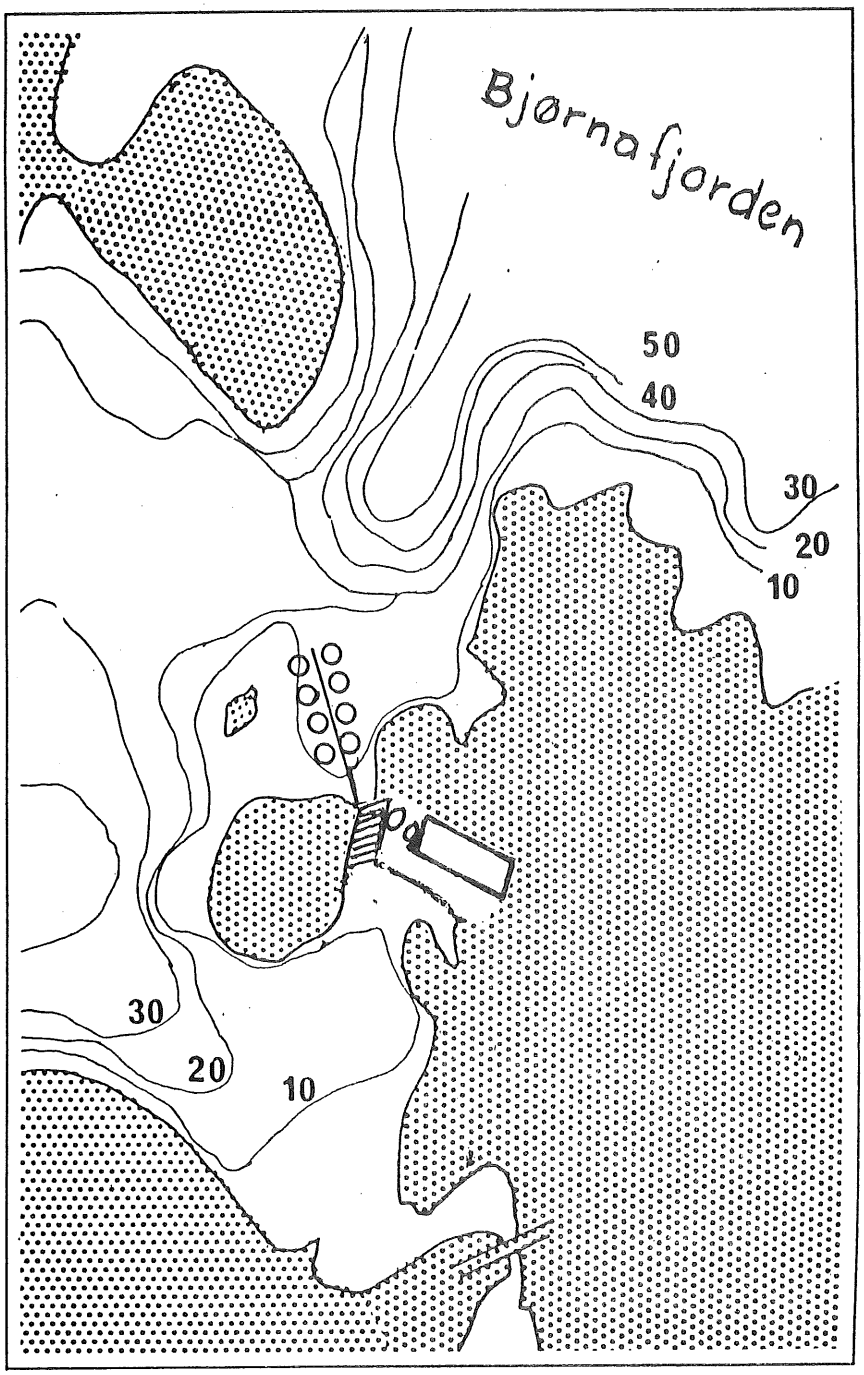


Fig. 1 Austevoll Marine Aquaculture Station is situated in a protected area with one acess to the open sea(Bjørnafjorden). The current conditions are not satisfactory.

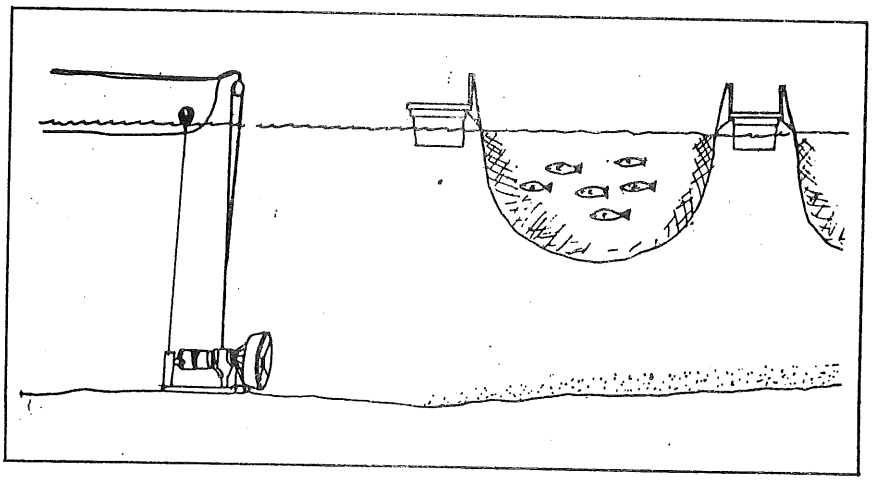

Fig. 2 A cleaning operation below the fish pen by use of a submersible mixer placed at the sea bed.

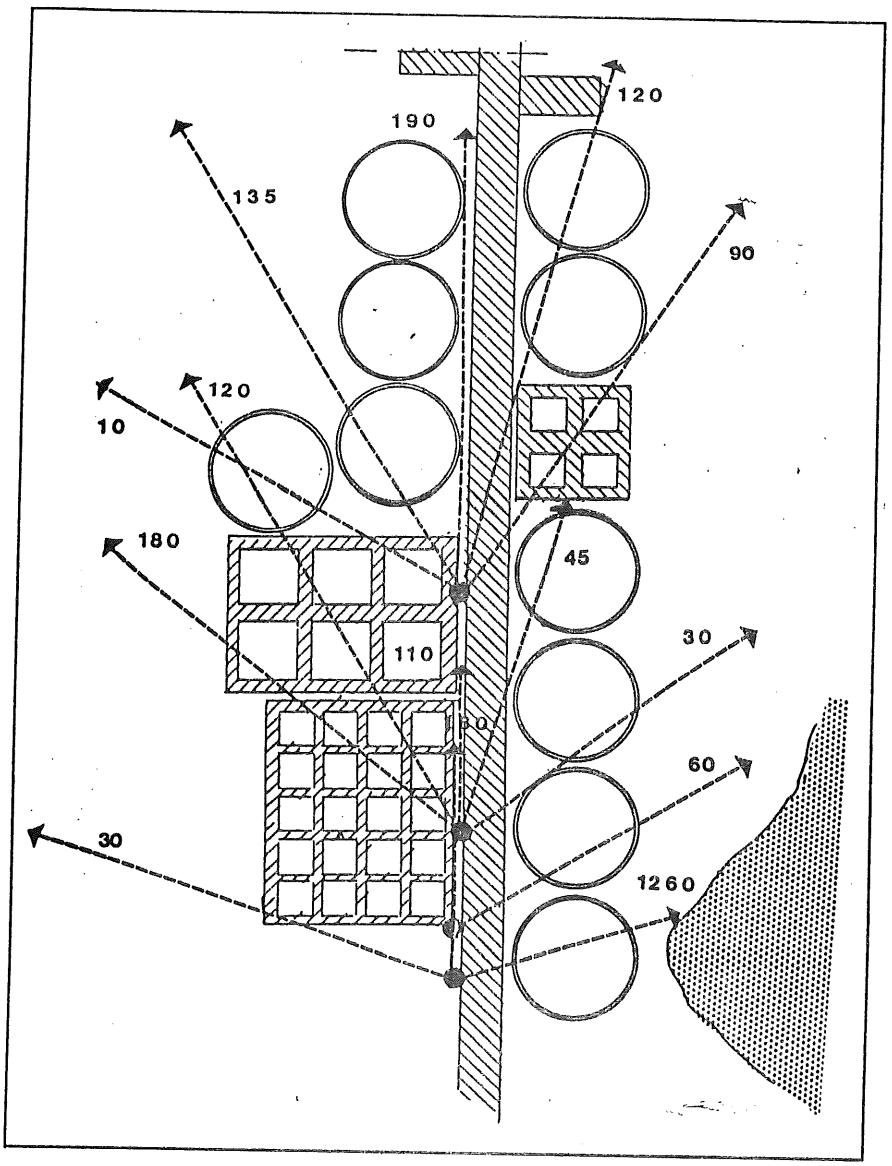


Fig 3 The position of the mixer and time interval in minutes at each cleaning position.