ICES 1995 PAPER CM 1995/R:7

REGULATION OF ENVIRONMENTAL EFFECTS OF MARICULTURE IN NORWAY

by

Arne Ervik*, Pia Kupka Hansen* and Håkon Kryvi**
* Institute of Marine Research, Department of Aquaculture,
P.O. Box 1870 Nordnes, N-5024 Bergen, Norway
** County Government of Hordaland, Environmental Protection Department,
Walkendorf gt. 6, N-5012 Bergen, Norway

ABSTRACT

The rapid development of the mariculture industry in Norway has caused pollution problems in the marine environment as well as conflicts with other users of the coastal zone. Research and practical experience have helped to identify the environmental problems caused by fish farming and have enabled the authorities to set up environmental objectives for Norwegian mariculture regarding escapes of cultivated fish, diseases, medicines, chemicals and organic matter. Simultaneously, the authorities have promoted coastal zone management, and a planning tool for Norwegian aquaculture at the regional level called LENKA has been developed. As a continuation a new regulation system at site level called MOM is now under development. The two systems will facilitate coastal zone planning and site management

INTRODUCTION

The rapid expansion of the Norwegian mariculture industry during the past ten to fifteen years has generated various types of conflicts in the coastal zone. These have included the problems connected with effluents from fish farms and the competition with other users of the coastal zone. During the same period there has been a growing public awareness of environmental issues and demand for a sustainable mariculture industry have been presented more and more forcefully. In the early eighties it was feared that mariculture would lead to regional eutrophication of coastal waters caused by the release of nutrients and organic matter. This turned out to be a minor problem in Norway, although there has been local problems in certain landlocked fjords. However, other environmental problems did emerge, including genetic interactions with wild stocks (Gausen and Moen, 1991), the dissemination of diseases and parasites (Egidius et al. 1981; Egidius, 1987), accumulation of antibacterial agents (Samuelsen et al., 1992a), and overexploitation of sites in sheltered and shallow areas (Braaten et al. 1983). During this period the number of escapes was high , health conditions of the fish were poor, and epidemic diseases such as cold water vibriosis and furunculoses were treated by means of large quantities of antibacterial agents. The documentation and understanding of these environmental effects was fragmentary, but the public was alarmed, and efforts were made to try to clarify these impacts. Research in Norway and other countries helped to identify the major environmental problems associated with mariculture and made it possible to develop management systems like LENKA and MOM and to formulate the environmental objectives described in this article.

LENKA

In 1987 the Norwegian authorities initiated a project known as LENKA (A Nationwide Assessment for the Suitability of the Norwegian Coastal Zone and Rivers for Aquaculture), that had the aim of developing a management tool for assessing the potential space and capacity available for aquaculture in Norway (Kryvi et al., 1991). LENKA dealt with both user conflicts and environmental aspects through standardized procedures, and incorporated the requirements of the Planning and Building Act to integrate the various coastal zone interests in the planning process at municipal level. Many aspects of the coastal zone are taken into account, including topography, environmental conditions, existing utilization, infrastructure and special areas such as nature reserves. The coast is divided into zones of different sensitivity to organic effluents, and the maximum production of farmed fish in each zone is calculated. The initial simple calculation of the holding capacity of an area has since been replaced by a mathematical model developed for Norwegian fjords (Aure and Stigebrandt, 1990).

MOM

The LENKA system is used in overall planning at municipal level, but it is not suitable for planning at site level. For this reason a new management tool, MOM (Modelling - Ongrowing fish farms - Monitoring), was developed in order to regulate fishfarm production in relation to the holding capacity of the site (Ervik and Hansen, 1994). It is based on the concept that the production of a farm must be adjusted to the sensitivity of the site, and that the environmental impact must not exceed predefined levels. MOM includes environmental quality standards, a monitoring programme and a simulation model. The system is flexible and can accommodate both changes in the industry such as new species and technology, as well as a better understanding of environmental impacts and changes in the environmental regulations. A central element of MOM is the adjustment of the monitoring frequency to the exploitation of the site. LENKA and MOM offer a standardized method of regulating fish farming activity for the benefit of both the society as a whole and the fish farmers.

ENVIRONMENTAL OBJECTIVES

As a consequence of the concern for the environmental impact of aquaculture special research programs were formed. The purpose of these was to support and coordinate research to help elucidate and reduce undesirable environmental impacts of mariculture. These programmes and research in various other countries made it possible to formulate environmental objectives for Norwegian mariculture agreed upon by all the authorities involved. This is an important mile stone, since only mutual understanding of these problems enables us to form a strategy for meeting our objectives. The main areas for which environmental objectives have been set are: escapes, diseases, medicines, chemicals and organic matter (Annon., 1993)

Escapes of cultivated fish

Long-term environmental objectives: The number of escapes from fish farms should not represent a threat to the maintenance of Norwegian strains of wild salmon.

Short-term goals (by the end of 1994): The number of fish escaping from fish farms should not exceed 400,000 a year.

Due to improvements in the technical standard of fish farms, the number of escaped fish fell below 600,000 in 1993 and to between 400,000 and 500,000 in 1994. In comparison between 1988 and 1992 the annual average escapes were 1,6 million. The number of escapes is still too high and the effect of these on wild stocks is not yet known.

Diseases

Long- term environmental objectives: The risk of infection from cultivated to wild fish should not constitute a threat to the preservation of the wild strains.

Short-term goals: Several goals for the end of 1995 are given, the most urgent being

improvement of the health of farmed fish through preventive health care, and the reduction of attacks of sea lice and the fluke *Gyrodactylus salaris.*

By and large, the disease situation for Norwegian populations of wild salmon can be mapped to the distribution of the same diseases in Norwegian fish farms. The most important methods of limiting infections are thus to improve the health of cultivated fish and to reduce the number of escapes. Numerous preventive measures are therefore employed, including extensive vaccination programmes, separation of generations, regionalization, fallowing of sites, removal of dead fish, use of more exposed sites and maintaining suitable stocking densities. More research on breeding and vaccination may make a valuable contributions to the task of reducing the risk of infection. Sea lice still represent a major problem and research is needed.

Medicines and antibacterial agents

Long-term environmental objectives: All medicines prescribed for cultivated fish should be as efficient as possible and have good bioavailability. The environmental impacts of all new medicines should be assessed, and the annual quantity of medicine reaching the external environment from fish farms should not exceed 7,250 kg per year.

Short-term goals (by the end of 1995): The quantity of medicine reaching the external environment from fish farms should be reduced to 14,500 kg per year.

The mean annual amounts of antibacterial agents used in aquaculture in the period 1988 to 1992 was 29,000 kg. In comparison, the use in traditional veterinary and human medicine was 10,000 and 25, 000 kg respectively. The most serious problem with the release of antibiotic agents to the environment is the development of resistant bacteria. This is mainly a problem for the mariculture industry itself, but in a global context it is undesirable to have an increase in resistant bacteria and it is important to reduce the total use of antibacterial agents. Residues of antibacterial agents in wild fish close to farms has been found after medication (Samuelsen et al., 1992b). The levels are far too low to effect human health, but the residues in wild fish represent an ethical problem for the industry.

During the past few years preventive measures aimed at improving the fish health in farms have resulted in a dramatic reduction in the consumption of antibacterial agents, and the use in 1994 was 1,495 kg. The use of drugs to combat sea lice has been reduced by 70%, partly as a result of the use of Nuvan instead of the less efficient Neguvon, but also due to the employment of cleaner fish (wrasse) and regional treatment strategies.

Chemicals

Long-term environmental objectives: Chemicals used in aquaculture should be as efficient as possible with no unacceptable environmental effects. Consumption should be kept at a minimum, and the use of copper should cease.

*Short-term goals (*by the end of 1995): The environmental impact of chemicals should be

assessed, and the use of copper should be reduced by 80% compared to 1991 levels.
Chemicals used for net impregnation mostly contain copper, which is known to have several effects on marine biota, and a worldwide decrease in its use has been proposed by the Hague Convention. The types and quantities of disinfectants used in aquaculture is now being registered by the authorities, but the effects of these substances on the environment are still unknown. Efforts are being made to find alternatives with no environmental effects.

Organic matter

Long-term environmental objectives: The impact of organic matter on the recipient must not exceed predefined levels, and 90% of all fish waste should be recycled and 75% used in feedstuff.

Short-term goals (by the end of 1995): 90% of all fish waste should be recycled, and environmental quality standards for recipients should be established.

In order to reduce the releases of organic matter from fish farms research is being done on better feeds and feeding procedures. The effect of organic matter on the recipient may be predicted by the Fjordmiljø model and the MOM model. A preliminary set of environmental quality standards has been defined and the MOM monitoring program is being tested.

Systems for collection, transportation and treatment of fish waste products are in operation, but must be improved and should reach all fish farmers.

FINAL REMARKS

Interactions between mariculture and the environment, apart from the impact discussed in this paper, include the impact of the marine environment on fish farms (e.g. oil spills, industrial pollution), and the fish farms´ impact on its own environment (e.g. reduced oxygen concentrations, outgassing from sediment). The former is covered by the more general concern for the marine environment, since it is of importance beyond the mariculture industry itself. The impact on his own environment is primarily the concern of the fish farmer. However, the environment in the net pens affects the impact of the farm on the marine environment. For example, poor water quality will make the fish more susceptible to infections; any consequent outbreak of disease will result in the release of antibacterial agents to the marine system. A challenge for mariculture will be the interaction between environmental conditions and the wellbeing of the fish (e.g. health, growth rate and quality). Furthermore, these factors must be coupled to the economic viability of fish farming operations.

In many countries the prosperity of the mariculture industry is of national interest since it is of major regional importance. If we are to realize the potential of mariculture as a main source of high quality sea food, all the three types of environmental impact must be taken into consideration. The interaction between aquaculture and the environment will also be an issue in

the future. Environmental problems such as sea lice and genetic interactions remain to be solved, and with increasing understanding new approaches will arise and the environmental quality standards may be more stringent.

REFERENCES

Annon. 1993. Environmental objectives for Norwegian aquaculture. Report, Norwegian Pollution Control Authority, pp.17

Aure, J., Stigebrandt, A. 1990. Quantitative estimates of the eutrophication effects of fish farming on fjords. *Aquaculture* 90: 135-156.

Braaten, B., Aure, J., Ervik, A., Boge, E. 1983. Pollution problems in Norwegian fish farming. ICES C.M.1983/F:26

Egidius, E., Andersen, K., Clausen, E., Råå, J. 1981. Cold-water vibriosis or "Hitra-disease" in Norwegian salmonid farming. *J.. Fish Dis.* 4: 353-354

Egidius, E. 1987. Import of furunculosis to Norway with Atlantic salmon smolts from Scotland. ICES C.M.1987/F:8

Ervik, A., Kupka Hansen, P. 1994. Case histories and new approaches to planning and modelling for Norwegian mariculture. ICES C.M1994/F:26

Gausen, D., Moen, U. 1991. Large-scale escapes of farmed Atlantic salmon (*Salmo salar*) into Norwegian rivers threaten natural populations. *Can. J. Fish. Aquat. Sci.* 48: 426-428

Kryvi, H., Ibrekk, H. O., Elvestad, S. 1991. LENKA. *Mar. Pollut. Bull.* 23: 785-788.

Samuelsen, O. B., Torsvik, U., Ervik, A. 1992a. Long-range changes in oxytetracycline concentration and bacterial resistance towards oxytetracycline in a fish farm sediment after a medication. *Sci. Tot. Environ.* 114: 25-36

Samuelsen, O. B., Lunestad, B. T., Husevåg, B., Hølleland, T., Ervik, A. 1992b. Residues of oxolinic acid in wild fauna following medication in fish farms. *Dis. Aquat. Org.* 12: 111-119