

# SJÁVARÚTVEGURINN

## VEFRIT UM SJÁVARÚTVEGSMÁL

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Sjávarútvegurinn - Vefrit um sjávarútvegsmál

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### Cod Farming in Nordic Countries

Summary of the main points from the conference held in Nordica Hotel,  
Reykjavík 6 - 8 September 2005

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#### Introduction

This conference aims to give an overview of cod farming activities and research in Nordic countries and define future challenges. The conference was running alongside the Icelandic Fisheries Exhibition and held in Nordica Hotel, Reykjavík 6 - 8 September 2005. This is the second Nordic Cod Farming Conference. The first conference was held in February 2003 in Bergen.

This conference was organized by the Nordic Cod Farming Network in co-operation with the AVS Aquaculture group in Iceland. AVS stands for Added Value in Seafood which is a project launched by the Minister of Fisheries to look at possible ways to increase the value of Icelandic fisheries products. The Nordic Cod Farming Network is a cooperation project involving representatives from the Faeroe Islands, Denmark, Sweden,

Iceland and Norway ([www.torsk.net](http://www.torsk.net)).

The conference was divided into six sessions: juvenile production and selective breeding, farming of wild cod, on-growth and rearing technology, health and environmental considerations related to cod farming, status and perspectives in cod farming in Nordic countries and finally quality, processing and marketing. A total of 28 presentations were given at the conference by speakers from Iceland, Norway, Faeroe Islands, Denmark, Sweden, Canada and

USA. Total number of participants was 157 from 12 countries. Additionally, there were participants coming from Chile, Germany, Ireland, Russia and United Kingdom.

Presentations and photos from the conference and excursion can be seen on the conference web site: <http://www.fiskeldi.is/codconference.html>



From the conference room on Tuesday (Photograph: Valdimar Ingi Gunnarsson).



*The Minister of Fisheries reception on Tuesday (Photograph: Valdimar Ingi Gunnarsson).*



*Norwegian Cod Breeding Centre opened August 2005 with capacity to start feed 300 full-sib groups (Photo from Atle Mortensen's presentation).*

Sponsors to Cod Farming in Nordic Countries were Nora - Nordic Atlantic Co-operation, AVS fund, fisheries companies and firms in Iceland. Nordic Cod Farming Network and AVS Aquaculture group in Iceland wish to thank the sponsors for grants and the speakers for their presentations.

### Address by Minister of Fisheries

In the book of abstracts, the Minister of Fisheries in Iceland said in his greetings: "Cod farming on a large scale is a challenging undertaking for all our countries and the stakes are high. State of the art research and knowledge form the basis on which cod farming can grow into a prosperous industry. The Icelandic Ministry of Fisheries is therefore emphasising this field and directing research funds into projects that improve our knowledge of cod farming". "The market for cod has existed for many centuries and parts of our countries have maintained their economic viability by catching and supplying cod to the market. The traditional cod fishery is basically stable but the market for cod is always ready for more. Cod farming is therefore a logical step in the progress of our Nordic economies".

In his opening speech the Minister of Fisheries said: "I want to urge caution here, but at the same time not to discourage initiative. We have learned valuable lessons from the aquaculture misadventures of the past and know that any actions must be founded on solid research knowledge. Which is why a conference such as this one is extremely important".

### Juvenile production and selective breeding

A programme for selective breeding of Atlantic cod was initiated by the Norwegian government in 2002. The production of family groups (full- and half-sibs) started in 2003. The base population of the breeding programme consists of wild caught coastal cod from the Western and Northern Norway and Northeast Arctic cod. Norwegian Institute of Fisheries and Aquaculture Research (Fiskeriforskning) was given the task of establishing and running the programme. All necessary facilities for the breeding programme are now established and operative. These include a breeding station for the juvenile production and a cage farm for the grow-out phase. In addition two test stations (cage farms), one outside Bergen and one in the northernmost county (Finnmark), have been put to use. The aim is to reveal genotype-environmental interactions. In one study in Norway interactions between environment and genotype in individually tagged Atlantic cod juveniles have been demonstrated. Norwegian government selective breeding programme has collected approximately 200 viable families in the years 2003-2005. Other scientific activities involve disease resistance, juvenile production / water quality, database development and DNA-markers.

In 2002, Akvaforsk Genetics Center Ltd. established its subsidiary MarineBreed Ltd. for the development and sale of genetically improved material of Atlantic cod. The first batch of families was produced by single pair mating in 2002. The company operates its family based breeding nucleus at Sunndalsøra, and is currently performance testing 88 selected F2





*Marine Research Institute, Mariculture Laboratory (Photo from Agnar Steinarsson's presentation).*



*From the excursion to the Marine Research Institute, Mariculture Laboratory on Wednesday (Photograph:*

families. The first selected material was marketed in February 2005, and is now used in commercial production by several cod farmers in Norway. MarineBreed breeding goal are: Increase growth rate and feed efficiency, delayed early sexual maturation, improved carcass quality (fillet yield) and improved disease resistance.

The IceCod Ltd. family selection programme for cod farming began in the year 2003 in Iceland. Over 705 family groups were produced from 10 different spawning sites around Iceland. Approximately 350 viable families have been established and will be used to form the base population for the selection programme. The main role of IceCod is to create and run a selective programme for cod based on DNA profiling, where the breeding nucleus is kept in land-based farms in Iceland. Eggs or fry from the nucleus can be disseminated throughout the industry. IceCod in cooperation with the biotechnology company Prokaria is developing fast and efficient techniques to profile individuals to their parents to make a full pedigree. Since 2003 a computer simulation model has been developed. The programme estimates the optimal number of individuals and/or families needed (numbers of dam and sire per year), to maximize the gain with constrained rate of inbreeding to run the breeding programme at the lowest possible cost. Selective breeding of cod have not yet started in Faeroe Islands, Denmark and Sweden.

In Canada they have newly started with the project "Cod Genomics and Broodstock Development" (CGP). The overall goal of the CGP project is to develop a breeding program and a set of fundamental genomics tools which will be used to supply the developing Atlantic cod aquaculture industry in Canada with improved broodstock.

In Iceland there is only one marine hatchery specializing in the production of cod fry for aquaculture. At the Marine Research Institute in

Grindavík (MRI), the production of cod fry has been carried out on a research scale since 1994. Under Icecod a selective breeding program was launched and the cod production taken to a semi-commercial scale in MRI's new hatchery. During the three following years, the hatchery has produced over 200,000 cod fry per year which have been delivered to cod farms in Iceland and the Shetlands.

Quality of farmed juveniles has been defective both in Norway and Iceland mainly due to spinal deformities. Last year the frequency of deformities in juveniles stocked in sea cages decreased both due to improvements in culture methods and quality grading.

The project NorthCod with participants from Iceland, Norway, Scotland and Russia, aims to contribute to a successful and sustainable development of cod production in hatcheries in northern regions by working on standardization of production methods, brood stock management and by publishing a manual on hatchery production of cod. The project is uniquely organized around networks of research institutes and producers of juvenile cod in the participating countries. All of the partners bring with them their experience and know-how on the production of marine finfish which will fast-track the learning curve and provide more rapid dissemination of new and innovative production methods.

### Farming wild cod

Capture-based aquaculture is the capture of live animals from the sea in order to store or grow them to improve their size, quality and market value.



*Modified sea cage used as a trap (Photo from Björn Björnsson's presentation).*



*Panel in session 3: On-growth and rearing technology (Photograph: Valdimar Ingí Gunnarsson).*

Capture-based aquaculture has been growing last years in Norway. Recent R&D on capture-based aquaculture on cod has mainly focused on increased survival and lowering incidents of wounds and damages. Several gears have been evaluated, but seine-net still dominates the catches. At present approximately 20 vessels are active in this fishery, the majority north of Vestfjorden (68 °N). As the Norwegian industry in capture-based aquaculture of cod is growing from its present 1500 tons, there will be increased concern regarding welfare. New legislations are being put forward to regulate this industry and make it even more fish-welfare friendly.

In 2002 the Ministry of Fisheries in Iceland decided to allocate 500 ton quota annually to promote cod farming in Iceland. Quotas are allocated to 10-12 farmers, the amount depending on how much cod was produced on the farm, their scientific contribution and the quality of their report. Each year MRI organizes a meeting with cod farmers to discuss their farming results and priorities in R&D. Specialists at the MRI in collaboration with cod farmers compile results from all the fish farms in one report published by MRI. Wild cod (1-2 kg) for on-growing are mainly caught with seine-net, but also with Newfoundland trap and other type of traps, shrimp trawls, longlining and jigging. The cod are still mainly fed with capelin.

Two experimental studies of fjord ranching of cod have been carried out in Iceland, one in Stöðvarfjörður, a small fjord on the east coast in 1995-96 and one currently in progress in Arnarfjörður, a large fjord on the northwest coast. In the former project it had been established that wild

cod could be conditioned to feed regularly in certain feeding areas. The conditioned fish were annually gaining three times more weight than their wild counterparts. Regular feeding in the latter project began in April 2005 and in June four "herds" of cod had been established. The estimated biomass of the herds in July was about 100 tons. The plan is to capture the conditioned cod with a pocket net equipped with feed bags and also to try to develop a special trap made of a sea cage with a large opening on the bottom which can be closed after luring the fish with a feed bag into the cage. The largest fish can be slaughtered at the time of capture whereas the smaller fish will be reared to market size in sea cages. One of the aims of the study is to find out if fjord ranching can be operated economically on a commercial scale. It is not inevitable that cod farming based on selective breeding will be the only form of cod production in the future. On the contrary, harvesting the wild cod stock will always be economically feasible. The main aim with fjord- or sea-ranching is to harvest the cod stock (and its valuable prey stocks) in an optimal way.

Experimental capturing of wild 0-group cod has been carried out since 2001 in Ísafjardardjúp, a large fjord on the north-west coast of Iceland. Wild juveniles (3-5 g) are caught in autumn with a shrimp trawl and reared in a land based farm (Háafell Ltd) until spring and then in sea cages to market size. In August 2004 a total of one million 0-group cod were captured and around 450,000 juveniles stocked in sea cages in 2005.

## On-growing and rearing technology

One of the big challenges in developing cod farming in Nordic countries is to prevent early sexual maturation of farmed cod before they have reached optimum marketable size. This problem is caused by the surplus food we offer farmed fish. Experiments have been carried out using additional submerged lights to delay maturation and spawning, with varying results. During the spawning period the cod will use a lot of energy to produce roe and milt. The sexual development will lower growth, increase mortality, reduce feed efficiency and increase the rearing cost. Future research must concentrate on improving lighting systems and study their effects in commercial sea-cages, and study lighting thresholds and light perception of cod.

Feed, feeding, growth rate and FCR (feed conversion ratio) are of great importance to reach the goal of profitable farming. Several feed companies have been running many feed trials to develop the best and most economical feed. Now there is ongoing a Nordic project "Feed for Atlantic cod" with participants from Iceland, Norway, Faeroe Islands, Denmark and Sweden. One of the conclusions from this project is that soybean meal (60%) can substitute fishmeal with no effect on growth, yield or quality of the final product (*post rigor* filets). Soyabean oil appears also to be a good alternative to marine oil. Optimum distribution of feed both during the day, and what is the optimum depth and temperature for feeding and growth are other challenges. Several cod farms in Norway are using feed equipment that is run by AF (appetite feeding). The potential for reducing FCR is large.

In Norway there have been problems with cod escaping from sea cages. Farmed cod have been observed biting the threads in the net and making holes. Escape has to be controlled by better net quality and drifting routines.

## Health and environmental considerations related to cod farming

Increasing frequency and diversity of diseases are being detected in cod farming in Nordic countries. There are, however, limited data about different causes of mortalities in today's cod farming. Some similarities in disease patterns are emerging, but there are also certain differences between geographic areas. The main health problems



*Sigurður Helgason speaker in session 5: Health and environmental considerations related to cod farming (Photograph: Valdimar Ingi Gunnarsson).*

encountered can be focused on: a) hatching and larval rearing and b) juveniles and the on-rearing phase to slaughter size fish. The former category involves aspects of nutrition and different physical parameters related to the rearing environment, in addition to certain infectious diseases. Fish of the second category are mainly affected by infectious agents.

There is still much to be learned about exact nutritional requirements for different age groups of cod. Especially this is true for brood fish and their offspring, as a proper nutritional status of the larvae is vital for their development and health in later life. During the hatching and larval development various skeletal and organ deformities have been observed causing major direct and indirect losses at this life stage. After metamorphosis mortality rates decrease significantly and are mainly due to various infectious agents. Among viruses, infectious pancreatic necrosis (IPN) virus and nodavirus causing viral neural necrosis (VNN) should be ranked as highly significant. These viruses are detected in many marine fish species, and are especially lethal to their larval and juvenile stages. IPN-virus caused heavy losses among farmed cod juveniles, both in Denmark and Faroe Islands, several years ago, and there are recent reports of serious nodavirus outbreaks in juvenile cod in USA, and Canada. Nodavirus outbreaks have also been reported from Scotland. In Norway one of the most significant pathogens of cod larvae and juveniles is the bacterium *Listonella (Vibrio) anguillarum*, but in Iceland this is still more of a problem in older fish. In Iceland one of the major pathogens of concern is the bacterium *Aeromonas salmonicida* subspecies *achromogenes*, causing





From the reception on Tuesday (Photograph: Valdimar Ingí Gunnarsson).

losses at all age classes of cod. This bacterium is not yet a problem in farmed cod in other countries. Parasites have not caused significant problems. In Iceland, however, *Loma* sp. is emerging as a serious pathogen among farmed cod of wild origin; in Scotland on the other hand, there is an increasing concern of fish lice.

The only cod vaccines available are against *L. anguillarum*. Water based vaccine do not give 100% protection and oil based vaccine is under testing. The impression is that the vaccine must be improved and there are large differences in the effect of the vaccine.

The present geographic differences in disease patterns mentioned above highlight the difficulties when attempting to predict significant disease threats in the future rearing of a particular fish species, and in which direction future research should be focused. Apparently it is urgent to: 1) collect data of disease outbreaks, and relate them to geography, environmental conditions, cod populations and pathogens involved; 2) develop nutritionally sufficient food for different life stages of cod; 3) improve larval and juvenile rearing techniques; 4) develop vaccines and vaccination techniques against hazardous pathogens, and 5) study the virulence and transmission of potential pathogens to farmed cod.

In Iceland, 258 wild and 282 farmed cod were collected during a temporal study carried out at a spawning ground located south of Iceland. The aquaculture strain had less genetic variability than their native source population both in terms of allelic diversity and heterozygosity. With microsatellite loci, whatever the year considered, the farmed samples



Panel in session 6: Quality, processing and marketing (Photograph: Valdimar Ingí Gunnarsson).

exhibited a lower mean number of alleles and level of heterozygosity than the wild samples, indicating a reduction of genetic diversity due to selection of individuals. The presentation provoked discussion and criticism by the audience of the methodology used and the conclusions made by the speaker. These are the kind of discussions we can expect in the future about the possible effects selective breeding and interbreeding of farmed cod can have on the wild cod population.

### Quality, processing and marketing

For future marketing and sales of aquaculture products the main issues will be the consumers' demands and preferences. The important food products will be prepared as fresh/chilled, organic and functional foods - ready made meal solutions instead of traditional meal ingredients. This includes innovation in products, packaging, distribution channels and eating out-of-home opportunities.

Aquaculture makes it possible not only to produce safe, healthy and fresh seafood but also seafood with targeted nutritional benefits for the consumer. However, the average fish consumption is below the recommendations given by the FDA and other agencies in Europe. Omega 3 fatty acids are known to be a healthy food component and about 80% of omega 3 fatty acids in the diet in Iceland are of seafood origin. Even lean fish species such as Atlantic cod, are an important source of omega 3 fatty acids. Proteins as nutritional components of seafood origin are receiving an increased attention. It is known that only about 10% of proteins in the human diet are of seafood origin.



Magnus Skretting and Jørgen Borthen from Norway  
(Photograph: Valdimar Ingi Gunnarsson).

Genetic potential for maximum cod quality product and optimal fish health are important. However, the nutritional parameters, quality and the safety of the product need to fulfil the consumer's expectations.

Production of farmed fish gives the possibility to control the handling through the overall production line from feeding to the consumer. The production of farmed cod offers new possibilities in processing and quality control and traceability.

Farmed cod are mainly sold fresh. From Iceland slaughtered wild farmed cod are mainly exported whole fresh with head or headless. Slaughter weight has increased and is now generally 5-6 kg.

In a market study "Perceptions of Farmed Cod in the US - Issues and Opportunities" these were the key conclusions: farmed cod has great potential in the US, groups are conscious of consumer perceptions of wild/farmed products, it is important for the industry to promote eco-friendly, sustainability of farmed cod, the producers/suppliers should be proactive in educating industry and general market on product safety, traceability and finally "Country of Origin". The last point gives an opportunity to develop solid association between brand/origin = quality/value parameters, so that country of origin does become important.

A short review was given about cod farming in Canada which is one of the countries that could possibly compete with cod farming in Nordic countries. Production from hatchery was around 0.5 million juveniles in 2004, but the production of farmed cod is still restricted mainly due to limited capital for ongrowing.

## Status and perspectives in cod farming in Nordic countries

### Norway

In Norway juvenile cod (>2 g) production has increased from one million in 2001 to five million in 2004. Prognosis for the year 2005 is 8-10 million juveniles sold to on-growing farms. In Norway there are 12 companies with juvenile production in 2005.

Production of farmed cod was 3,200 tons in 2004. It is expected that the total production of farmed cod will be around 5000 tons in 2005. This volume will increase in the nearest years, and the plan is to yearly produce 100,000 tons in the years 2010-2015. Production in Norway is mainly based on hatchery produced cod fry.

In Norway there is a communication network called *Go for Cod!* consisting of producers, researchers, land-based industry related to farming, exporters and also institutions, non-governmental and governmental organizations. The network is working with information vertically and horizontally.

### Iceland

The interest in cod farming amongst the fisheries companies in Iceland has been growing. Several of them have already started some farming trials with cod. The main objective for fisheries companies is to find out if it is possible to make a profit out of cod farming in Iceland.

In the year 2004 and 2005 around 0.5 million juveniles have been stocked in sea cages each year mainly wild juveniles captured for ongrowing. Production of cod has increased from a few tons in the year 2000 to 600 tons in 2004. Prognosis for the year 2005 is that production will exceed 1,000 tons, 2,000 tons for 2006 and 3,000 tons for 2007. Production is mainly based on ongrowing of wild cod which may be a temporary solution while progress is being made in selective breeding. Next year we get juveniles from the second generation of selective breeding and with every new generation we expect increased demand for hatchery produced cod juveniles. But, before scaling up the production we need to develop vaccines, acquire more knowledge about diseases and prevent sexual maturation of farmed cod.

Today the on-growing of wild cod is profitable for some farmers in Iceland. This form of cod farming

may not be able to compete in the long run with cod farming based on selective breeding. It is still too early to tell if cod farming in Iceland can in the future compete with cod farming in the neighbouring countries. The environmental conditions for farming cod in sea cages may be less favorable in Iceland than in countries such as Norway and Scotland. But we hope that some other factors will be more favorable in Iceland. If it turns out to be profitable to farm cod in Iceland a large increase in production is to be expected after the year 2010.

### Denmark

Today there is no commercial cod farming in Denmark. Since marine cage culture is not an option in Denmark due primarily to environmental considerations, work will focus on assessing the economical viability of rearing cod in land-based recirculation systems. The aims of a new two year project are to provide the relevant information on optimal temperature, fish density, food conversion and growth in North Sea cod reared in recirculation systems.

In the case of the Baltic Sea cod, it has been shown that there is a potential for restocking and thus rearing activities focus on brood stock and hatchery facilities to provide the fry for stocking. The aim of a new pilot study is to enhance the stock by 10% of the average year class.

### Faroe Islands

Today there is no cod farming in Faroe Islands. In the spring of 2005, Fiskaaling received enquiries from three Faroes companies, considering to order more than 100,000 juveniles in 2006. Fiskaaling now aims at collecting cod this fall (2005) for spawning next spring and at producing a number of juveniles relevant in magnitude to indications yet to be given by the industry. If Faroese cod culture expands, the initiation of a breeding programme is essential.

### Sweden

An attempt was done in 2002 to start commercial

farming based on hatchery reared cod. The results were, however, poor and the enterprise was laid down after only one year test-production. Today there is no cod farming in Sweden.

To find out the future potential for cod farming in Sweden a feasibility study was carried out and a report published "The prerequisites for, and potential of, cod farming in Sweden". The general conclusion was that cod farming is feasible in Sweden and the development of such activities should be encouraged.



*Josianne Støttrup from Denmark and P-O Larsson from Sweden (Photograph: Valdimar Ingi Gunnarsson).*

*Grein þessi hefur áður birtst á vefnum fiskeldi.is í nóvember 2005.*



# NORA

Nordic Atlantic Cooperation