

ALASKA LEGISLATIVE SUBJECT FILE 8672
SCOMM 75: MARSH FARMING; 1987-1990

1102

Recipient

Area

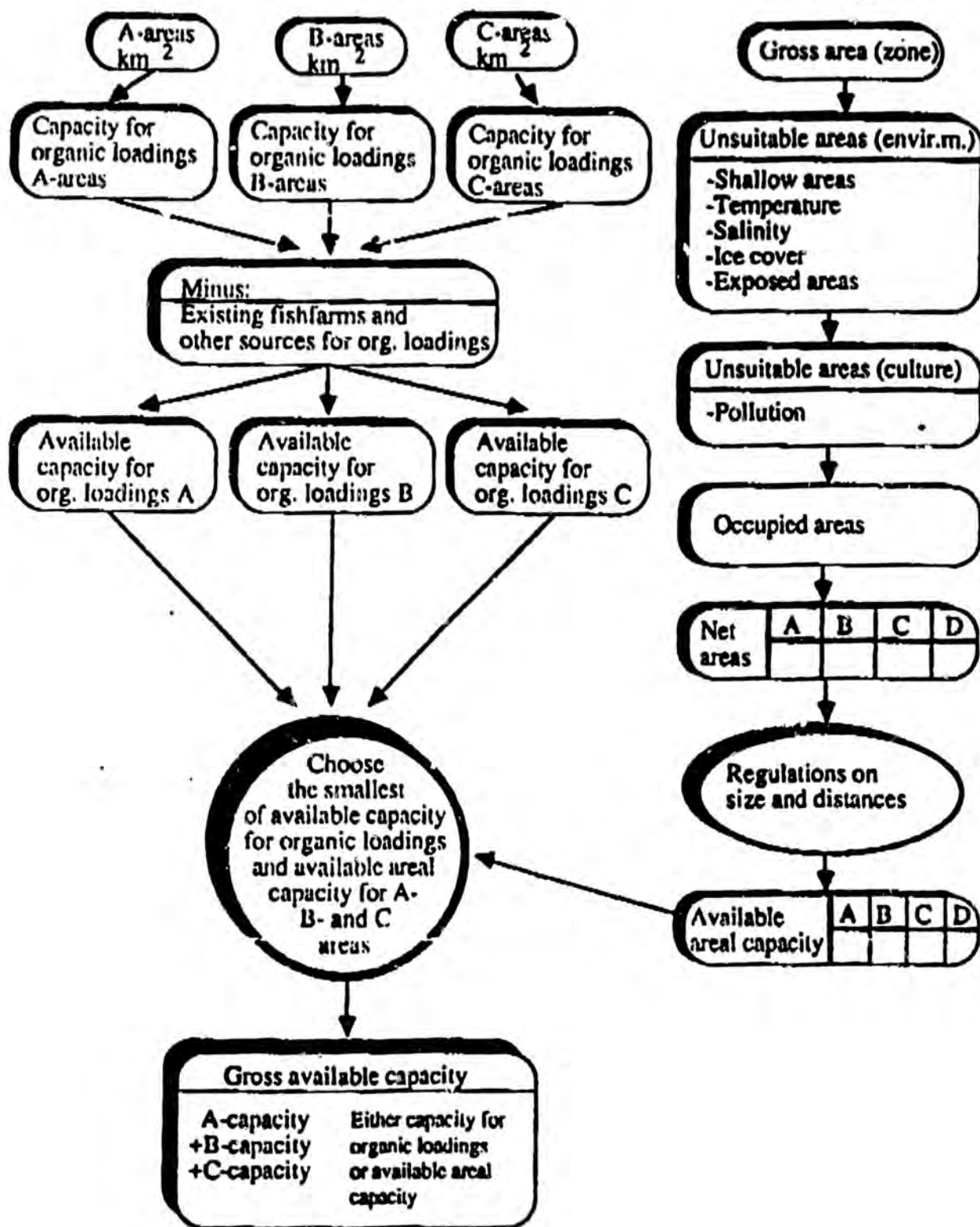


Figure 4 : Calculation of gross available capacity.

property as a recipient. An exact classification with illustrations is given in Appendix 2.

For each recipient category A, B and C there is given an index for how much aquacultural activity is recommended. This is expressed as a certain production in terms of tonnes per square kilometre. Here we would like to emphasize what care was taken before these indices were given. The procedure was as follows :

From empirical data we were able to extract the general statement on how large production one could have in a specific area without it causing damage to the environment. The effects were investigated by sediment fauna monitoring. These levels of production were converted to production per square kilometre. Again, based on facts about Norwegian fish farms, these values were converted to organic loadings, expressed as oxygen consumption, total phosphorous and total nitrogen.

As a correction factor one would have to adjust these figures for other major outlets of organic waste. At the moment we are, together with the appropriate institutions, giving a simplified method for estimating the impact on the marine recipient based on key figures ready available. The capacity is calculated in terms of organic waste, and is therefore independent on the technology being used. New technologies resulting in reduced outlets from the farms can easily be incorporated in the calculations.

Further, when capacity is expressed as production as tonnes per km², this sets restriction to the size of single farms and to the total activity in larger areas. The values are not decided yet, but the capacity will be expressed as the following :

A - categorized areas : a maximum production per (4x4) km², but not more than a lesser specifies quantity at a single site. A site is defined as occupying a minimum of 1 km². Where the recipient conditions are particularly good, and the number of sites available is restricted, one may exceed these recommendations.

B - categorized areas : similarly as above, there is given a maximum production per (4x4) km², and a lesser one at a single site.

The capacity per (4x4) km² will be in the magnitude within one thousand metric tonnes for both A- and B - categorized areas.

C - categorized areas : these areas are basins and silled fjords, and special care should be taken in such areas. Aure & Stigebrandt have developed a model for the calculation of oxygen consumption in silled fjords (Aure and Stigebrandt 1982, Stigebrandt and Aure 1988), and this can in turn be used as a method for the calculation of capacity in terms of organic loadings. The calculations can be done given the hydrographic data and topographical maps.

Where there is oxygen depletion in the basin water, aquacultural activities are not recommended in silled fjords. In basins within archipelagos one should ensure that the water in the deeper layers of the basin does not suffer from oxygen depletion. This means that in an area categorized as a C grade recipient, no aquacultural activities are recommended before one has sufficient data so that damage to the environment is avoided.

This method is dependent on a monitoring and control scheme, and this will have to be a perpetual process. In this way there is the possibility of adjusting the proposed capacity assessment, and at there is possibility of keeping an eye on what is happening to the environment. The monitoring and control schemes are not established.

The areal capacity

Unsuitable areas :

Each LENKA - zone has a gross area divided into A, B and C type recipients. Parts of these areas may be unsuitable for aquaculture, that is, unsuitable for cage culture for as it is practiced in Norway. Unsuitable areas consist of environmentally unfavorable areas from both natural conditions and as a result of man's activities. The last case is mainly pollution, and in this case pollution of toxicants that directly affect the fish health and marketability.

The environmental parameters taken into account are : Shallow areas, cold water, low salinity, ice cover and exposed areas.

In addition to these unsuitable areas there are certain areas that are

bound up by other activities. Such areas are :

- area already occupied by existing aquacultural activities
- nature reserves and animal protection areas (both birds and sea mammals)
- security zones for salmonid fish

In addition areas are occupied for military purposes and for ship navigation.

Having subtracted all these areas, one is left with a net areal capacity which can be compared with the recipient capacity. The smallest of these will set the limit. All these calculations will be performed by computers as all the information is to be tabulated ready for a for this purpose constructed work sheet.

Finally, we would like to mention the work initiated to eliminate the interactions between wild stocks of salmon and trout and farmed fish. The possibility of affecting the genetics and spreading of diseases has been much debated. There is now suggested temporary protection zones for salmonids, with a supporting research program. Further information on this is available on request.

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Submitted to : Estuarine, Coastal and Shelf Science 88 : 01.

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Appendix 2 :

Division of the coastal zone into smaller areas based on assumed water exchange rate caused by topography.

A : Open coastal areas and large fjords where depth is larger than 50 m.

A₁ : Open coastal areas where depth is larger than 50 m.
Size and sills are not considered.

A₂ : Large fjords where :
Length of more than 10 km, and
No presence of sills¹⁾.

B : Other areas with good water exchange.

B₁ : Open, sill - free areas as A₁ (archipelagos) and large fjords as A₂ but where largest depth is less than 50 m.
Length above or less than 10 km.
Depth²⁾ is less than 50 m.
No presence of sills.

B₂ : Smaller fjords, bays and inlets where :
Length is less than 10 km.
No presence of sills.
Depth is greater than 50 m.

B₃ : Large, silled fjords³⁾ where :
Length is greater than 10 km.
Presence of sills.
Depth may be more than 50 m.

C : Small silled fjords and other silled areas (archipelagos) :
Length of fjord less than 10 km.
Presence of sills⁴⁾.
Depth may be more than 50 m.

Examples are shown on the sketch on the next page.

¹⁾ : A silled area is defined as an area where the inside basin is at least 10 m deeper than the sill. Sills down to 50 m are registered.

²⁾ : Fjords are reckoned as shallower than 50 m when more than 60 % of the area fulfills this criterion.

³⁾ : Fjords and other areas with several succeeding sills is reckoned as a "new fjord" when the succeeding sill is shallower than the preceding one.

⁴⁾ : In sounds and basins within archipelagos with several sills, the deepest sill is reckoned as the main entrance to the basin.

THE ESTABLISHMENT OF A SALMON SPERM BANK IN NORWAY

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Introduction

Extinction of local, indigenous fish stocks and erosion of genetic resources are subjects of growing concern for salmon management in Norway. The primary causes of excess salmon mortality in the present century are acid precipitation and the parasite Gyrodactylus salaris. Approximately 25 stocks are nearly or entirely extinct in southern and western sections of the country, which are heavily affected by acid precipitation (information from county conservation authorities). According to official statistics, an additional 15 stocks are extremely reduced in the same area (Hesthagen & Mejdell-Larsen 1987). Gyrodactylus salaris has spread to 28 watercourses, and in many cases is responsible for enormous fish mortality. The fisheries is estimated to have lost between 250 and 350 tons of fish (Johnsen and Jensen 1985).

Escapes by salmon from fish farming pens in the sea, represent a new, and potentially greater, threat to natural genetic resources. Hybridization between farmed and wild salmon is expected to reduce genetic variation within and between natural stocks. Investigations carried out by fish managers and members of the gene bank project suggest that more than 13% infusion of farmed salmon may already have taken place in the salmon rivers of Southern Norway. A rapid increase in this proportion is anticipated over the next few years, in association with expansion within the salmon farming industry.

With these problems in mind, the Directorate for Nature Management decided to establish of a national sperm bank for wild salmon. This measure was recommended by the Advisory Committee of the Sea Ranching Program and was made financially possible by grants from the Ministry of Environment. The sperm bank project was included in a sea ranching program which was officially begun

by the directorate on January 31, 1986. The aims of the program are to develop better methods and improve our knowledge of how salmon production may be increased, and to preserve local salmon stocks. Genetic aspects of the program involve establishing a sperm bank, population genetic mapping and registration of the genetic and biological effects of introductions. The program is planned for a ten year period. During initial phases, the sperm bank will be based exclusively on deep freezing of sperm, but the program eventually hopes to build up a technical capacity for maintaining salmon stocks over several generations in a so-called "living gene bank".

Objectives and strategy

The main purpose of the sperm bank is to preserve genetic variation. A sperm bank can contribute to nation-wide preservation of genetic variation in natural salmon stocks, between stocks and within specifically designated stocks.

The population genetics of salmon stocks in Norway have not been previously mapped to any great extent. The selection of salmon stocks for storage in a sperm bank must therefore be based on other criteria. Marshall & Brown (1975) discuss sampling problems in cases where genetic variation is unknown, and suggest the following optimal collection strategy for gene banks:

1. 50 - 100 individuals should be collected from each location.
2. Sampling should be carried out at the maximum possible number of locations for a given time period.
3. Sampling locations should represent a wide ecological spectrum.

A somewhat modified form of this same strategy has been employed by the sperm bank project.

1. Sperm from at least 50 individuals from each stock is frozen.

2. Emphasis is placed on sampling from stocks representing a wide geographical and ecological range.
3. Stocks threatened by extinction are given priority over other stocks.
4. Stocks which are of particular scientific value, or valuable for fishing purposes, are given priority.

The last-mentioned point complies with recommendations made by the "Nordic symposium on gene banks and other methods of preserving genetic resources", which was held in Finland in 1978.

Methods

Deep freezing of sperm is a realistic gene bank alternative which today facilitates gene storage over a nearly unlimited period of time (review in Stoss 1983). The following method was applied: Fresh sperm is cooled to temperatures between 0° and 4°C, and a freezing medium comprised of 10% DMSO and 0,3% glucose is added (Stoss & Refstie 1983). The mixture (1 part sperm and 3 parts freezing medium) is formed into pellets using a pasteur pipette and dry ice (-79°C). After three minutes on dry ice, the pellets are cooled in liquid nitrogen to -196°C, and transferred to covered cryo-tubes. The tubes are stored in a large nitrogen container with an internal drawer system.

1,5 millileters of sperm from each fish (120-130 pellets) are frozen and divided among two 5 ml cryo-tubes. The total sperm volume may potentially fertilize 1000 eggs. This sperm is not to be used in ordinary cultivation projects because of limited volume and high expenses involved in collection. The sperm will exclusively be used in the establishment of parent fish populations, and for maintaining genetic variation in a "living sperm bank".

Organization of the sperm bank project

The sperm bank project is administered by personnel associated with the Fish Management Division of the Directorate for Nature

Management. Collection is planned in cooperation with the Environmental Protection Offices of the varying County Administrators. These offices provide advice about potential stocks for inclusion in the sperm bank from each county, and arrange local contacts.

Collection is carried out in close cooperation with local organizations which collect parent fish for use in the cultivation of individual rivers; fishing and hunting associations, land owners associations, salmon boards and hyrdo-power development boards. Staff from the directorate, equipped with a mobile field laboratory, visits localities where parent fish are held. Sperm are frozen at these locations. A special sperm sample for later genetic analysis is taken from each fish. In addition scale samples are taken and all fish are weighed and measured. The permanent sperm bank is located at the breeding station for Norwegian Red Cattle (NRF) in Trondheim. Liquid nitrogen is provided by NRF.

Results and experiences

The sperm bank project was partially a pilot project in 1986. Some of the main objectives were to test methods and equipment, and to discover the most efficient methods for carrying out and organizing the project.

Field work began on October 8, and continued over 46 days. A distance of over 10 000 kilometers was travelled and total expenses amounted to 320 000 Norwegian kroner. Salmon sperm was collected in nine counties from Finnmark to Rogaland, and samples were taken from a total of 371 fish from 47 different stocks. An outline of the material collected is presented in Appendix 1. A comprehensive presentation is given in Figure 1.

In 1987 the work continued following the same guidelines. The project was granted more money permitting the inclusion of one more field-team. After two years in operation the gene bank now contains sperm samples from 857 salmon from 69 stocks.

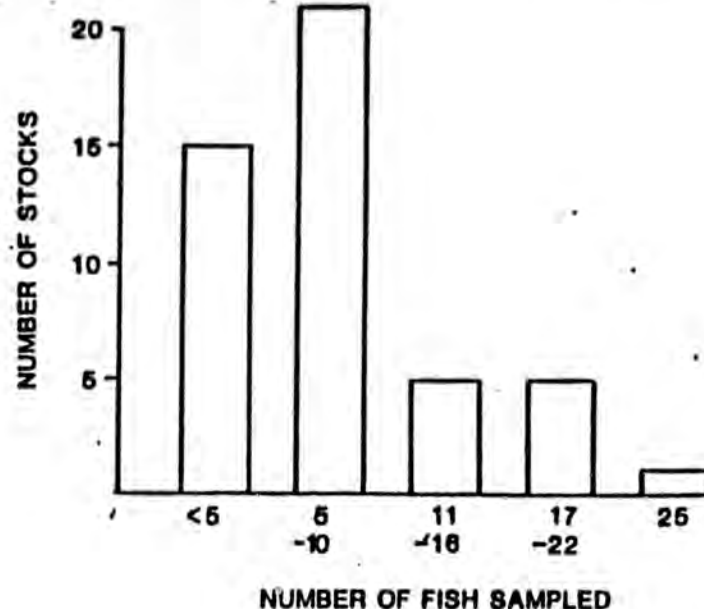


Figure 1. Distribution of stocks with regard to the number of fish sampled.

With few exceptions, sperm freezing was carried out at fish culture stations (parent fish facilities, hatcheries, or smolt facilities where parent fish are held). Only one fish stock is usually held in each facility. An average of eight fish from each stock were sampled. Fish stripping and sperm freezing procedures therefore only slightly influenced the effectiveness of the field work in terms of number of stocks sampled each day. Stock sampling was more often restricted by daily commuting distance and the execution of tasks other than stripping and freezing (preparation of equipment, disinfection, packing and unpacking of equipment, ordering of disposable supplies, and visits to local contacts etc.). Given the above restrictions and a daily commuter distance of over 200 kilometers, a maximum of one stock sampling per day was within the realm of reasonable expectation.

Restricted time was another factor which influenced the total number of samples taken. Samples could only be taken during the interval between the onset of maturation for stripping in male fish and the cessation of sperm production. Male fish may be stripped from the middle of October in most areas of northern Norway, but maturation occurs somewhat later in southern Norway where large variation is found between stocks.

Field work therefor began in the counties of Troms and Finnmark, and proceeded in a southerly direction. Problems encountered because of diminished sperm production began by the end of November. Some fish had already been stripped once for river cultivation purposes and had ceased to continue producing sperm. At the same time problems with increasing male fish mortality occurred at culture stations.

The number of sperm samples from each stock was restricted by the number of male fish at the station. Several factors influence the number of male fish used in the cultivation of individual rivers. However, the most significant limiting factor is potential for catching parent fish. This was extremely difficult when fish stocks were reduced by G. salaris, acid precipitation and other forms for pollution. Collection of sperm from 17 highly endangered stocks was initially planned. Attempts were totally unsuccessful for 6 of these, and less than 5 male fish were caught in a further 6 stocks. Special measures are required in order to insure the inclusion of sperm from many of the most threatened stocks in the sperm bank.

The autumn of 1986 was extremely wet, a factor which complicated fishing for parent fish in many rivers. This increased difficulties in catching parent fish in rivers with threatened stocks, and also caused problems in rivers where fishing is usually good. The relatively large number of stocks represented by few samples (Fig. 1) should be considered in the light of sampling difficulties.

Existing fish cultivation projects in individual rivers are of decisive significance for the success of the sperm bank project. Project expenses would have been astronomical without the assistance of fish culture stations in catching and holding parent fish, which has facilitated the establishment of a nation-wide sperm bank. The extent of fish cultivation activities therefore is a significant factor which may limit the number and selection of stocks included in the sperm bank in the future.

Parent fish collection is carried out in 130 of the 400 salmon-carrying rivers in Norway. Some of these are not potential candi-

dates for the sperm bank. On the other hand a number of high-priority stocks are not cultivated and therefore no milt fish is available. The project undertook the collection and storage of fish from one such stock in 1986. If genetic material from some of the most threatened stocks is to be saved from extinction, activities of this kind should increase.

The practical experience gained through the sperm bank project in 1986 was extremely valuable. Deep freezing methods were adapted to field conditions, and effective work routines were established. A great deal was learned about equipment and staffing requirements, and our experiences should assist the future development and administration of the project.

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APPENDIX I. Localities of salmon stocks included in the sperm bank project in 1986, and the number of fish sampled (N).

<u>County</u>	<u>Locality</u>	<u>N</u>	<u>County</u>	<u>Locality</u>	<u>N</u>
Finnm.	Altaelva	11	Sogn & Fj.	Sogndalselva	5
Troms	Skibotnelva	3	"	Lærdalselva	6
"	Reisaelva	12	Hordaland	Oselva	6
"	Målselva	20	"	Loneelva	15
Nordland	Bleikvassdr.	15	"	Vosso	18
"	Bukksnessvassdr.	5	"	Etneelva	16
"	Ranaelva	20	Rogaland	Vorma	3
"	Røssåga	4	"	Ardalselva	8
"	Vefsna	6	"	Håelva	2
N.Trøndelag	Namsen, nedre	9	"	Suldalslågen	8
"	Namsen, øvre	9	Aust-Agder	Byglandsfjorden	25
"	Sanddøla	8		Neva (USSR)	7
"	Nordelva	3		(Scientific purposes)	
"	Søråa	3			
"	Bjøra	1			
"	Byaelva	1			
"	Ogna	1			
"	Moldeelva	1			
"	Verdalselva	6			
S.Trøndelag	Orkla	4			
"	Gaula	3			
"	Nidelva	5			
"	Stordalselva	9			
Møre & Roms.	Surna	10			
"	Eira	6			
"	Rauma	5			
"	Måna	7			
"	Ørstaelva	18			
"	Bondalselva	17			
"	Bøvra	1			
Sogn & Fj.	Eidselva	7			
"	Stryneelva	9			
"	Hyenvassdr.	4			
"	Jølstra	3			
"	Arøyelva	7			

PROTECTION ZONES FOR SALMONS - A CONCEPT FOR THE
PRESERVATION OF GENETIC DIVERSITY OF WILD SALMONS
AND REDUCTION OF THE SPREADING OF DISEASES BETWEEN
DOMESTIC AND WILD SALMONS

by

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BACKGROUND

Norway has some 500 local populations of wild salmon, each having its particular spawning river. During thousands of years these populations have developed local, genetic, distinct characteristics as regards size, growing speed, behaviour and ecological adaption.

These local populations constitutes a vast genetic recourse, which we, in the line of the recomanditions of the Brundtland commission, believe we are responsible to protect and manage as intact as possible as a resource for the coming generations.

From the Nature Conservation part of view, the protection of genetic diversity is an aim in itself. From the aquacultural industry's point of view, the genetic variations found in wild salmon populations constitutes the biological basis for the future sustainable development of salmon R-94

farming, with particular importance for breeding programmes.

There is therefore a general agreement among the authorities in Norway that the wild salmon populations should be kept healthy and strong, an agreement also of course shared by those who have a commercial or recreational interest in wild salmon fishing.

Let me also for the background mention that the different salmon populations over the years have been severely affected, by acid rain, water course regulations, parasites and overfishing both in the rivers and in the seas.

IMPACT ON WILD SALMON POPULATIONS FROM AQUACULTURE.

During the last years there has been a growing concern in Norway on what effects the growing fish farming industry will cause for the wild salmon populations.

Two main points have come into focus:

1. The breeding programmes have resulted in a domestic salmon, which are genetically significantly different from wild salmons.

Surveys in 1987 in 54 rivers in the southern part of Norway shows that out of 615 caught salmons, 83, that is 13%, were escaped salmons from fish farms. The actual figure is probably however much higher. The catches were organized through the Norwegian gene bank project. Catching was done by local co-workers, who were instructed to drop all salmons which could be identified as domestic salmons in the first hand. The 83 salmons in this figure are thus the remaining domestic salmons identified by the experts of the project after the sorting out done in the first hand by local co-

workers.

Because of figures like there is a growing fear that continuous interbreeding between escapees and wild fish will cause a considerable reduction of the natural genetic diversity in salmon populations.

The most alarming and pessimistic prognoses by one the leading experts in Norway on genetics, professor Harald Skjærvold at the Norwegian Agricultural University, anticipates that we may have 50% reduction of the natural genetic variety in the course of a periode of 7 to 10 years. I must add, however, that there are different points of view among norwegian genetic experts, mostly because of uncertainty as regards the spawning success of escapees in competition with the wild salmons.

2. The two-way spreading of diseases between wild fish and fish farms is another problem. The general picture in Norway is that the different fish diseases mainly cause problems for the farms, not the wild populations. The diseases exist in nature and is part of the ecological balance broadly speaking.

As an example of this, the second best salmon river in Norway, the Numedals-lågen was infected by furunculosis in the seventies. But during all the years furunculosis where found in Numedals-lågen it did not have any significant effects on the magnitude of the catches.

But there is one important exeption in this picture, the Gyrodactyllus Salaris, a parasite which now has spread to 30 Norwegian rivers causing death to young salmons in their first three living years in the fresh water periode. The parasite has virtually wiped out the salmon populations in many of those 30 rivers. We believe

that the reasons for these dramatic effects is that the parasite is introduced to norwegian watercourses (it is native to Sweeden and the Baltic sea). Norwegian salmon populations has no "ecological defence" against it. The Gyrodactylus Salaria is spread mainly through the distribution of fry and waters from infected hatcheries.

Let us add that there is a considerable concern in Norway on the long-term effects of the growing pressure of fish-diseases on the environment. The alarming growth in use of antibiotics is one question of particular importance. To day the use of antibiotics in agriculture extends the use in agriculture and human medicine, put together.

A research programmed was therefore startet in 1987 to strengthen the knowledge on long term effects of the use of antibiotics.

THE PROTECTION ZONE CONCEPT.

The concept which was put on the agenda of Lenka by the Ministeries of the Environment and the Fisheries was to see if one could hope to reduce genetic mixing and the two-way spreading of diseases by establishing zones in the fiord areas outside the outlets of the most important salmon rivers where fish farming should be restricted or not allowed at all.

To have a thorough discussion and evaluation of the zone concept, Lenka arranged a meeting in February 1988. Most of the norwegian experts in the field of genetics, fish diseases, and the ecology and behaviour of salmons were participating.

The recommendations from the meeting were in short:

1. The zone concept should be elaborated in detail for a sample of the genetically most important salmon populations by an expert group.
2. Because of the uncertainty on whether the zones will prove to be an efficient measure, zones should be established for a temporary periode of 5 years. After 5 years there should be a evaluation of the effects of the zones.
3. A research programme covering both genetic effects, veterinary research, and the development of more escape proof farming plants should be established for the same periode to support the following evaluation of the zone concept.

As a follow up of the meeting, Lenka established two fast working groups, one expert group which should work out a detailed proposal for zones, and a group which should work out the frames of a research programme.

The expert group proposed 51 zones covering 125 rivers which were considered of high genetic importance.

The sampling of the 125 rivers were done according to the following criteria:

- one should have sample of rivers along all the coastline of Norway, so that conditions following gradients like north-south, inner fiords/ outer coastal areas, temperature and salinity which are believed to be important for the ecological adaption and genetic diversity were included.
- one should include all rivers where the local populations has special features which represent extreme deviation from the "normal",

as regards morphology, behavior, growing speed and ecological adaption.

- one should include rivers with populations with big numbers of individuals, which generally are more resistant against genetic pollution than populations with a fewer individuals.

The detailed designing of the zones followed three main criteria:

- The zones stretches roughly out 20 km from the outlet of the river. Studies indicates that there are a considerable larger procentage of escaped domestic salmons in rivers if salmon farms are located within a range of 20 km from the outlet, than in rivers where farms are located further out. The critera however was to a great part adjusted by topography and local conditions. In fact zones varies from very great ones in the long fjords to rather small ones round the outlet of rivers.
- Between the zone border and the outlet of the river there are other rivers on both sides of the fjord, which in this connection are believed to function as "buffer" rivers. The idea is that escaped domestic salmon in the spawning periode will tend to go up in these rivers before they reach the river one is trying to protect.
- The borders of zones for rivers infected by Gyrodactylus Salaris are drawn roughly where the salinity during the spring flood is 15- 18 pro mille. Experiments show that Gyrodactylus Salaris survives only 15 minutes in waters where the salinity is higher than 15 pro mille. If salmon farms are located in waters with a salinity higher than this, one should be fairly safe that the farms will not turn out to be

breeding places for this particular parasite.

The research group recommended a programme covering the following aspects:

- A monitoring programme covering a sample of rivers where zones are established, compared by rivers with no zones.
- The impact on genetic diversity from escaped domestic salmon.
- The development of genetic dominant markers to be used in pilot experiments to study the genetic effects on populations of wild fish through generations.
- The studies of the behaviour of escaped domestic salmon, particularly on the question of their spawning success.
- The development of escape proof technology in fish farming plants.
- The development of improved technology for disinfection of waste water from production and slaughtering units.
- Veterinary research, with particular emphasis on the pattern of two-way spreading of diseases between fish farming plants and wild populations.

The research activities are recommended to be implemented within an annual financial framework of 5 million N kr, and within a period of 6 years. A follow-up programme were recommended at the end of the 6 years- period, particularly with a view to the genetic consequences.

PUBLIC HEARING OF THE PROPOSAL

The proposals of the expert group were sent on a public hearing by The Ministry of Environment, and The Ministry of the Fisheries, late June. The time schedule is that the final decision on whether to establish protection zones or not will be made by the two ministries in course of 1988.

As for Norway, the concept of protection zones is a new strategy in the field of the protection of marine genetic resources. The protection zones is an effort to protect genetic resources in situ, and is regarded as a supplement to the salmon gene bank project, which has been going on for a few years. The monitoring of the research-programme is carried out by the gene-bank-project.

Whether the zones will prove to be an effective measure against genetic pollution and the spreading of fish diseases remains to be seen. However faced with the challenge of preserving genetic diversity in a time where more and more marine species are being commercially cultivated and farmed and more and more of the coastal zone areas are being occupied for mariculture we think the zone concept is well worth to be tried out and evaluated. The doubts on the real effects of the zones is in our opinion an argument for their establishment on a temporary basis, not against it.

If the zones should turn out to have no significant effects, we will simply terminate the project at the end of the 5 year period. But if they should prove to contribute to the preservation of genetic diversity, it would be a big failure not to establish them now, given the possible speed of the reduction of genetic diversity that I mentioned earlier.

NORTH ATLANTIC SALMON CONSERVATION ORGANIZATION

ORGANISATION POUR LA CONSERVATION DU SAUMON DE L'ATLANTIQUE NORD



CNL8821

COUNCIL

PAPER CNL(88)21

POTENTIAL IMPACTS OF SALMON FARMING ON WILD STOCKS

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POTENTIAL IMPACTS OF SALMON FARMING ON WILD STOCKS

1. INTRODUCTION

- 1.1 The Atlantic salmon has colonised roughly its present distribution range since the last glaciation some 10,000 years ago. Representatives of the salmonid group of fish have been found in fossils dating back 5 million years. For the first time in the evolutionary history of the salmon man has made a sudden intervention to artificially propagate domesticated, selectively bred Atlantic salmon on a large and rapidly expanded scale. The advent of this salmon farming industry is an exciting and valuable development. It may even exert some degree of protective influence, at least economically, on the wild stocks. Nevertheless, this new industry could pose new threats to the wild stocks and such concerns have been expressed by a number of national and international organisations.
- 1.2 This paper, which should be read in conjunction with the detailed review attached (Annex 1) is prepared in accordance with the decision of the Council at its Fourth Annual Meeting. It presents a summary of the potential threats, the activities of other organisations and suggests possible action by the Council of NASCO.

2. POSSIBLE INTERACTIONS BETWEEN FARMED AND WILD FISH

Production of farmed fish

- 2.1 Salmon aquaculture is not new. The first commercial salmon hatchery was established on the Rhine in 1852 and by the turn of the century hatcheries had been established in almost every salmon producing country. The recent large scale expansion of salmon farming is, however, unprecedented. The industry has expanded from a production of 10 tonnes in 1970 to a production by eight countries of over 65,000 tonnes in 1987. There are estimates of a production of between 90,000 and 259,000 tonnes by 1990. This may be seen in relation to a wild salmon catch averaging under 10,000 tonnes over the last twenty years (Fig. 1). The attached review, examines the occurrence and behaviour of farmed fish in the wild (Section 2), the possible genetic interactions (Section 3), diseases and parasites (Section 4), the introduction of non-indigenous salmonids (Section 5), economic interaction (Section 6), and the impact upon the aquatic environment (Section 7).

Occurrence of farmed fish in the wild

- 2.2 Farmed salmon may occur in the wild as a result of accidental release (escape) or deliberate release. There is direct evidence that salmon farm escapees are caught in the Faroese long line fishery. It has been estimated that on average 15% of the fish held in fish farm cages escape accidentally. If this percentage is applied to the 1987 harvested production, up to 10,000 tonnes of farmed fish may have escaped to the wild. Recent reports from Norway suggest that up to 13% of the fish ascending rivers in southern Norway may be of farmed origin. In addition to escapees, unwanted parr may be deliberately released into the wild by salmon farmers or given to fishery managers for stocking.

Genetics

- 2.3 The Atlantic salmon is being domesticated by the salmon farming industry; farmed fish have been selected for traits favourable for rearing in captivity, e.g. tameness, growth rate and late maturity. Hatchery production produces marked reductions in genetic variabilities. On the other hand it has been estimated that 2,000 distinct stocks of wild Atlantic salmon exist in Europe and North America. Clear genetic differences can be demonstrated between European, North American and Baltic salmon and studies within these groups have demonstrated genetic differences between and in some cases within river systems. These studies are supported by strong circumstantial evidence of physiological differences which are heritable. Several studies conclude that Atlantic salmon rivers should all be regarded as having genetically separate populations. The adaptive significance of these genetic differences has been demonstrated. The genetic variability in a wild salmon population enables adaptation to differing environmental conditions and therefore assists its long term survival.
- 2.4 In view of the risk of hybridisation posed by the large number of farmed fish in the wild there have been warnings of the need for the formulation of a strategy on how best to conserve the genetic resources that are still available. There has been one recorded instance of the risks of such introductions. The transfer of 350 million chum salmon eggs (from the Kalininka to the Naiba River in the Soviet Union) took place and twenty years later the run of salmon into the Naiba River was virtually extinct. This is an important example because Atlantic salmon show more genetic variability than Pacific salmon.

Introductions, diseases and parasites

- 2.5 The rapidly expanding aquaculture industry has led to an associated increase in the number and severity of diseases of farmed fish and such disease problems have led to growing concern about the possibility of the introduction and transfer of diseases from farm stocks to wild fish. The possible dangers to wild fish from introduced diseases and parasites have been highlighted by the problem of *Gyrodactylus salaris*, a monogenean fluke introduced to Norway with imported hatchery stock. The parasite now occurs in more than 28 watercourses and annual losses of salmon are already estimated to be 250-500 tonnes. The ICES ad hoc Study Group on Environmental Impact of Mariculture believed that the importation of exotic species or disease organisms is the greatest environmental risk associated with mariculture because the consequences may be widespread and irreversible. Concern has recently been expressed in the North American Commission of NASCO about the growing interest in the use of rainbow trout in sea-cages along the eastern seaboard of North America. The rainbow trout has the potential to pose a severe ecological threat to Atlantic salmon management.

Environment

- 2.6 The rapid growth of the salmon farming industry has led to an increased awareness that there may be considerable impacts on the aquatic environment, both in freshwater and marine conditions. The most significant characteristics of fish farm wastes as they affect water quality are nitrogen and phosphorous compounds, oxygen consumption, suspended solids and a range of therapeutic and prophylactic chemicals. Although the industry has posed only localised environmental problems to date its continued development, given anticipated growth, is likely to cause greater

problems. Furthermore, there is concern that the behaviour of wild fish may be modified by the presence of cages.

3. ACTIVITIES OF OTHER ORGANISATIONS

- 3.1 The subject of inter-relationships between farmed and wild salmon was considered by the ANACAT Fish Committee at its 1987 meeting. The papers presented dealt mainly with the methods of distinguishing farmed and wild salmon, the occurrence of farmed salmon in the wild and possible impacts. It is intended that this topic could be considered further as part of a mini-symposium on spawning variability in 1989. ICES has established a Working Group on the Environmental Impacts of Mariculture which will meet for the first time in 1988 to consider, among other things criteria for site selection which will minimise the environmental impacts of mariculture.
- 3.2 Several Working Groups concerned with Introductions and Transfers have been established including those of ICES, EIFAC and the North American Commission of NASCO. ICES and EIFAC have prepared Codes of Practice concerning introductions and transfers. Some countries have not endorsed either code of practice while in some other countries the codes are only applied to the import of non-indigenous species. The NAC Working Group has produced a series of recommendations, which apply specifically to salmonids in Canada and the USA and which recognise the potential for adverse genetic effects, in addition to diseases and other ecological interactions, resulting from introductions and transfers. These recommendations included the prohibition of transfers of eastern hemisphere and Icelandic Atlantic salmon, and the use of alternate sources of stocks for both enhancement and aquaculture until appropriate protocols could be developed. Such protocols are now being drawn up by Health and Genetics sub-groups. The NAC group also prepared a computer-based inventory of salmonid introductions and transfers.
- 3.3 The Norwegian authorities have responded to the threats to the genetic resources of their salmon by establishing a sperm bank. Sperm banks have also been established to supply the salmon farming industry with disease free milt and research is currently underway into the feasibility of cryopreserving salmon eggs and embryos.
- 3.4 Commercial trials in the UK of the performance of all female, triploid salmon are now being undertaken. These fish are sterile and therefore avoid the problem to the farmer of maturation in the sea cages. This development, if adopted by the industry, could have favourable implications with regard to possible genetic effects of fish farm escapees. However, further research into the behaviour of these fish in the wild may be required.
- 3.5 In Norway and British Columbia regulations requiring a minimum distance between net-pen facilities and major salmon spawning streams, i.e. aquaculture-free zones, have been introduced.

POSSIBLE ACTION BY THE COUNCIL

- 4.1 NASCO holds the international responsibility for conservation of salmon stocks. There is clearly a need for further research into the effects of the new aquaculture industry on these stocks. Areas of research which have been highlighted include further development of methods of stock identification; assessment of the number of farmed salmon escaping, their migration pattern and whether or not they breed; and the effects of hybridisation between wild and farmed fish if this occurs. The Council might like to consider how such research might be stimulated.
- 4.2 The North American Commission of NASCO established a Bilateral Scientific Working Group in 1986. Their Report has been published separately as Annex 13 to NAC(87)20. It includes recommended actions to be taken to reduce potential risks. The NAC group also developed an inventory of salmonid introductions and transfers. The Council may wish to consider if such actions should be recommended to the North East Atlantic Commission. As with the NAC Group this Commission might well liaise with the ICES Working Group on Introductions and Transfers.
- 4.3 The Council might like to consider whether an internationally agreed Code of Practice to protect wild stocks might be developed. Such a code could consider recommendations on, for example, aquaculture-free zones, the use of local broodstock, the disposal of surplus stock from aquaculture, the possible use of all female triploid stocks etc. A review of the main elements which might form the basis for a code could be carried out by the Council as part of its role in the conservation of salmon stocks under the Convention.
- 4.4 The Council might wish to consider in further detail the mechanics, costs and benefits of establishment of gene banks. In addition to established techniques for cryopreservation of sperm, research is underway in the UK and in other countries on cryopreservation of salmonid ova and embryos. A review of the state of these techniques and other methods of preserving genetic resources could be considered at the Sixth Annual Meeting.
- 4.5 The Council may wish to consider in more detail any evidence on the environmental effects of sea cages on wild stocks and review the evidence for diseases being transmitted from farmed to wild.
- 4.6 The Council may wish to see a review of the legislation relating to the interactions described in this paper as taken from the Laws, Regulations and Programmes Database which now exists.

5. **SUMMARY**

- 5.1 The attached review requested by the Council examines in some detail the possible interactions between wild and farmed salmon. It concludes that the growth of aquaculture has produced new potential threats to the Atlantic salmon. Some of these are known to be serious but the effects of others are not known. These potential threats include loss of genetic variability, to introduction and transfer of diseases and parasites and changes in the aquatic environment. A number of organisations are studying the evidence for some of these interactions. The Council of NASCO may wish to consider which action it should take. Some options are listed above.

Secretary
Edinburgh
18 May 1988

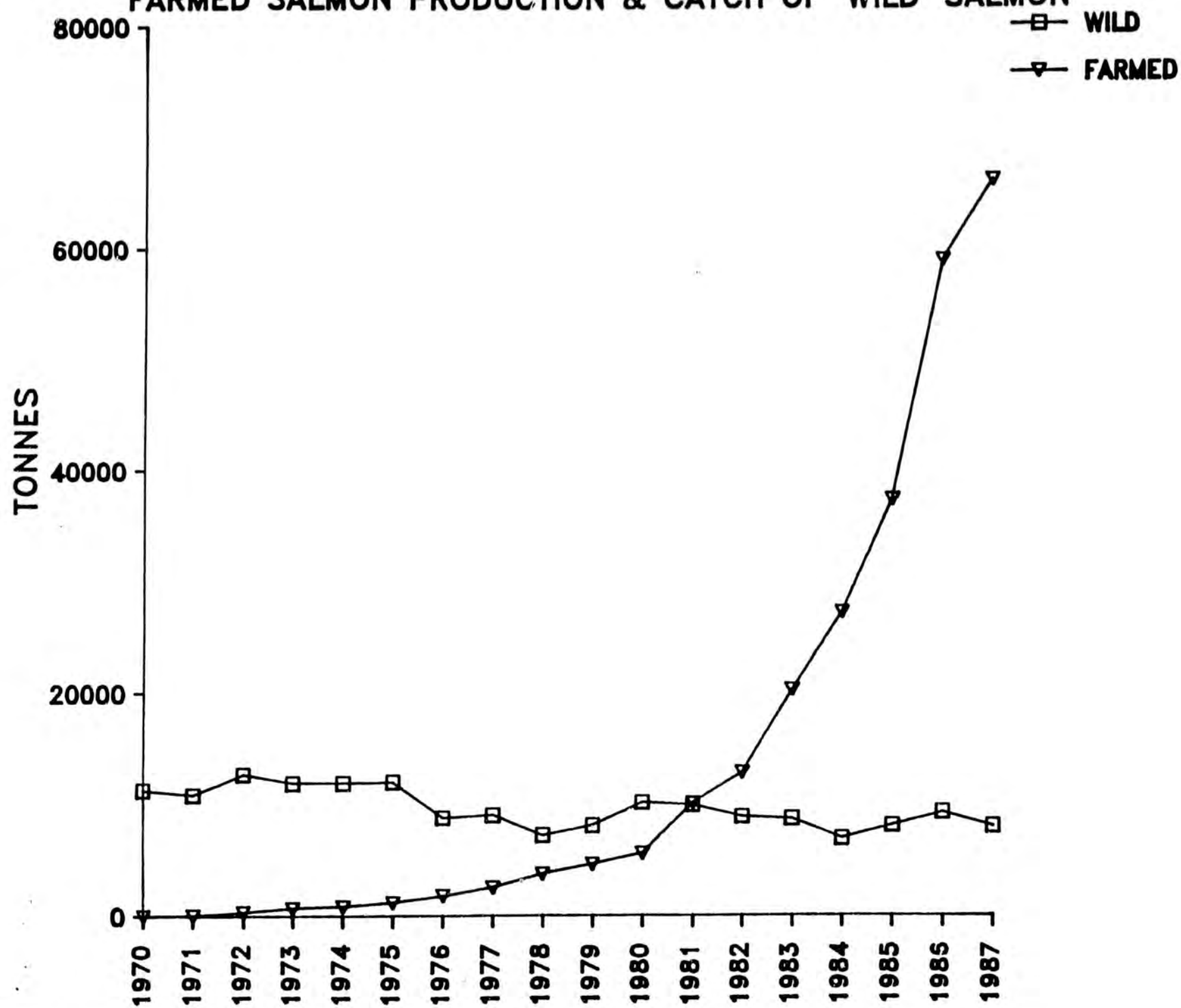
ANNEX 1

1. INTRODUCTION:

- 1.1 At its Fourth Annual Meeting the Council agreed that a brief review of the potential threats from salmon aquaculture on wild stocks be undertaken by the Secretary, including information on the activities of other organisations and the role NASCO may have in this matter. This paper concerns principally the salmon farming industry since this is the most rapidly expanding section of salmon aquaculture. Many of the potential threats also apply to the other sections of salmon aquaculture-enhancement, stocking and ranching.
- 1.2 There has been a recent large scale expansion of salmon aquaculture with the development of salmon farming i.e. rearing salmon in a system of total protection to the time of harvest (see Figure 1). In 1987, the industry produced over 65,000 tonnes of farmed salmon. The majority of this production (90%) was from Norway and Scotland other countries have also developed salmon farming on a significant scale. Recent reports have indicated scope for further large scale increases in production. For example, a recent Norwegian study estimated that a market potential of $120,000 \pm 30,000$ tonnes will exist by 1990. Other estimates suggest a production level in Europe alone of $140,000 - 259,000$ tonnes by 1990 with additional significant production from Chile, Eastern Canada and the United States of America. In the long term the most likely constraints to production within these estimates are economic with market saturation reducing prices, and increased capital costs associated with more difficult sites reducing profitability (Shaw and Muir, 1987). However, over the last ten years there has been continued growth with only short term reductions in the rate of growth reflecting problems associated with smolt supply and disease.
- 1.3 The advent of salmon farming is an exciting and valuable development and there is much to admire in the energy and growth of the new industry. The industry produces a high quality product with all year round availability and has created employment opportunities in remote rural communities. Furthermore, the industry's research and development programmes have provided much scientific information regarding growth patterns, survival and maturity of the Atlantic salmon (Laird and Needham, 1985), although this information has principally been of value to the salmon farmer. However, there is growing concern about possible interactions between farm reared salmon and the wild stocks. Among the organisations that have expressed their concern are the Atlantic Salmon Trust (UK), the Atlantic Salmon Federation (North America), Restoration of Atlantic Salmon in America Inc (USA), the Nature Conservancy Council (UK) and the Directorate for Nature Management (Norway).
- 1.4 This paper is a review of the available literature on the possible interactions. These interactions include genetic interactions such as intraspecific hybridisation, ecological interactions between Atlantic salmon and introduced species, transfer of diseases and parasites from farmed to wild fish, economic interactions and interactions with the environment of wild salmon. We have attempted to bring together information from a variety of sources and in general terms place it in some perspective so assisting the Parties to the NASCO Convention to consider what action might be taken in the light of the Convention which calls for the conservation of salmon stocks.

FIGURE 1

FARMED SALMON PRODUCTION & CATCH OF 'WILD' SALMON



2. THE OCCURRENCE AND BEHAVIOUR OF FARMED FISH IN THE WILD

- 2.1 Clearly, some of the interactions noted above require the occurrence of farmed fish in the spawning and nursery areas of the Atlantic salmon. There is now growing evidence that substantial numbers of farmed Atlantic salmon have gained access to the wild through accidental release (escape) and deliberate release.
- 2.2 Accidental releases of farmed salmon may occur through handling errors, faulty gear, weather damage, predator damage or other forms of damage (e.g. vandalism, collisions etc.). In sheltered sites, simple square or rectangular cage units, capable of containing a stock of about 5 tonnes, are frequently used. The flotation collar of such units is intrinsically weak so the frequency of failure may be relatively high, but individual losses resulting from such failures may be relatively low (Institute of Aquaculture, 1987). As more exposed sites have been developed more sophisticated units capable of containing between 100-150 tonnes have been designed e.g. Bridgestone "High Seas" cage. A single incident involving one of these cages could result in a massive loss of stock to the wild although the frequency of failures may be relatively low (Institute of Aquaculture, 1987).
- 2.3 In 1986 direct evidence that salmon farm escapees were being caught in the Faroese long-line fishery became available. Muscle tissue canthaxanthin analysis revealed that 3% of a sample of 219 fish were of farmed origin having escaped after the smolt stage (Anon, 1987a). Furthermore, single incidences involving the escape of significant quantities of farmed salmon have been reported (e.g. 20-30 tonnes (Hansen et al, 1987); 90,000 salmon (Maitland, 1987); and 30,000 salmon (Mills, 1987)). It has been estimated that on average 15% of the fish held in fish farm cages escape accidentally (RASA, 1987). If this figure is applied to the 1987 production, approximately 2.5 million fish (up to 10,000 tonnes) of farmed fish may have escaped to the wild. Evidence from freshwater rainbow trout cage units has indicated that harvests of between 2.5 - 5% of total cage production may occur in the surrounding water body (Phillips et al, 1985). Recent reports from Norway suggest that up to 13% of the fish ascending rivers in southern Norway may be of farmed origin (see CNL(88)22). Studies in Norway have shown that immature farmed fish released into the wild migrated to North Atlantic feeding areas whereas mature fish entered rivers at random when they were ready to spawn (Hansen et al, 1987).
- 2.4 In addition to accidental release, surplus farm stock may be released or be available for release into the wild. High pre-smolt growth rate produces one year old smolts (S1s) thereby enabling early transfer to marine units and reducing the cost of the expensive freshwater stage (Naevdal, 1981). There may be other advantages in that it has been reported that one year old smolts produce a lower grilse rate than two year old smolts thereby reducing the problems posed by maturation (Ritter and Newbould, 1977; Laird and Needham, 1985). Those parr that do not smoltify after 1 year (the potential S2s) are largely unwanted by the salmon farmers although if parr maturation has no deleterious effect on later age at maturity there may be a role for precociously mature male parr in reducing the generation interval in breeding programmes (Naevdal, 1983). However, in general, unwanted potential S2 smolts are removed during grading and either released into neighbouring rivers, sold to fishery managers or other fish farms, given away or rarely killed (Maitland, 1987; Mills, 1987). In some cases these smolts have been used to stock rivers which have lost their salmon stocks e.g. River Thames, England and River Carron, Scotland. In addition, however, they have been released into rivers already containing salmon populations.

Again the scale of the problem is largely unknown but individual large scale releases are known. For example, Maitland (1987) reports that 60,000 of these fish were released into the river Ness system and 8,000 were released into a small stream flowing into Loch Lomond. With the rapid expansion of the salmon farming industry enormous numbers of smolts are now being produced. For example, Norway now has the capacity to produce 183 million smolts a year, enough to give a grow-out of 130,000 tonnes and it is estimated that in excess of 23 million smolts will be produced in Scotland in 1988.

3. GENETIC INTERACTION:

- 3.1 Salmonid fish exhibit striking ecological and morphological intraspecific differences between and even within various waters. The widespread distribution and well marked homing instinct of the Atlantic salmon are attributes favouring the development of distinct stocks i.e a stock is a population which differs genetically from other populations of the same species (Wilkins, 1985). On the basis of circumstantial evidence the species has often been subdivided into genetically distinct sub-units (Ryman, 1983). For example, Saunders and Bailey (1980) estimated that 2000 stocks of Atlantic salmon exist in Europe and North America.
- 3.2 Recent electrophoretic studies have demonstrated clear genetic differences between European, North American and Baltic salmon. Moller (1970) demonstrated regional differences in North American salmon populations and although Payne (1974) argued that there was a latitudinal cline in North America, an analysis of more extensive data by Verspoor (1986) did not support this argument. Payne et al (1971) also demonstrated regional differences in British and Irish salmon populations but analysis of more extensive data by Cross and Healey (1983) provided unequivocal evidence of stock discreteness (Thorpe and Mitchell, 1981). Similar evidence was presented by Stahl (1983) for Baltic salmon where discreteness within and between river systems was demonstrated. These electrophoretic studies are supported by strong circumstantial evidence in the form of different physiological capacities which have been shown to be heritable and morphological differences between river populations (Thorpe and Mitchell, 1981). Cross and Healy (1983) concluded that the rivers in their study and possibly all Atlantic salmon rivers should be regarded as genetically separate populations.
- 3.3 Several studies have demonstrated the adaptive significance of genetic differences in salmonid populations. Riddell et al (1981) compared juvenile salmon from two tributaries of the Miramichi River and demonstrated that the juveniles from the river characterised by higher flows had more fusiform bodies and longer fins than fish from the slower flowing river. By rearing the progeny of salmon from the two tributaries under identical conditions they demonstrated that this interpopulation variation in body morphology had a genetic basis. Winter et al (1980) demonstrated that transferrin genotypes exhibit differential resistance to infections such as BKD and Kanis et al (1976) showed that mortality in salmon, particularly for the egg and alevin stages, was heritable. There is also evidence that the homing ability of salmon may be under genetic control. For example, Bams (1976) showed that while imprinting alone brought back some of an introduced donor stock of pink salmon, addition of the locally adapted paternal genes improved the returns. Browne (1986) considered that the differences in the relative performance of hatchery and wild smolts were mainly associated with accuracy of homing and overall survival. Ferguson (1986) concluded that

genetic variability is a key factor in a populations capacity to produce new adaptations in response to environmental change and therefore to its long term survival.

- 3.4 During the selection of stock for the developing salmon farming industry, the genetic diversity present in wild stocks enabled the farmers to select for rapidly growing, late maturing fish which were suitable for improvement of productive capacity e.g. Norwegian river Alta stock (Naevdal, 1981). Selective breeding has subsequently resulted in significant genetic gain in growth rate, reduced frequency of early sexual maturation and tameness of the fish (Gjedrum, 1985). The Atlantic salmon is being domesticated, a process including selection for calmness, little fear of handling and tolerance to noise and the presence of people (Gjedrum, 1979). In contrast to the genetic diversity demonstrated in wild salmon, hatchery production results in significant reductions in genetic variation compared to the wild fish from which they were derived (Ryman and Stahl, 1980; Cross and King, 1983). This loss of genetic variation has been attributed to the use of small numbers of parents and the effects of genetic drift (Allendorf and Phelps, 1980; Cross and King, (1983), Johansson (1981) and Cross and King (1983) believed that hatchery procedures select for salmon well adapted to rearing conditions but less well adapted to survival in the wild. The salmon farming industry has also resulted in international transfers of stock. For example, Norwegian stock have been imported into Scottish fish farms and vice-versa and Finnish and Scottish stock have been imported to aquaculture facilities in Maine. In addition techniques such as gene implantation and induced ploidy may be used by the salmon farming industry (NAC, 1987).
- 3.5 In view of the genetic differences between hatchery and wild stocks, Stahl (1983) warned that there is a strong need "for the formulation of a strategy of how to best conserve the genetic resources that are still available". There are very few examples in the scientific literature of studies that have monitored the genetic effects of hatchery stocks on the recipient wild stock's performance. Reisenbichler and McIntyre (1977) compared the survival of offspring from matings of hatchery x hatchery, hatchery x wild and wild x wild, summer steelhead, Salmo gairdneri. They demonstrated that in the study streams wild fish had the highest survival rates and they concluded that if the hatchery fish interbred with wild fish there may be a reduction in smolt output. Such introgression was demonstrated by Taggart and Ferguson (1986) as a result of a 15 year stocking programme in the Erne-Macnean system. The potential dangers of introgression have been described by Altukhov (1981). Between 1964-1971 350 million fertilised chum salmon (Oncorhynchus keta) eggs were transferred from the Kalininka river to the Naiba river on Sakhalin Island. By 1969-1970 there had been a genetic shift in the later running Naiba stock and by 1985 the population, which previously supported a run of about 650,000 chum salmon, was virtually extinct. Thorpe (1987) stressed the importance of this example for managers of Atlantic salmon stocks which are known to exhibit more genetic variability than Pacific salmon stocks.
- 3.6 Saunders and Schom (1985) believed that the effective spawning population of wild salmon populations, which may comprise sexually mature parr and anadromous adults of various ages, even in small populations may be quite large thereby leading to low levels of inbreeding. Maitland (1987) considered that the genetic problem associated with farmed salmon stems from the fact that farmed salmon became more genetically distinct from wild stocks with each generation in captivity and that large numbers of these domesticated fish are now being released into river systems. In the past, relatively small numbers of fish have been moved or have strayed from one system to

another and these incomers are less likely to be successful and so have little genetic impact when present in small numbers (Maitland, 1987). Similarly, Isaksson (1985) considered that large scale releases of ranched salmon, which are genetically distinct from neighbouring wild stocks, could have an effect on the wild stock if straying occurred, whereas moderate releases would have minimal effects.

4. DISEASES AND PARASITES:

4.1 The rapidly expanding aquaculture industry has led to an associated increase in the number and severity of diseases of farmed fish (Smith, 1985). For example, Hitra disease, which was first identified in 1979, has recently caused severe losses in Norway (Anon, 1987b). Such disease problems on salmon farms have led to growing concern about the possibility of transfer of diseases and parasites from fish farms to wild stocks. The potential negative interactions are not one sided, with both farmed and wild stocks potentially at risk (Anderson, 1987). In the case of diseases introduced to the wild, however, treatment is not usually possible while, in contrast, the farming industry has responded rapidly to disease problems e.g. a vaccine against Hitra disease has already been developed (Anon, 1987b). In addition, there have been considerable trans-Atlantic and other international movements of salmonid stocks associated with the aquaculture industry. Mills (1987) considered that although considerable concern has been expressed regarding the introduction and transfer of disease with stock there is little record of wild fish being affected by farm stock. Similarly, Cobham Resource Consultants (1987) considered that the available data provide no conclusive evidence of significant adverse effects. However, as Anderson (1987) points out, transmission of disease from farmed to wild stock is hard to establish.

4.2 Egidius (1987) describes the import of furunculosis, Aeromonas salmonicida, to Norway with Scottish salmon smolts. The disease has subsequently been reported from a free living salmon. Similarly, although Munro et al (1976) reported the spread of Infectious Pancreatic Necrosis from farmed stock to wild fish they demonstrated a low prevalence and limited distribution of the virus in wild fish and the infection appeared to be "inactivated" within a short distance of the farm. Concern has recently been expressed about the possible import of Infectious Hematopoietic Necrosis (IHN) with stock movements from the west to east coasts of North America (NAC, 1987). IHN was, isolated from two rainbow trout farms in France during 1987. Prior to this the virus had not been isolated from Europe (ICES, 1987). The most severe documented damage to wild salmon stocks which appears to have resulted from international stock movements has been caused by the monogenean fluke Gyrodactylus salaris and highlights the dangers of introducing exotic diseases or strains of diseases and parasites with international stock movements. The most likely hypothesis is that this parasite was introduced to Norway and subsequently dispersed by fish stocking from infected hatcheries (Dolmer, 1987). The parasite now occurs in more than 28 Norwegian salmon rivers and appears to pose one of the most serious threats to salmon in Norway. It has been estimated that annual losses of 250-500 tonnes of salmon have occurred (Johnson and Jensen, 1986) and the Norwegian authorities are now treating entire river systems with rotenone in order to try to eliminate the parasite. Gyrodactylus has recently been added to the list of notifiable diseases by the Ministry of Agriculture, Fisheries and Food in the United Kingdom as a precautionary measure.

- 4.3 Cage rearing can cause eutrophication and this has been linked to increased parasite loads in some fish populations and pathogenic fungal infections are more common in eutrophic waters. Bacterial numbers are also related to trophic status (Philips et al, 1985).

5. INTRODUCTION OF NON-INDIGENOUS SALMONIDS:

- 5.1 Non-indigenous species, with attributes favourable to the fish farmer or salmon rancher, have been introduced into the North Atlantic, often accompanied by accidental introductions of disease organisms (Institute of Aquaculture, 1987). The ICES ad hoc Study Group on Environmental Impact of Mariculture believe that the importation of exotic species or disease organisms poses the greatest environmental risk of mariculture since the consequences may be widespread and irreversible.
- 5.2 In eastern North America, coho salmon (Oncorhynchus kisutch), which were introduced in order to develop an aquaculture industry based on sea-ranching, have spawned regularly in the Cornwallis river, Nova Scotia. It is thought that there would be little interaction between juvenile coho and Atlantic salmon because of habitat segregation. However, superimposition of redds could occur in rivers where spawning substrate is limited and juvenile interactions could occur in rivers where Atlantic salmon occur in pools e.g. Newfoundland (NAC, 1987). Concern has recently been expressed about the growing interest in the use of rainbow trout (Salmo gairdneri) in sea-cages along the eastern seaboard of North America. This species has the potential to pose a very severe ecological threat to Atlantic salmon management (NAC, 1987).
- 5.3 In Europe, coho salmon eggs have been imported to France since 1971 as part of a cage rearing project in Brittany and Normandy. Considerable escapes and intentional releases have occurred but as with many other introduced populations of Pacific salmon the coho appear to have died out after initial spawning success (Euzenat and Fournel, 1981). Pink salmon, Oncorhynchus gorbuscha, introduced to the Kola peninsula have aggregated in Norwegian rivers since 1960 and successful spawning has occurred (Bjerknes and Vaag, 1980). However, Solomon (1979) considered that since this species migrates to sea as fry before commencing feeding the possible adverse interaction with native salmonids is much reduced.
- 5.4 Solomon (1979) concluded that, before any introduction is undertaken, it is desirable to investigate any possible risks including adverse competitive interactions and introduction of new disease organisms or strains of disease organisms. Protocols regarding introductions and transfers are presently being prepared by the Bilateral Scientific Working Group on Introductions and Transfers of the North American Commission of NASCO through health and genetic sub-groups.

6. ECONOMIC INTERACTIONS:

- 6.1 Prior to the advent of salmon farming, trading in Atlantic salmon was very much a seller's market (Stansfeld, 1985) with availability of the wild stocks and regulations governing the harvest, rather than the demand, determining the supply from the fisheries (Anderson, 1987). The advent of a large supply of high quality, fresh farmed salmon with all year round availability has had a marked effect on the traditional wild salmon market with consequences for commercial netmen.

- 6.2 In Scotland the effect of the influx of farmed salmon was to reduce and stabilise salmon prices. At the same time the premium price enjoyed by wild salmon over farmed salmon has been generally reduced in Scotland and Norway. In Canada, farmed salmon attain a premium price (Anderson, 1987). Tuomi (1987) believed that the development of the salmon farming industry would end the traditional commercial fishery for salmon in Canada. In Scotland, price reductions have resulted in many marginal stations closing and other stations working shorter seasons. These changes are likely to result in a change in the pattern of exploitation of salmon and may favour the development of salmon ranching (Stansfeld, 1985).
- 6.3 Another effect of the all year round availability of fresh salmon has been a reduction in the market for frozen salmon in Scotland. It is possible that this market will be particularly hard hit by the salmon farming industry. The small market that still exists for frozen salmon in Scotland is now largely supplied by the Greenland and Faroese fisheries (Stansfeld, 1985).
- 6.4 Hansen et al (1987) reported that reared fish augment the commercial catches of wild salmon in Norway but warned that if an increased output of reared fish lead to higher fishing effort in mixed stock fisheries natural salmon stocks may be over-exploited.

7. IMPACT ON THE AQUATIC ENVIRONMENT:

- 7.1 The rapid growth of the salmon farming industry has led to an increased awareness that there may be considerable impacts on the aquatic environment, both in freshwater and marine conditions. This concern is shared by conservationists and the fish farmers who fear that the harmful feedback could affect the economic viability of the farm (Gowen and Bradbury, 1987).
- 7.2 The most significant characteristics of fish farm wastes as they affect water quality are nitrogen and phosphorous compounds, oxygen consumption and suspended solids. The impact of these wastes is influenced by the nature and amount of waste produced and the characteristics of the recipient environment (Institute of Aquaculture, 1988). In addition a wide variety of chemicals including pharmaceuticals and other chemicals used in disease treatment, materials incorporated in feeds and treatments applied to equipment may enter the recipient water.
- 7.3 Salmon cage culture understandably requires the maintenance of an environment suitable for salmon and studies on the impact of cage culture of rainbow trout have been unable to demonstrate any adverse impact of eutrophication (Phillips et al 1985). However, vitamin and trace materials may have subtle effects and there is evidence that the toxicity of Gyrodinium aureolum is enhanced by biotin, a constituent of fish farm wastes. There are also examples of localised phytoplankton blooms occurring in enclosed sea lochs causing mortality of farmed stock. Problems associated with sedimentation and reduced dissolved oxygen concentrations are likely to be localised in nature. These problems are likely to be more severe on farms using fresh fish or moist pelleted feeds.
- 7.4 Solbe (1982) carried out a questionnaire survey of fish farms in the United Kingdom and concluded that there was little deterioration in either biotic indices or fishery status as a result of fish farm effluent. Where fishery status had declined intensive use of water was a common feature. Similarly, Alabaster (1982) showed that downstream fisheries were generally not adversely affected unless the total flow of recipient water was less than

5 litre/sec/tonne of annual production. Maitland (1985) considered that more information was needed on the effect after discharge of therapeutic and prophylactic chemicals.

- 7.5 There is increasing evidence that the behaviour of wild fish may be modified by the presence of cages. Clearly it is important to ascertain whether the migratory behaviour of salmon is adversely affected by farming in and around rivers supporting wild populations of salmon (Phillips et al, 1985).

8. ACTIVITIES OF OTHER ORGANISATIONS:

- 8.1 At its 1987 meeting the ANACAT Fish Committee of ICES held a special topic session on the "Inter-relationships between wild and farmed salmon and wild and farmed eels". Nine papers were presented on the inter-relationships between farmed and wild salmon. These papers covered methods of distinguishing reared and wild salmon, the occurrence of farmed salmon in the Faroese fishery and the possible impact of farmed fish on the wild stocks. The Committee endorsed a proposal for a mini-symposium at the 1989 Statutory Meeting to discuss "Spawning Variability and the Implications for the Dynamics and well being of Stocks". The Committee considered that contributions to this symposium could include comparative studies of wild and cultured anadromous fishes as relative contributors to the reproductive potential of the stocks.
- 8.2 Both ICES and EIFAC have established Working Groups to consider the possible adverse effects of introductions/transfers of aquatic organisms. The ICES Working Group on Introductions and Transfers of Marine Organisms prepared a Code of Practice to Reduce the Risks of Adverse Effects arising from Introductions of Non-Indigenous Marine Species which was adopted by ICES in 1973. A similar code of practice was prepared for inland aquatic organisms by the EIFAC Working Party on Introductions. These Codes of Practice recommend careful assessment of the effects of an introduced species and lay down guidelines to minimise the risk of introducing disease agents with the introduced organism. However, some countries have not endorsed either Code of Practice (NAC, 1987) while in some other countries the code is only applied to the import of non-indigenous species (ICES, 1987). Concern about the trans-Atlantic and other transfers of Atlantic salmon relative to the genetic and ecological implications of stock mixing has recently been expressed by the ICES Working Group on Introductions and Transfers of marine organisms. This Group recommended that studies on stock identification and the effects of stock movements be encouraged. The Group is also establishing a computerised inventory and bibliography of Introductions and Transfers of marine organisms.
- 8.3 In 1987, the Bilateral Scientific Working Group of the North American Commission on Salmonid Introductions and Transfers made a series of recommendations to the North American Commission of NASCO regarding both introduction and transfer of salmonids to the eastern sea-board of North America. These recommendations recognised the potential for adverse genetic effects, in addition to disease and other ecological interactions, resulting from introductions and transfers. These recommendations included the prohibition of transfers of eastern hemisphere and Icelandic Atlantic salmon and the use of alternate sources of stocks for both enhancement and aquaculture efforts from within the local area until appropriate protocols can be developed. The Group also established a computerised database on

salmonid introduction transfers. Since their report was published the Group has established Health and Genetics sub-groups whose primary tasks are to develop protocols and/or model fish health and genetics programmes for the protection of wild stocks in the NAC area.

- 8.4 In response to a recommendation from an ad hoc Study Group ICES has established a Working Group on the Environmental Impacts of Mariculture which will meet for the first time in 1988. The Working Group will review ongoing research projects on environmental issues related to mariculture; evaluate techniques and monitoring strategies; determine criteria for site selection which will minimise environmental impacts and compile a directory of chemicals and their properties currently used in mariculture.
- 8.5 The Norwegian authorities consider that salmon farm escapees represent a potentially greater threat to natural genetic resources than either surface water acidification or *Gyrodactylus*. The proportion of farmed fish occurring in some Norwegian rivers is expected to increase above the present level of 13% as the industry continues to expand. With this problem, together with surface water acidification and *Gyrodactylus* in mind, the Directorate for Nature Management has established a national gene (sperm) bank for wild salmon (see paper CNL(87)47 for details). In the first year of a 10 year programme, field techniques were developed and samples were collected from 47 different stocks. A gene (sperm) bank designed to provide the Scottish salmon farming industry with large volumes of disease free milt has been established at Stirling University's Institute of Aquaculture (Rana, 1988).
- 8.6 Cornerstones of the successful marketing of farmed salmon by Organisations such as the Norwegian Fish Farmers Sales Organisation and the Scottish Salmon Growers Association have been the health value of salmon in the diet and the image of the wild fish occurring in unpolluted waters. The industry has tended to respond rapidly to environmental issues which could adversely affect the marketability of their product, e.g. the use of the antifoulant tributyl-tin. Concern in the industry about the possible degradation of the aquatic environment, particularly in the vicinity of the salmon farm, has led to a growing interest in the production of high digestibility, low pollution feeds. The marketability of these feeds will, however, depend on their expense (Institute of Aquaculture, 1987).
- 8.7 Problems of maturation in rainbow trout farming have led to the development of all female, triploid stocks which are sterile. These fish are now widely used by the trout farming industry in the UK and the techniques are now being tested with Atlantic salmon. Experimental trials have indicated that triploid fish grow slightly less well than diploid fish to the grilse stage but their growth is more predictable and there is no problem of maturation thereby avoiding the labour intensive grading of grilse. Full scale commercial testing of triploid smolts is now being undertaken (Anon, 1986). It remains to be seen if the industry will adopt this technology since the use of hormones, albeit one generation away from harvested fish, may be perceived as a threat to the marketability of the product. The adoption of this technology by the industry would have implications in the consideration of the possible genetic interactions of farmed and wild stocks. Sterile fish farm escapees clearly cannot interbreed with wild fish and in the absence of maturation it is possible that these fish might not even enter freshwater. However, if they did ascend into freshwater in large numbers there may still be the possibility of adverse interactions with wild stocks. Maitland (1987) describes several examples of biological control where mass release of sterile males has been used in order to control unwanted populations e.g. the sea lamprey *Petromyzon marinus* in the Great Lakes. The release of sterile

females might be expected to have less of an effect than release of sterile males although the behaviour of these fish has not yet been studied in the wild.

- 8.8 In Norway and British Columbia regulations laying down required separation distances between cage units have been introduced. In addition, regulations requiring a minimum distance between net-pen facilities and major salmon spawning streams (3km) have been introduced. In the Maritime Provinces of Canada the density of salmon cage culture is restricted to not more than 24 cages and a maximum of 2 hectares per lease. Recent Norwegian legislation has placed a complete embargo on the movement of any salmonid fish from one river system to another and on the large scale release of smolts (Maitland, 1987). In Sweden, a recent statute has enabled salmon rivers to be classified on being of national interest on the basis of its genetic characteristics.
- 8.9 In the United Kingdom, the Nature Conservancy Council (NCC) has recently commissioned two reports (Maitland, 1987; Institute of Aquaculture, 1988) on the environmental impacts of salmon farming. Maitland's report concerns the genetic impact of farmed Atlantic salmon on wild populations and he concludes:

"The threats to wild stocks from salmon farming are potentially serious and must be taken account of in the development of the industry. The current practice in Scotland of the release of large numbers of parr and smolts from fish farms into lochs and rivers may result in the deterioration of wild salmon stocks. This practice should be stopped and suitable research into the various potential problems posed by salmon farming initiated. The development of codes of practice is an important step in solving the problem....."

The NCC plans to promote the development of nature conservation guidelines for the marine environment using the Institute of Aquaculture report and other commissioned work (Cobham Resource Consultants, 1987). Guidelines on nature conservation and freshwater fish farming have already been developed.

- 8.10 A further report entitled "An Environmental Assessment of Fish Farming" (Cobham Resource Consultants, 197) has recently been prepared for the Countryside Commission for Scotland, the Crown Estate Commissioners, the Highlands and Islands Development Board and the Scottish Salmon Grower's Association. The report concludes that, to date, the industry has posed only limited environmental problems, but that the continued development, given anticipated growth, is likely to pose greater problems. Recommendations as to good practice in fish farm siting, design and management were made although nature conservation was outwith the remit of the report.

9. POSSIBLE ROLES FOR NASCO

- 9.1 This paper has attempted to bring together information from a variety of sources and to place it in some perspective thereby assisting the Parties to the NASCO Convention to consider what action might be taken in the light of the Convention which calls for the conservation of salmon stocks.

- 9.2 The salmon farming industry has developed extremely rapidly and there is clearly a need for further research into the possible effects of the industry on wild stocks. Hansen et al (1987) considered that there is an urgent need to estimate the number of fish escaping from farms; to study their migration pattern, and to investigate their possible effects on wild stocks. The ICES Working Group on Introductions and Transfer of Marine Organisms recommended that studies be encouraged by member countries to determine means of stock identification and to examine the effects of trans-Atlantic and other transfers of Atlantic salmon and the NAC Bilateral Scientific Working Group on Introductions and Transfers considered that there was an urgent need to develop new techniques to study the effects of intra-specific hybridisation. The Council might like to consider if NASCO has a role to play in stimulating this research.
- 9.3 The North American Commission of NASCO established a Bilateral Scientific Working Group in 1986. This group reported back to the Commission at its Fourth Annual Meeting and their report has been published separately as Annex 13 to NAC(87)20. The Report included recommended actions to be taken to reduce the potential risks to eastern seaboard salmon stocks until appropriate protocols can be developed. These protocols will include model programs for the protection of fish health, genetic integrity and productivity of salmonid stocks. The NAC Working Group also developed an inventory of computer-based salmonid introductions and transfers. Council may like to consider if such actions should be considered for the entire Convention area.
- 9.4 The Council might like to consider the production of a Code of Practice to minimise the adverse effects of aquaculture on wild stocks. Such a Code of Practice could consider recommendations such as "aquaculture free zones"; the use of all female triploid stock; the use of local broodstock; disposal of surplus stock etc. A review could be prepared for consideration by the Council at its Sixth Annual Meeting.
- 9.5 Atlantic salmon gene (sperm) banks have been established in Norway in response to concern about loss of genetic resources in the wild stocks and in Scotland in order to supply the industry with disease-free milt. Research is presently being undertaken by Cell Systems, a Cambridge (England) based biotechnology company, into cryopreservation of salmonid ova and embryos. The development of cryopreservation and the establishment of gene banks and other methods of maintaining genetic resources such as "pristine preserves" could be reviewed for consideration by the Council at its Sixth Annual Meeting.
- 9.6 The Council may wish to see a review of the legislation relating to the interactions described in this paper as taken from the Laws, Regulations and Programmes Database which now exists.

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MUTUAL IMPACT OF WILD AND CULTURED ATLANTIC SALMON IN NORWAY

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ABSTRACT

The development and current status of the fish farming industry, enhancement and sea ranching of salmon in Norway are briefly described, and an account is given of the natural salmon river populations in different parts of the country.

Record of cultured salmon in the open sea, coastal waters and rivers are briefly reviewed, and so are also migration studies on liberated farmed salmon. Diseases common to wild and cultured populations are described and discussed in relation to mutual impact.

The current situation is discussed in relation to actual and potential effects on natural gene pools and spreading of disease agents. Initiatives to protect natural gene pools are discussed, and experiments to gain additional knowledge of the genetic resources are outlined.

INTRODUCTION

Farming of Atlantic salmon in Norway commenced around 1970, and since then the production has increased steadily. In 1987 the annual production amounted to 47.417 metric tons, and the predictions for 1988 are around 75.000 tons. The production takes place along larger parts of the coast, but is low in southeastern parts and in the northernmost county Finnmark.

Wild Atlantic salmon is found in rivers all along Norway, and despite damage of stocks in southern Norway due to acid precipitation and in mid- and northern Norway due to the parasitic monogenean fluke Gyrodactylus salaris, the total reported catch of salmon has varied between 1050 and 2147 metric tons over the last 27 years. The annual variation in the production of the different rivers is considerable. All rivers seem to have their own stock with specific life histories and productive traits. Investigations of the population structure of Norwegian salmon using gene markers have been conducted by Ståhl and Hindar (1987).

Atlantic salmon has been released in Norwegian rivers for many years to enhance local stocks. They have mostly been released as unfed fry (10-15 millions a year), but also as underyearlings or smolt. Smolts (4-500 000 a year) are released primarily to compensate for damages to recruitment caused by river regulations (Hansen *et al.* 1987). Most fish released are from local stocks (Ståhl & Hindar 1988). Ocean ranching has so far been carried out on an experimental basis only, although the results have been most encouraging (Hansen and Jonsson 1988).

It is a reasonable assumption that the fish farming industry in Norway will continue to increase, and we therefore need to take good care of our several hundred local populations of wild salmon. Moreover the possibilities to augment the stock enhancement work and to develop ocean ranching of salmon should be assessed.

Many questions have been raised about the impact of the growing fish farming industry on the natural salmon populations. This concern has mainly been focused on two aspects; the transfer of disease from farmed to wild fish and the danger of eradicating salmon gene pools by

breaking down isolation mechanisms between stocks, and decreased fitness of the wild salmon due to introduction of nonindigenous gene or gene combinations. Transfer of diseases from wild to farmed fish is also a matter of concern, and for the fish farming industry strong and healthy wild populations with a high degree of genetic variation is a good insurance if the cultured populations should be subject to massive disease infections or unexpected genetic alterations.

The aim of the present case study is to give an overview of the relationship between wild and cultured salmon in Norway, including initiatives to protect the natural gene pools. The greater part of the study is based on published papers and reports, and in addition some discussion on validity of concern is included.

DESCRIPTION OF THE SITUATION

Recent development in farming and ocean ranching of Atlantic salmon has led to an increased proportion of reared fish in nature. Based on fin morphology and scale analysis the proportion of reared fish (ranching and farm escapees) has increased from about 10% in 1986 to about 20% in 1988 in commercial fisheries in Norwegian home waters (Hansen *et al.* 1987a, Lund and Hansen 1988, Lund *et al.* in prep.). If not caught in the fisheries, the adult salmon enter rivers to spawn (Hansen *et al.* 1987b). Using direct observations of body morphology, brood stock surveys in rivers in southern Norway in 1987 revealed that 23 (43%) out of 54 rivers examined contained reared salmon (Gausen 1988). In total of 615 salmon examined 83 (13%) were determined to be of reared origin.

These escaped fish spawn in the streams. For instance, in the small river Imsa there is an annual run of between 100 and 200 mature rainbow trout which have escaped from fish farms. They spawn and they leave the river system as kelts (Jonsson and Hansen, in prep.). The number of viable offspring is extremely low. Because Atlantic salmon is a species native to Norway it is likely that reared salmon can yield viable offspring in nature. However, the reproduction success of reared salmon in nature is still unknown (Ståhl and Hindar 1988).

Experimental releases of farmed Atlantic salmon show that there is a

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seasonal variation in survival. Survival of escaped salmon during their first sea year is much higher for those escaping in spring than for those escaping during the rest of the year (Hansen & Jonsson 1986, 1989). Adults escaping during summer seem to enter rivers at random and behave like homeless fish (Hansen et al. 1987b). When escaping from sea cages at the smolt stage the fish return to the same area from which they escaped and enter rivers in this area to spawn (Hansen et al. 1989).

Reared salmon might affect natural populations in several ways. For example the fluke Gyrodactylus salaris is at present spread to 32 rivers by stocking fish from infected hatcheries. This parasite attacks salmon parr and causes heavy mortality. In 1984 the estimated loss of salmon to Norway was around 250-500 tonnes (Johansen & Jensen 1986), and now the damage is still higher as the fish in more rivers have been infested by the fluke. Salmon smolts are still imported to Norwegian fish farms from other countries, which imposes a continuous risk of importing disease and parasites to which Norwegian salmon stocks are not adapted.

Extinction of local, indigenous fish stocks and erosion of genetic resources are subjects of growing concern to salmon management in Norway. The primary causes of excess salmon mortality in the present century are acid precipitation (Hesthagen & Mejdell-Larsen 1987), and the parasite Gyrodactylus salaris (Johnson & Jensen 1986, 1988). Effects of escapees from salmon farms on natural stocks also is a matter of concern among biologists. For these reasons the Directorate of Nature Management has established a gene bank for salmon based on deep frozen sperm. In 1986 and 1987 sperm collected from a number of salmon rivers throughout the whole country were stored (Gausen 1986 and pers comm.). In total sperm from 69 stocks are by now stored in the sperm bank.

DISEASES

Of the interaction problems between wild and farmed salmonids, diseases is possibly the largest and most serious one. Disease in fresh water farmed fish has been known for considerable time. Sea water farming started more recently, and it was believed that

conditions in seawater would be much better, with cleaner water and less disease problems.

Very little was known about diseases and parasites in free-living marine fishes when the fish farming industry started, and still there are immense gaps of knowledge. It has also appeared that diseases expected to occur only in fresh water, thrive very well in seawater.

The case of the salmon lice, Lepeophtheirus salmonis, is maybe the one giving the best illustration of an interaction between wild and farmed fish. This parasite was well known, it was described by Krøyer as early as in 1838. It is a copepod with a life cycle of 10 stages, 3 pelagic stages and 7 attached to or living on the host. It is found circumpolarly in the northern hemisphere and is host specific for salmonids; the lice disappears from the fish in fresh water within a short time. When and where the free-living fish is infected is not known. The chance for a pelagic-living larvae to encounter its specific host in the open sea, does not seem very large. When wild salmon still were abundant in the rivers, the saying of experienced fishermen was that a high density of lice on the upward migrating fish, was indicative of a good salmon run. Only once, in Canada in 1940, lessions and death probably due to salmon lice were reported (White 1940). Actually, it should have been foreseen that salmon lice could become a potential problem in salmon farming. Under the intensive conditions found in farms, it is no longer a problem for the pelagic larvae to find their spesific host and complete their life cycle producing new larvae easily finding new hosts and so on. It soon became evident that the lice, if present in large numbers, were harmful to salmon. They live on mucus, skin and blood and in the most advanced cases fish are seen with large open lessions especially in the head region. Even if wild-living salmonids arround fish farms have been observed carrying large numbers of lice (Djupvik, pers. com.) lessions or mortality in such fish are not reported.

We still know little about diseases in free-living marine fish, clearly it is among the farmed fish we really encounter the problems. The largest problems are seen in connection with bacterial infections. Vibriosis due to the bacterium Vibrio anguillarum is probably the most well known of such diseases. Vibriosis was one of the economically

most important diseases in marine fish farming, but can now be controlled efficiently through vaccination. Vibriosis is known from a large amount of freeliving marine fish, but epidemics are rarely seen. Along the Norwegian west coast local outbreaks of vibriosis in young saithe are found annually, reaching epidemics proportions in certain years (Egidius et al. 1983). Experiments have shown (Egidius and Andersen 1978) that there is some host specificity amongst V. anguillarum strains isolated from for example rainbow trout and saithe, and more recent investigations have shown that there at least at the DNA level is a slight difference between strains from different hosts (Wiik et al., in press). Mass mortality due to vibriosis is reported in homeward migrating salmonids when entering the rivers, but it does not seem to occur very frequently. Coldwater vibriosis due to V. salmonicida has not yet been reported in wild salmon.

Furunculosis due to the bacterium Aeromonas salmonicida var. salmonicida is another of the important bacterial diseases that must be considered. Furunculosis is endemic in the wild salmonid populations in Scotland, Ireland and Canada, but free-living affected fish are not frequently seen. In fish farms on the other hand the disease can be disastrous and in general of great economic importance. With furunculosis it seems clear that the free-living fish is the reservoir for the disease in farmed fish. In farmed fish the disease outbreaks seem linked with fish density in tanks and cages and other stress inducing factors.

The bacterium Yersinia ruckeri is a newcomer in European fish farms. Even if the disease was believed to be a fresh water one, it has spread to salmon farms all along the Norwegian coast. Possible effects on free-living salmonids are not known. Although the bacterium has been isolated from marine scavenger fish like saithe around affected sea cages, it is not known if the saithe just harbours the bacterium for a short time or if it can be pathogenic also for this and other marine species.

Bacterial kidney disease (BKD) due to Renibacterium salmoninarum is probably the most dreaded of the salmonid diseases mainly because its development is slow and because the diagnostics is difficult and time consuming. BKD was first thought to be purely a disease of farmed

fish, but with improved diagnostic methods the bacterium was also found in wild stocks though its impact there is unknown. We most probably have the same situation as with furunculosis: that the infection reservoir is in the wild stocks, but the disease problems break out under farming conditions. The disease in farms can lead to higher infection rates of wild stocks in the vicinity.

Of fungal disease agents Ichtyophonus hoferi is common and often harmful in several species of marine fish. It has been found in farmed salmon, but until now without showing much effect.

Of parasites the monogenean fluke Gyrodactylus salaris has done great harm in Norwegian salmonid rivers. The fluke is believed to have been imported with smolts for farming from Sweden to Norway in the early seventies. This fluke is now spread to about 30 salmon rivers, many of which are nearly emptied of Atlantic salmon. In the fish farming industry Gyrodactylus is no problem. Infected fish are easily treated and the parasite disappears when the smolts are put into sea water. This is the only disease mentioned here where apparently wild stocks are the losers.

Examples have been given of disease interactions between free living and farmed salmonids, mostly to our knowledge in the disfavour of the farmed fish. Our general knowledge on disease in free living marine populations including salmonids, is still far too restricted, but there clearly is reason for great consideration and carefullness in movements of fish from different regions.

GENETIC VARIATION AND GENETIC STRUCTURE OF SALMON IN NORWAY

Population structure of salmon in Norway

Ståhl and Hindar (1988) have made a comprehensive monograph of the Norwegian salmon stocks with reference to the population structure, number of spawners (population size) and differences within and between wild and farmed salmon stocks. From studies on biochemical genetics they concluded that the natural salmon is divided into genetically distinct populations; sometimes more than one within the

same river system. Farmed salmon (commercial stocks for intensive farming and culture aimed stocks) is not a homogeneous group and it is not possible to distinguish between wild and cultured salmon on the individual level by use of biochemical gene markers.

Potential genetic impact

Skjervold (1988) gave an overview of the types of genetic impact the fish farming could have on natural salmon stocks. In spite of the difficulties in estimating the numbers of escapees from fish farms, and of the magnitude of their contribution to the recruitment of salmon, evidently a great potentiality exists of significant gene transfer risk from farmed salmon to occasional rivers.

The farmed salmon has been subjected to intensive selection for improvement of productive traits, especially improved growth rate and late maturation. Genetic selection is performed systematically through a large scale program on improvement for fish farming conducted by the Fish Farmers Association and the Fish Farmers Sales Organization in Norway. In addition most egg producers make phenotypic selection of broodstock, and probably also seminatural selection as an adaptation to life under farming condition (domestication) has taken place for 4-5 generations. The genotypes of the farmed fish may differ in several respects from the genotype of the population from which they originated several generations ago. It is difficult to predict how this change will affect their adaptation with respect to survival in the natural environment, but escapees which reproduce in rivers chosen by random will always decrease the differentiations between the wild salmon populations.

The origin of the salmon used for fish farming is important. Ståhl (1987) has shown that especially the Baltic salmon differs in genetic composition from the salmon in the north-east Atlantic, and east-Atlantic salmon differs in several aspects from the west-Atlantic stocks. As far as we know there has been no import of west-Atlantic live salmon to Norway (except for scientific purpose), but for several years we have had importations of smolts from Iceland, Scotland and especially from Sweden and Finland (Baltic salmon).

Gjedrem and Aulstad (1974) observed that a strain of Baltic salmon showed much lower resistance to vibrio disease than the Norwegian strains, indicating that genetically differences in resistance to certain diseases exist between geographically distant groups. Escapement of fish with other adaptations to diseases and parasites in the environment will represent a risk for transferring such disease agents to natural population. Thus newly established or potential hybride populations may be eradicated due to spontaneous or accidental disease outbreaks.

Hybridization, hybride vigor and short term adaptation

Crossbreedings of natural and escaped salmon in the rivers are expected to cause increased heterozygosity, which may lead to hybrid vigor for some traits. Hybride vigor most often is found for traits with low heritability (Skjervold 1988), and survival traits have low heritabilities as far as they have been studied (Gjerde 1986). Thus, hybridizing with natural salmon in a river may give the impression of very well adapted fish; an adaptation which may oust nonhybride natural salmon, but last only for the first generation. Altukhov (1981) described a similar case with chum salmon where liberation of non-indigenous fish resulted in very low production both of the introduced fish and of the indigenous fish in the same river.

Genetic drift, reduced genetic variability and low numbers of spawners

Low numbers of spawners (effective population size) will always increase genetic drift, decrease heterozygosity and consequently increase the risk of loss of genes. A number of 100 specimens of each sex is recommended by Allendorf and Ryman (1987) but in several cases of artificial reproduction for enhancement work and intensive fish farming, the spawning populations are considerably less than recommended based on theoretical considerations. However, judged from the results of Ståhl and Hindar (1988) the heterozygosity is higher in artificial than in most natural populations, and the genetic variability within populations is not reduced due to culture activities. This may be due to the fact that cultured populations usually represent different natural populations and contain more genetic variation than any single population. Therefore the risk of

reducing the fitness of salmon through reduced genetic variability does not seem to be serious for the moment, although it should be kept in mind by monitoring both cultured and natural populations through several generations.

In conclusion the escapement of farmed salmon, and liberation of non-indigenous salmon for enhancement work represents a risk of decreasing the genetic variability between populations, possibly also reducing the long time fitness by first generation hybrid vigor in adaptive traits through hybridization between indigenous and non-indigenous fish. For the moment, however, loss of genetic variability through low numbers of broodstock for culture purpose does not seem to represent a risk.

INITIATIVES

To avoid impact of cultured salmon on wild stocks a series of initiatives have been taken or are being planned in Norway. These initiatives are listed below with a statement of the status of each of them.

Technical improvement

In addition to representing a risk for wild salmon, salmon escaping from fish farms always represent a loss for the fish farmer. Improvement of technical facilities to prevent escapement therefore is an immediate initiative to prevent contact between wild and cultured salmon. Usually, the security of a fish farming facility is a compromise between the chance of loss and the cost of investment. Landbased facilities are more safe than ordinary net pens, and closed or semiclosed pens are also an alternative. For the moment, landbased facilities for marine culture are not much used in Norway, but closed or semiclosed systems are under development. No specific demand is required for fish farming devices, but it has been proposed to establish protective areas for salmon where no farming activities will be allowed unless they are secured with respect to escapement. Within the zones technical improvements may prevent contact between natural and farmed salmon.

Gene banks (sperm banks)

Salmon from Gyrodactylus-treated streams are taken care of by artificial breeding and liberation, partly also in intensive culture (Ståhl and Hindar 1988). A sampling program for deep-freezing of sperm is undertaken (Gausen 1986). In 1986 sperm from 48 strains were preserved, while in 1987 the sperm bank increased to contain sperms from 69 populations. By using such sperms, populations which have been eradicated may at least partly be reconstructed. By use of androgenetic techniques more complete natural populations may be reconstructed from sperm banks (Scheerer et al. 1986).

Restriction on transfer of live material

For many years there has been a lack of smolts for the fish farming industry in Norway, as the smolt production did not increase as fast as the development of food fish production. For this reason, some imports have been legislated, in some cases with disastrous results concerning cultured salmon (i.e. import of furunculosis from Scotland) and natural populations (possible import of Gyrodactylus salaris from Baltic countries). In 1988 there was a surplus of smolts in Norway. This situation is expected to persist, and there is no longer any reason for import of live salmon, although even this year (1988) there has been an import of salmon eggs from Iceland. Transport of live material within the country probably also has contributed to the spread of Gyrodactylus. This seems to be a problem especially in cases where salmon farms are situated in fresh water systems also supporting anadromous salmonids, or in brackish water with a salinity lower than 14 to 18 o/oo. For this reason restrictions of transfer within Norway are also proposed, but not yet decided upon.

Use of indigenous fish for enhancement work

Enhancement has been conducted for several years by releasing offspring from occasional salmon of unknown origin, also farmed fish. To protect the between strain variation, in principle now only endemic fish are allowed to be used for enhancement of natural stocks. Only when such fish is unavailable, non-indigenous fish are allowed used.

Areas protected from fish farming

Hatcheries for commercial production of smolts for intensive fish farming are usually not located in or close to rivers with anadromous salmonid populations. However, some existing hatcheries are located close to rivers with sea-run fish, and inland in Norway plants for rainbow trout productions (mostly small) are sometimes located in lakes draining to salmon rivers. Such fish farms have probably spread Gyrodactylus salaris. Hereafter no new installation for intensive production or for enhancement work for other than indigenous populations, will be allowed in rivers supporting anadromous populations.

To protect larger areas, a plan has been formulated for time restricted protective areas for wild salmonids. This plan is now subjected to consideration by involved official agencies and private organizations, and the fate of the proposal is yet uncertain. The aim of the proposal is to protect larger areas and secure references for observation of gene introgression and spread of disease agencies. To prevent further spread of Gyrodactylus salaris no new culture activities will be allowed where this parasite has been found. This include the river drainage and a defined area usually within about 20 km of the river mouths. Usually, rivers having a mean annual catch of more than 500 kgs anadromous salmonids will be protected. A few larger fjord areas (Sognefjorden, Trondheimsfjorden) are also proposed to be held free from new aquaculture installations. Such protective areas are proposed for five years as it is desirable to gain experience about the effect of such restrains before long-lasting decisions are made. If escapement free facilities are constructed, limited farming activities may be allowed, and existing farms within the areas will be allowed to continue.

MONITORING AND RESEARCH

The establishment and increase of the intensive fish farming industry represent a new and possibly serious threat to the natural populations of Atlantic salmon in Norway as well as in several other countries. From a management point of view actions are taken or will be taken to

conserve the natural population in coexistence with the developing fish farming industry, and possible commercial sea ranching activities. A first approximation to such management is to monitor the changes that really take place, and then to develop new methods for interaction studies. Further studies on quantities of escaped reared salmon in coastal areas and in the rivers, studies on infection sources for disease agents, occurrence of disease agents in natural populations and development of methods for defence against parasites (i.e. Gyrodactylus) in natural environment are required. Reconstruction of eradicated (or strongly decreased) natural populations from live gene banks or sperm banks by androgenesis is another area of research and development. Concerning genetic impact, the discussion is often loose and concentrates more on potential impact than on actual facts. To base this discussion on observed or experimental data will be a great challenge for scientific activities in the near future. Further studies on genetic differentiation of natural populations is important. To study hybridization and gene introgression, use of gene markers is a promising method. For other species (cod, brown trout) broodstocks homozygous for specific gene markers (biochemical or morphological) are developed (Skaala *et al.* 1988). No suitable markers are yet found for salmon, but this will be further investigated for application in field studies on interaction between populations. If such studies are difficult or impossible to perform with salmon, they will be performed with brown trout as a model species.

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MEMORANDUM

State of Alaska

DEPARTMENT OF LAW

DATE: July 5, 1988

TO: Hon. Don W. Collinsworth
Commissioner, ADF&G

FILE NO:

~~The~~ Hon. Dick Eliason
Alaska State Senate

TELEPHONE NO:

THRU:

SUBJECT: DeNardo v. State
(mariculture moratorium
challenge)

FROM: Sarah E. McCracken ^{SEM}
Assistant Attorney General
Natural Resources-Anchorage

CONFIDENTIAL
ATTORNEY-CLIENT PRIVILEGE

The Attorney General's office has been served with a complaint filed in the Superior Court by Daniel DeNardo (acting pro per), in which Mr. DeNardo requests the court to issue a judgment declaring that the legislature's extension of the moratorium on finfish farming (ch. 145, SLA 1988) is unconstitutional, in violation of the interstate commerce clause, privileges and immunities clause, and the Fourteenth Amendment, and enjoining enforcement of the "acts of the legislature forbidding issuance of the necessary licenses for salmon farming."

Mr. DeNardo is a fairly well known pro se litigant and has filed numerous actions against various state officials and challenged several statutory provisions, including a current challenge to the Olympic ballot checkoff. The mariculture case has been assigned to Judge Karen Hunt, although I suspect she may recuse herself in light of the fact that Mr. DeNardo filed an action against her for judicial misconduct in 1986.

I expect to file a motion to dismiss the action based on standing in the near future. I will keep you informed on developments in this case. If there is any one else you know of who should be on the distribution list for material relating to this suit, please let me know. Best regards.

SEM/jmo

cc: Larri I. Spengler, AGO JNU

STATE OF ALASKA

DEPARTMENT OF NATURAL RESOURCES

SOUTHEAST REGIONAL OFFICE
DIVISION OF LAND AND WATER MANAGEMENT

STEVE COWPER, GOVERNOR

400 WILLOUGHBY AVENUE
SUITE 400
JUNEAU, ALASKA 99801-1000
PHONE: (907) 465-3400

June 19, 1989

Dear Interested Alaskan:

Please find enclosed a copy of the Department of Natural Resources's aquatic farm regulations. The regulations will be effective on July 1, 1989 and will govern how the department accepts and processes aquatic farm applications.

Please contact me at the above address or phone number if you have questions.

Sincerely,


Janet Burleson
Project Coordinator

Enclosure

TITLE 11. NATURAL RESOURCES.

Part 1. Office of the Commissioner (11 AAC 03--11 AAC 06)

Part 6. Lands (11 AAC 52--11 AAC 98)

PART 1. OFFICE OF THE COMMISSIONER.

Chapter

05. Fees for Department Services (11 AAC 05.010--11 AAC 05.900)

CHAPTER 05. FEES FOR DEPARTMENT SERVICES.

Section

010. Fees

11 AAC 05.010. FEES. (a) Non-refundable fees to apply for authorizations and fees to obtain publications or services from the department are as follows:

(6) surface leasing

(K) application for aquatic farmsite permit or lease; for amendment or renewal of aquatic farmsite permit; or for amendment, extension, or assignment of aquatic farmsite lease, \$50;

(Eff. 1/1/86, Register 96; am 8/10/86, Register 99; am 9/28/86, Register 99; am 8/23/87, Register 103; am 1/28/88, Register 105; am 7/1/89, Register 110)

Authority: AS 03.10.020
AS 27.21.030
AS 38.05.020
AS 38.05.035
AS 38.05.295
AS 38.05.856
AS 38.09.110
AS 38.35.020
AS 38.35.050
AS 38.50.160

AS 38.95.240
AS 41.06.020
AS 41.21.020
AS 41.21.026
AS 44.17.030
AS 44.37.020
AS 44.37.025
AS 45.50.315
AS 46.15.020

PART 6. LANDS.

Chapter

63. Aquatic Farmsite Permits and Leases (11 AAC 63.010--11 AAC 63.900)

11 AAC is amended by adding a new chapter to read:

CHAPTER 63. AQUATIC FARMSITE PERMITS AND LEASES.

Section

- 010. Applicability; aquatic farmsite permit defined
- 020. District application periods
- 030. Aquatic farmsite permit applications
- 040. Associated facilities; upland owner preference right; upland owner access right
- 050. Application review; best interest finding
- 060. Notice and opportunity to comment
- 070. Aquatic farmsite permit
- 080. Required security
- 090. Transition; permits under AS 38.05.850
- 100. Aquatic farmsite lease
- 110. General permit and lease provisions
- 900. Definitions

11 AAC 63.010. APPLICABILITY; AQUATIC FARMSITE PERMIT DEFINED. (a) This chapter covers aquatic farmsite permits issued under AS 38.05.856 and leases issued under AS 38.05.083 for the development and operation of an aquatic farm or related hatchery, as those terms are defined in AS 16.40.199. An aquatic farmsite permit or lease will, in the commissioner's discretion, be issued for tideland, submerged land, and shoreland managed by the department under AS 38, but will not include land within a state park or other land that has been withdrawn from the state public domain. The aquatic farmsite authorization will, in the commissioner's discretion, include authorization for associated storage and housing facilities, including facilities on adjacent

upland managed by the department under AS 38, in accordance with 11 AAC 63.040.

(b) Issuance of an aquatic farmsite permit is a disposal of an interest in state land. An aquatic farmsite permit is revocable only for breach of its provisions. It conveys the exclusive, non-transferable right, during a three-year term, to improve and develop the site as an aquatic farm or related hatchery in accordance with the permit's provisions, and includes a preference right to an aquatic farmsite lease if the permittee develops the site for aquatic farming or related hatchery operations in accordance with the permit's provisions.

(c) A person who only wants to test a site's suitability for aquatic farming, without developing it or acquiring any property right, may be authorized to do so in accordance with 11 AAC 63.090(e)(1). A person who wants to acquire property rights so that he or she can develop the site into an aquatic farm may do so by applying for an aquatic farmsite permit, in accordance with 11 AAC 63.030, during the application period for that district. The applicant might be eligible for a preference right if the applicant is already lawfully operating an aquatic farm (11 AAC 63.090(a)) or is an upland owner or lessee (11 AAC 63.040(f)). A preference right is not an entitlement to receive the authorization, but it protects the applicant against some or all competition for it. If the applicant receives an aquatic farmsite permit and successfully develops the site as mentioned in (b) of this section, the permittee has a preference right to lease the site. No one else may apply for the aquatic farmsite lease, nor may anyone apply directly for a lease without first obtaining an aquatic farmsite permit. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.083
AS 38.05.855
AS 38.05.856

11 AAC 63.020. DISTRICT APPLICATION PERIODS. (a) The commissioner will prepare a fixed schedule of the dates on which aquatic farmsite permit applications may be filed in a district. The schedule will be available to the public.

(b) The commissioner will give notice that a district is open to aquatic farmsite permit applications by publication, beginning before the application period opens, in at least one newspaper of statewide circulation and one newspaper of general circulation in the district. If a preapplication conference is scheduled under 6 AAC 50.040 so that potential applicants and other interested persons can discuss their plans and exchange information about the district, notice of the conference will be included.

(c) The commissioner will, in his or her discretion, set application filing guidelines for a district, such as minimum or maximum size limits for aquatic farmsites, minimum distances from anchorages or the mouths of anadromous fish streams, or a limit on the total number of applications that a person may file, or permits that a person may hold, in that district. Filing guidelines will be available at the places listed in the public notice announcing the application period.

(d) Maps of a district that is open to aquatic farmsite permit applications will be available at the places listed in the public notice announcing the application period. To the extent practical, the map will indicate areas known to be unavailable or unsuitable for aquatic farmsite permits. For example, an area might be unavailable because it is already subject to aquatic farmsite authorizations or because aquatic farming is prohibited by an applicable zoning ordinance, district coastal management program, or state land use plan. An area might be unsuitable if the Department of Environmental Conservation determines that known water pollution is incompatible with raising shellfish and aquatic vegetables for human consumption. The map will also indicate areas where aquatic farming is discouraged, but not prohibited outright, by a state land use plan. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.855
AS 38.05.856

11 AAC 63.030. AQUATIC FARMSITE PERMIT APPLICATIONS. (a) An aquatic farmsite permit application is subject to 11 AAC 67.007, except that it may be filed only at the regional office responsible for the relevant district. The application must

(1) be submitted on a form approved by the commissioner;

(2) include the non-refundable application fee required by 11 AAC 05.010;

(3) include a clear scaled drawing of the site boundaries on a U.S.G.S. map at a scale of 1:63,360 or a navigation chart, as required by the application form;

(4) be accompanied by a completed coastal project questionnaire as required by 6 AAC 50, unless the application is solely for shoreland outside the coastal zone; and

(5) comply with all application filing guidelines set under 11 AAC 63.020(c), except that the applicant may request a waiver of a filing guideline that sets a maximum size limit; the

commissioner will, in his or her discretion, waive the size limit if (A) the applicant shows that a waiver is justified by the applicant's experience, capitalization, and need for a larger site in order to form an economic unit and (B) the commissioner, after considering the reason for which the size limit was imposed and public comment on the proposed waiver, determines that the waiver is in the state's best interest; the commissioner's proposal to waive the size limit will be included in the preliminary finding under 11 AAC 63.050.

(b) Each application must include sufficient detail on the applicant's proposed site improvements to allow the commissioner to determine the amount of the security required under 11 AAC 63.080. It must also include a proposed development plan and schedule. The development plan and schedule must result in reasonable use of the site and must ensure that the site is developed for aquatic farming or related hatchery operations before the permit expires. The commissioner will, in his or her discretion, approve the development plan and schedule, or amend it as the commissioner considers necessary to make reasonable use of the site. The application may include both a minimum and maximum development plan and schedule; if both are approved, fulfilling the minimum development plan and schedule will fulfill the development requirement, and the permittee may operate at any higher level up to the maximum development plan and schedule without the need for an amendment.

(c) An applicant may file as many non-overlapping applications as desired, unless the commissioner has limited the number by setting a filing guideline under 11 AAC 63.020(c).

(d) Except as provided in 11 AAC 63.040(f) and 11 AAC 63.090(b), all complete applications received during a district application period are considered to have been simultaneously filed. If the number of applications filed for a particular area exceeds the number of sites that the commissioner decides to grant, the commissioner will hold a lottery to draw the proper number of applications.

(e) If two applications overlap in an area where the commissioner does not propose to limit the number of authorized sites, the applicants will be granted 30 days to agree on amendments that eliminate the overlap. If an application overlaps an existing aquatic farmsite permit or lease, or a mariculture testing or development site subject to a preference right under 11 AAC 63.090(a), the applicant will be granted 30 days to amend the application so as to eliminate the overlap. The commissioner will, in his or her discretion, amend an application

(1) to eliminate an overlap if the applicant has failed to do so, or

(2) to eliminate or reduce other site or resource use conflicts. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.855
AS 38.05.856

11 AAC 63.040. ASSOCIATED FACILITIES; UPLAND OWNER PREFERENCE RIGHT; UPLAND OWNER ACCESS RIGHT. (a) The commissioner will, in his or her discretion, authorize associated facilities for storing equipment or housing personnel at an aquatic farmsite, including upland managed by the department under AS 38, if the commissioner is satisfied that the associated facilities are necessary for aquatic farming. An applicant who wants authorization for associated facilities at either the permit or lease stage must request it as part of the permit application so that it can be considered during agency and public review.

(b) The conditions in this subsection apply to an authorization for personnel housing at an aquatic farmsite during the permit stage, but not at the lease stage. The commissioner will authorize such housing only if the applicant shows that (1) the level of site development at the time the housing is expected to begin will require that personnel be present on a daily basis, (2) the personnel cannot reasonably commute to the site by road, boat, or aircraft on a daily basis, and (3) no nearby land suitable for housing is available for rent or sale. The housing facility may not be used as the personnel's primary or full-time residence. It must be designed and constructed so that it can be removed and the site completely restored within 30 days if the permit terminates or if housing personnel at the aquatic farmsite ceases to be necessary. The housing facility may not be placed on a permanent foundation, except that a foundation of wooden pilings may be used if the applicant agrees either to remove the pilings or to cut them off at ground level if site restoration is required.

(c) The conditions in this subsection apply to an authorization for floating housing at an aquatic farmsite during either the permit or lease stage. The commissioner will authorize floating housing only if that use is consistent with the floathouse provisions and management intent of an applicable land use plan, zoning ordinance, or coastal management program, and if the Department of Environmental Conservation determines that such housing would not result in degraded water quality that would be incompatible with raising shellfish or aquatic vegetables for human consumption.

(d) The nature and extent of associated facilities are a factor in setting the security amount under 11 AAC 63.080, setting the fee for an aquatic farmsite permit under 11 AAC 63.070, and appraising the fair market value of a lease under 11 AAC 63.100.

(e) After a permit or lease terminates, the former permittee or lessee has no entitlement or preference right to continue using or occupying any portion of the aquatic farmsite, including anchoring a floathouse at the site.

(b) Under this subsection, the commissioner grants an aquatic farmsite permit preference right to eligible upland owners and lessees in order to increase the compatibility of aquatic farming with upland management policies. The owner or lessee of adjacent or nearby upland may request a preference right to an aquatic farmsite permit by agreeing to place his or her associated facilities for storing equipment or housing personnel on his or her own land or leasehold rather than on state-owned land or other public land. The following apply to a preference right under this subsection:

(1) For an upland owner or lessee to be eligible, the applicant's development plan and schedule must demonstrate that the associated facilities are necessary for aquatic farming.

(2) For an upland lessee to be eligible, the term of the upland lease must equal or exceed the combined terms of an aquatic farmsite permit and lease. A U.S. Forest Service special use permit does not constitute a leasehold interest that would make the holder eligible for a preference right under this subsection.

(3) A preference right granted under this subsection is secondary to a preference right that the commissioner grants under 11 AAC 63.090(a).

(4) If the number of applications eligible for an upland owner/lessee preference right exceeds the number of permits that the commissioner decides to grant, the commissioner will hold a lottery as set out in 11 AAC 63.030(d) among the preference-eligible applications only.

(5) An upland owner or lessee who wants a preference right for aquatic farming must apply under this subsection, rather than under AS 38.05.075(c). AS 38.05.075(c) does not give an upland owner or lessee any entitlement or preference right to an aquatic farmsite permit or aquatic farmsite lease.

(c) No aquatic farmsite permit or lease will be issued that would deny an upland owner's right of reasonable access to tidewater or deny access by boat to privately owned upland. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.083
AS 38.05.855
AS 38.05.856

11 AAC 63.050. APPLICATION REVIEW; BEST INTEREST FINDING.

(a) After an aquatic farmsite permit application period closes, complete applications will undergo review by agencies and affected coastal districts in accordance with 6 AAC 50.070 for consistency with the Alaska Coastal Management Program. Compliance with this requirement fulfills the agency consultation requirement of AS 38.05.855(c). Comments received will be considered both for the coordinating agency's proposed consistency determination and for the commissioner's preliminary best interest finding. If applications are filed for sites within a state game refuge or critical habitat area, the commissioner will request the approval of the commissioner of the Department of Fish and Game as required by AS 16.20.060 or 16.20.530.

(b) The commissioner will prepare a preliminary best interest finding that proposes sites for which permits may be issued. If the sites are unclassified, a proposed land use plan and classification order will be prepared, and might accompany or be included as part of the preliminary best interest finding. If the commissioner decides to deny an application, to require its amendment, or to limit the number of sites to be authorized, the finding will explain the reason. The finding will consider both advantages and disadvantages of the proposal. Criteria that will be considered in the finding include:

(1) whether the Department of Fish and Game considers the proposed aquatic farm or hatchery to meet the criteria of AS 16.40.105;

(2) whether the Department of Environmental Conservation determines that the proposed aquatic farmsite is protected from pollution from adjacent floating and upland support activities, to ensure product wholesomeness, and that effective pollution control measures can be implemented to protect land and water at the site from pollution caused by the proposed aquatic farm or hatchery;

(3) whether the coordinating state agency proposes to find the proposed aquatic farm or hatchery consistent with the Alaska Coastal Management Program;

(4) whether aquatic farming is compatible with official land management policies applicable to the proposed aquatic farm site and nearby upland, including legislative or congressional designations such as parks or wilderness areas and adopted federal, state, and local land use plans, land classifications, and zoning;

(5) whether aquatic farming conflicts with existing uses, or with pending uses, as that term is defined in 11 AAC 63.900, of the site and of nearby land, whether or not the nearby land is in state ownership, including consideration of

(A) impacts on nearby communities or residential land;

(B) traditional and existing uses of the site, including commercial fishing, sport fishing, subsistence activities, use as a primary anchorage, navigation, seaplane landing area, recreation, sightseeing, and tourism; consideration of this criterion will, in the commissioner's discretion, be combined with a traditional use finding if such a finding is required by AS 38.05.830;

(C) historic and cultural resources;

(D) commercial or industrial facilities, such as log transfer facilities, salmon hatcheries, seafood processing plants, or harbor development, that would be incompatible with aquatic farming;

(6) how public access to and along public waters, and the upland owner's right of reasonable access to tidewater, will be ensured by reserving easements under 11 AAC 53 or by other means; if upland access to the water is limited to a specific point by topography, existing improvements, or other factors, the commissioner will ensure that aquatic farming facilities do not obstruct water access to that point;

(7) how the interests served by the public trust doctrine, specifically the public's right to use navigable waters and the land beneath them for navigation, commerce, fishing, and other purposes, will be protected;

(8) whether special permit provisions or other measures are needed to mitigate identified conflicts; for this purpose the commissioner will consult guidelines set out in an applicable land use plan, zoning ordinance, or coastal management program, or, if no such document or guidelines exist or if it would otherwise be appropriate, will consult the guidelines set out on pp. 80-85 of the final 1988 Etolin Island Area Mariculture Pilot Project;

(9) other significant social, economic, and environmental effects of the proposed aquatic farming.

(c) In general, the commissioner will not grant aquatic farmsite permits that would encumber more than a third of the surface area estimated to exist at mean lower low water of a bay, bight, or cove, unless the commissioner finds that (1) it is in the state's best interest to concentrate permits in one such bay, bight, or cove so as to keep other specified water bodies completely unencumbered, (2) the cumulative impacts will not be excessive, and (3) the upland owner will retain a right of reasonable access to tidewater. Such a finding will be included in the best interest finding, as well as in the land use plan if one is being prepared. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.035
AS 38.05.127
AS 38.05.128
AS 38.05.855
AS 38.05.856

Editor's note: Pages 80-85 of the 1988 Etolin Island Area Mariculture Pilot Project, referred to in 11 AAC 63.050(b), may be obtained from DNR, Division of Land and Water Management, at either the Southcentral Regional Office (P.O. Box 107005, Anchorage, Alaska 99510-7005) or the Southeastern Regional Office (400 Willoughby Ave., Juneau, AK 99801).

11 AAC 63.060. NOTICE AND OPPORTUNITY TO COMMENT. (a) Notice under AS 38.05.945 that the preliminary best interest finding is available for written comment will, in the commissioner's discretion, be combined with notice of the time, place, and location of a hearing to be conducted under AS 38.05.946(b); notice of a proposed determination of consistency with the Alaska Coastal Management Program; notice of a proposed land use plan and classification, if the land is not yet classified; and notice of the approximate date when the final best interest finding, as well as the final land use plan, if required, is expected to be available.

(b) The commissioner will conduct the public hearing that AS 38.05.946 requires in each district either in person or by teleconference.

(c) The department will maintain a mailing list of persons who ask in writing to receive notice of district openings and

notice of comment opportunities. Any interested person may ask inwriting to be put on an aquatic farming mailing list. The department will use the mailing list to notify recipients of opportunities for public comment and involvement such as the opening of a district application period or the availability of a preliminary best interest finding.

(d) If the upland adjacent to an aquatic farmsite permit application is not managed by the department, the commissioner will notify the upland owner of the opportunity to comment under (a) of this section. If an aquatic farmsite permit applicant states that using upland for associated facilities is necessary for aquatic farming, and the upland owner notifies the commissioner in writing that the owner cannot or will not authorize the upland use, the commissioner will not grant the aquatic farmsite permit.

(e) Decisions made as a result of public and interagency comment will be incorporated into the final best interest finding and, if required, into the final land use plan. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.855
AS 38.05.856
AS 38.05.945
AS 38.05.946

11 AAC 63.070. AQUATIC FARMSITE PERMIT. (a) The commissioner will grant an aquatic farmsite permit to a successful applicant after the commissioner issues the final finding required by AS 38.05.035(e) and AS 38.05.855(d) and the coordinating state agency issues a conclusive determination of consistency with the Alaska Coastal Management Program.

(b) Within 30 days after receiving the permit, the applicant shall sign it and return it to the commissioner along with

(1) the security required by 11 AAC 63.080; and

(2) a use fee, set in a fee schedule approved by the commissioner, to provide the state a reasonable return for the permittee's use of the site, but less than the fair market value rent.

(c) An aquatic farmsite permit is subject to the provisions set out in this section in addition to the general provisions of 11 AAC 63.110.

(d) A permit might be also subject to special provisions that the commissioner imposes to make it consistent with the Alaska Coastal Management Program or that the commissioner otherwise considers necessary to serve the state's best interests.

(e) The aquatic farm development plan and schedule proposed in the application, as approved or amended by the commissioner, is incorporated as a provision of the permit.

(f) A permit will, in the commissioner's discretion, be cancelled, in whole or in part, if the permittee obtained it improperly through misrepresentation or error with respect to material facts.

(g) A permittee may apply for no more than two renewals of a permit, for an additional three years for each renewal. A new written finding is not required before the commissioner renews a permit. The commissioner will renew a permit if the commissioner is satisfied, based on information submitted by the permittee and testimony provided by interested persons after notice under AS 38.05.856 and notice to the upland owner, that

(1) the permittee is in substantial compliance with the permit's provisions and is in operation, or

(2) the permittee is in substantial compliance with the permit's provisions except that the permittee is not in operation, and that the failure to comply with the aquatic farm development plan and schedule and to begin operating is due to circumstances beyond the permittee's control. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.035
AS 38.05.850
AS 38.05.855
AS 38.05.856

11 AAC 63.080. REQUIRED SECURITY. For any aquatic farmsite permit or lease, a bond, cash deposit, certificate of deposit, or other form of security acceptable to the commissioner must be posted and maintained in an amount determined by the commissioner to be sufficient to cover the cost of site cleanup and restoration and any associated cleanup costs. Factors that the commissioner will use in determining the amount of the security include travel costs to reach the site for cleanup or inspection; the planned size and extent of improvements; whether the improvements (including associated facilities on state land) could be towed away for use by other operators, burned onsite, or disposed of at an authorized landfill; and whether heavy equipment would be needed for upland site restoration and filling a foundation excavation. The commissioner will, in his or her discretion,

subsequently change the amount of the required security, based on changes in the level of site development, new information, or other appropriate factors. The commissioner will, in his or her discretion, reduce the amount of the security if the property is subject to a collateral assignment as security for financing and the collateral assignee agrees to assume the permittee's or lessee's obligations and restore the site if the permittee or lessee defaults. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.035
AS 38.05.083
AS 38.05.856

11 AAC 63.090. TRANSITION; PERMITS UNDER AS 38.05.850. (a) If the commissioner finds that it is in the state's best interest to issue an aquatic farmsite permit, a person who has a permit in good standing that was issued under AS 38.05.850 for mariculture testing or development purposes has a preference right to the aquatic farmsite permit if

(1) as of June 9, 1988, the person was either lawfully operating an aquatic farm at that site, or had obtained and was complying with all permits necessary to operate an aquatic farm at that site and, in reliance on those permits, had undertaken the initial steps that would lead to full-scale operations; photographs, purchase orders, receipts, or other evidence acceptable to the commissioner must be provided to establish eligibility; and

(2) the person files a complete application for the site during the appropriate district application period.

(b) An application filed by a person who has a preference right to the site under (a) of this section is exempt from the amendment procedures of 11 AAC 63.030(e) and the lottery procedures of 11 AAC 63.030(d).

(c) A person who has a permit issued under AS 38.05.850 but who does not otherwise meet the requirements of (a) of this section does not have a preference right to an aquatic farmsite permit that might be issued for the site. However, the person may apply for an aquatic farmsite permit on a non-preference-right basis. If another person is chosen as the successful applicant, or if the commissioner decides that it is not in the state's best interest to grant an aquatic farmsite permit for the site, the commissioner will revoke the permit issued under AS 38.05.850 after reasonable notice to the permittee.

(d) A permit in good standing that was issued under AS 38.05.850 to a person who might have a preference right under (a) of this section will be renewed until the site is included in a district application period. In the interim, the permittee may continue operating so long as all required permits remain in good standing and no change of use occurs.

(e) Except as follows, no new permit will be issued under AS 38.05.850 for aquatic farming purposes unless the applicant filed a complete application before June 9, 1988:

(1) A person may obtain a permit under AS 38.05.850 solely to test a site's suitability for aquatic farming or, to the extent allowed by 11 AAC 96, may undertake such testing without a permit from the department. A permit for testing site suitability under AS 38.05.850 is limited to a period of no more than one year and the total area within which testing occurs may not exceed one acre. Testing includes placing data collecting equipment and up to 10,000 organisms in the water. The organisms may not be used for commercial purposes. A permit under AS 38.05.850 for testing site suitability may not be renewed.

(2) In an emergency, such as a dinoflagellate plankton bloom that could result in an unacceptable concentration of toxins in shellfish, the director will use his or her discretion under AS 38.05.850 to authorize the relocation of rafts or other rearing structures to another location until the emergency ends. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.083
AS 38.05.850
AS 38.05.855
AS 38.05.856
Sec. 18, ch.
145, SLA 1988

11 AAC 63.100. AQUATIC FARMSITE LEASE. (a) If the commissioner finds in accordance with AS 38.05.035(e) that it is in the state's best interest to issue an aquatic farmsite lease, an aquatic farmsite permittee who has developed the site for aquatic farming or related hatchery operations in accordance with the permit's provisions has a preference right to lease the site at its appraised fair market value without competitive bid. A person who does not have an existing aquatic farmsite permit may not apply for an aquatic farmsite lease.

(b) An aquatic farmsite permittee who has not succeeded in developing the site for aquatic farming or related hatchery operations does not have a preference right to any lease that may be offered for that site. However, if the commissioner offers the

lease at public auction, the unsuccessful permittee may bid for the lease. The commissioner will offer a former permit site for lease at public auction only if the former aquatic farmsite permittee does not qualify for a preference right or chooses not to exercise the preference right. (c) The term of an aquatic farmsite lease is 10 years. If the lessee applies for an extension before the lease's last day, the commissioner will, in his or her discretion, extend the term for an additional 10 years. The commissioner will, in his or her discretion, require a lease diagram before issuing the lease. Before the commissioner extends a lease, the commissioner will determine whether AS 38.04.045 or a successor statute requires a cadastral survey. If AS 38.05.102 or a successor statute is still in effect when the lease expires, the lessee may apply for a new lease in accordance with that statute.

(d) Before a lease is issued, security must be posted as required by 11 AAC 63.080.

(e) Unless the commissioner grants a variance for good cause, the lessee shall continue to operate the aquatic farm or related hatchery at or above the operating level reached when the permittee applied for the lease. For a lease offered at auction, the commissioner will either impose a minimum lease operating level or require the bidder or lessee to propose a lease operating plan for the commissioner's approval.

(f) A lease that is in good standing may, with the approval of the director, be assigned. The assignee shall promptly and diligently seek to obtain all permits necessary for lawful operations.

(g) Lease rental must be paid annually on or before the anniversary date of the lease. (Eff. 7/1/89, Register 110)

Authority: AS 38.04.045
AS 38.05.020
AS 38.05.035
AS 38.05.083
AS 38.05.856
AS 38.05.920

11 AAC 63.110. GENERAL PERMIT AND LEASE PROVISIONS. An aquatic farmsite permit or lease will contain at least the following provisions:

(1) A permittee or lessee shall operate so as to cause no significant damage to land, public trust resources, and public uses of public trust resources.

(2) A permit or lease is subject to all applicable federal, state, and local law, including statutes and regulations in effect on its effective date; statutes and regulations placed in effect after its effective date, to the extent constitutionally permissible; and the public trust doctrine regarding the public's right to use navigable waters and the land beneath them for navigation, commerce, fishing, and other purposes.

(3) A permittee or lessee shall obtain and remain in compliance with all other federal, state, and local authorizations necessary for lawful operations.

(4) The commissioner will, in his or her discretion, after the application fee required by 11 AAC 05.010 has been paid, amend a permit or lease to change the species of shellfish or aquatic plant being raised or to change the boundary or acreage of the aquatic farmsite, or the number of rafts or other rearing structures authorized, if the change is minor and does not increase obstructions to navigation or to other public use. However, no change of use, as that term is defined in 11 AAC 63.900, will be authorized. Amendment of an aquatic farmsite permit or lease does not relieve the permittee or lessee of the obligation to obtain other necessary authorizations.

(5) A permittee or lessee and its invitees may not use an aquatic farmsite for any unlawful purpose.

(6) A permittee or lessee may use an aquatic farmsite only for the purposes authorized by the permit or lease, and the state reserves all other interests in the site. The rights granted by the permit or lease must be exercised in a manner that does not unreasonably interfere with the rights of the state or of its permittees, lessees, or grantees, consistent with the principle of reasonable concurrent uses as set out in art. VIII, sec. 8, of the Alaska Constitution. A permittee or lessee shall pay for any damages that are payable by reason of the permittee's or lessee's failure to comply with the requirements of this paragraph.

(7) A permittee or lessee shall comply with the approved development plan and schedule or the approved lease operating level.

(8) A permittee's or lessee's failure to timely perform its obligations under the permit, or otherwise to comply with all express or implied provisions of the permit, constitutes a default. If a permittee or lessee fails to cure the default or to begin and diligently continue to remedy the default within 30 days after written notice of the default and an opportunity to be heard, the commissioner will order suspension of site development

or operations until compliance is achieved, or will take other action that the commissioner finds appropriate, including revocation of the permit or lease or attachment of the site restoration security.

(9) With the commissioner's written consent, a permit or lease that is in good standing may be relinquished. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.035
AS 38.05.083
AS 38.05.085
AS 38.05.855
AS 38.05.856

11 AAC 63.900. DEFINITIONS. (a) In this chapter,

(1) "aquatic farm" has the meaning given in AS 16.40.199;

(2) "aquatic farmsite permit" means a property right to improve and develop state-owned public domain land as an aquatic farm or related hatchery;

(3) "aquatic farmsite lease" means a lease to operate an aquatic farm or related hatchery on state-owned public domain land;

(4) "change of use" means (A) a change from one species of shellfish to a species other than shellfish, or from one species of aquatic plant to a species other than aquatic plants, (B) a change in the location of the aquatic farmsite, (C) a significant increase in the aquatic farmsite's acreage, or (D) a significant increase in the surface area of the farmsite that is encumbered by rafts or other rearing structures;

(5) "commissioner" means the commissioner of the Department of Natural Resources or the commissioner's delegate;

(6) "department" means the Department of Natural Resources;

(7) "director" means the director of the division of lands or the director's delegate;

(8) "good standing" means being in compliance with all provisions of all required authorizations;

(9) "pending use" means a project documented by government agency plans or authorizations, the acquisition of property rights, or other evidence of investment-backed expectations that the use will occur;

(10) "primary anchorage" means a large or heavily used anchorage, or an anchorage for which there is no reasonable alternative with comparable protection from locally prevailing weather conditions.

(b) In this chapter and in AS 38.05.083, "developed for aquatic farming or related hatchery operations" means that all planned capital improvements are in place and functioning at their planned capacity to produce aquatic plants or shellfish; however, the aquatic plants or shellfish need not be marketed or have reached marketable size in order to fulfill the development requirement. (Eff. 7/1/89, Register 110)

Authority: AS 38.05.020
AS 38.05.083
AS 38.05.085
AS 38.05.855
AS 38.05.856
AS 38.05.920
AS 38.05.945
AS 38.05.946
Sec. 18, ch.
145, SLA 1988



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910
Office of International Affairs
Foreign Fisheries Analysis Branch

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THE LATEST DEVELOPMENTS IN WEST EUROPEAN AND CANADIAN FISHERIES
(MARCH 1989)

The Branch of Foreign Fisheries Analysis, Office of International Affairs, which follows trends in world fisheries for the National Marine Fisheries Service (NMFS), NOAA, has prepared the following summary of recent significant fishery developments in Western Europe and Canada. This report was prepared by William B. Folsom and Brian D. McFeeters with the assistance of U.S. Foreign Service posts in Western Europe and Canada.

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I. EUROPE:

U.S. Fishery Trade, 1988 — The United States imported 163,600 metric tons (t) of fishery products worth \$2.4 billion from all the nations of Europe (including Eastern Europe and the Soviet Union) in 1988. U.S. exports to Europe were 156,000 t valued at only \$0.3 billion. (WF: U.S. Bureau of the Census)

II. EUROPEAN COMMUNITY (EC)

A. General

EC Fleet Reduction — The EC Fisheries Commission is planning to lift a freeze on the construction of new fishing vessels among EC Member States. This action comes despite the fact that only two countries (Denmark and Portugal) met their commitments to reduce the capacity of their fishing fleets in 1987. It also comes at a time when quotas for many countries (and species) are being reduced. (WF: Fishing News International, January 1989).

EC in South America — The EC has initiated a major new effort to expand its influence in South America. The EC has signed a \$10 million program with Peru, Ecuador, and Colombia to develop and expand their fisheries. The program will involve many phases of fisheries development and training. Details on the benefits that will go to the EC were not reported, but the EC is interested in finding new fishing grounds for its fleet. (WF: Fishing News International, January 1989)

See page 2



Icelandic Fish to Japan — Flying Tigers, a U.S. air cargo firm, has started using Iceland as a refueling stop on its flight from Europe to Japan. An Icelandic firm, Flugfax, has been established to sell cargo space on Flying Tigers; the firm hopes to ship as much as 200 t of fish (or other products) a week if the market for Icelandic products justifies additional flights. The first shipment from Iceland, on January 10, 1989, consisted of 3 t of herring, salmon, and haddock—all less than 24 hours old. Exporters hope that Japan will offer a market for products that are not popular in Iceland or in its traditional markets, including monkfish heads and cheeks and fish livers. It also hopes to expand sales of fresh, farm-raised salmon. (WF: U.S. Embassy, Reykjavik, February 7, 1989)

Norway's Arctic Cod — Norwegian scientists have estimated that the Arctic cod stock is at its lowest level in the past 120 years. Norwegian scientists believe that the total 1989 stock is 855,000 t versus 1,400,000 t in 1988 and estimate the spawning stock at only 187,000 t. Scientists say that the spawning stock could reach 400,000 t by 1991, if steps are taken immediately to protect it. Scientists would like to set the Arctic cod TAC at 300,000 t for 1989. (WF: Fishing News International, January 1989)

Norway Targets UK — Norway is launching a major offensive to increase exports of fresh and frozen fishery products in the UK in 1989. Norway increased its exports to the UK by 50 percent in 1988 (to 9,500 t worth \$55 million) and hopes to sharply increase these figures in 1989. The UK purchased 2,155 t of fresh and frozen Norwegian salmon worth \$17 million (44 percent higher than in 1987). Sales of frozen demersal fillets averaged about 30,000 t and shrimp exports rose from 2,700 t to 3,600 tons. Weekly shipments of fresh fish by truck and ferry, and a newly introduced fast catamaran service from Norway to the UK have helped expand sales. (WF: Fishing News, February 10, 1989)

Norwegian Farmed Salmon Escaping — An estimated 1 million farmed salmon have escaped from fish farms along Norway's coast during the 1988/89 winter, prompting concern among fisheries scientists that the wild salmon gene pool may become irreparably damaged. There are many breeds of Norwegian wild salmon, each of which returns to spawn in a specific river. Fisheries scientists fear that interbreeding with farmed salmon could upset genetic characteristics of wild salmon which have taken thousands of years to evolve—including the innate ability of salmon to find their way back to the river where they were spawned. (BM: Norinform, February 14, 1989)

Norwegians Fight Fish Lice — Norwegian salmon farmers are conducting tests to determine whether small wrasses can improve the health of pen-raised salmon. Preliminary tests indicate that fewer than 1,000 labrid fishes (such as gold sinny, a member of the wrasse family indigenous to Norway) can protect a pen of 26,000 salmon fry from salmon lice. Such parasite infestations have previously been prevented using medication. If tests prove successful, use of the small fish may replace chemical treatment of farmed salmon. (BM: Norinform, February 14, 1989)

Alaska Department of Fish & Game
GENETIC POLICY

by

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Date: 6.11.85