ENVIRONMENTAL REPORT

Environmental report for Norwegian aquaculture with an emphasis on statistics and facts for 2008

Norwegian Seafood Federation

Preface

The world faces many challenges in the environmental area. These are challenges that require both preparedness and action in order to be solved. At the same time we have a growing population that demands increased food production, preferably of healthy consumer products.

Producing food also results in an environmental cost, regardless of whether it is harvested directly from natural resources on land, in freshwater or in the sea – or if it is to be produced and processed. FHL's environmental policy goal is that *seafood production shall be environmentally sustainable and environmental contamination shall not restrict the potential to produce safe seafood.* It is about operating in such a way that the environmental impact is minimised and kept within acceptable limits.

This is FHL's first environmental report for the aquaculture sector. There are two intentions with this report. The industry wishes to have a joint and concise summary of the knowledge, status and challenges regarding environmental issues. At the same time we wish to spread the same information to politicians, the public and interest organisations. Dialogue and openness are important and a necessary basis for debate and co-existence between the various interests along Norway's coast.

In order to contribute to a knowledge-based discussion about these questions, FHL aims to provide regular updates related to the topics illuminated in this report.

The members of FHL cover feed producers and fish farmers of shellfish, marine fish species and salmonids. Since the industry operators represent the entire value chain from roe and fry to harvestable shellfish and fish ready for slaughter, this report must necessarily be mostly general. This first edition covers subjects that concern the majority of the industry and that are most relevant to the current debate in society regarding aquaculture, the environment and sustainability.

The environmental report is based upon facts and analyses from FHL and industry operators, authorities and the administration as well as a number of research and expert bodies. FHL is responsible for the publication.

More information about FHL's work on environmental issues can be found at www.fhl.no/miljo.

We hope you find this report useful.

Oslo, August 2009

Ole-Eirik Lerøy

Chairman of the Board
The Norwegian Seafood Federation

Contents

	Summary	5
1	**Sustainable food production**	8
2	**About FHL**	10
2.1	About FHL and its members	10
2.2	FHL and environmental work	11
3	**Use of raw materials and natural resources**	13
3.1	Use of marine areas	13
3.2	Release and production of fish	16
3.3	Utilisation of by-products and residual raw materials from production	18
3.4	Feed and feed raw materials	19
3.5	Energy use	28
4	**Escapes**	30
5	**Sea lice**	39
6	**Emissions from aquaculture**	45
6.1	Climate accounting for the aquaculture industry	45
6.2	Nutrient emissions and organic materials	46
6.3	Use and emissions of chemicals	54
7	**Waste and waste handling**	56

Summary

The Norwegian coastline is long and characterized by many fjords with high water exchange making it both robust and highly suitable for aquaculture. The coastal areas represent a major potential for seafood production but also demand that commercial operators are aware of their responsibility with regard to the environmental impact of fish farming. The government's strategic plan for aquaculture states that the "environmental status in the industry is generally good, and with regard to the growth in production the environmental effects have been less over the years in relative terms".

Norwegian aquaculture depends on natural resources. As an efficient and important producer of good and healthy food, the industry aspires to continued growth and development. There is also broad political agreement on this. It is thus both necessary and an important goal for the aquaculture industry to act in harmony with nature.

Norway is the second-largest exporter of seafood in the world in value terms and exports 27 million portions of seafood every day. Of this, salmon makes up some 11 million meals (2008). With Norway's natural conditions and expertise in seafood through fishing and aquaculture, seafood production through aquaculture can be increased significantly without unacceptable negative consequences for the environment.

This is dependent on production based on sustainable principles. It is thus important to understand the term sustainable. The UN convention on economic, social and cultural rights (established in Norwegian law on 21 May 1999) stipulates that access to food is a human right, and that *"...food must be obtained in a socially, economically and environmentally sustainable manner."*

The term sustainability thus covers three different pillars: economic, social and environmental sustainability. The UN's commission for the environment and development defines sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs".*

Put simply, this means that the seafood industry, in collaboration with the authorities and research and development bodies must ensure that operations are adapted and the environment is protected. In this way future generations can also be secured access to healthy seafood along the same coast and river systems that we use today.

All human activity has an effect on the environment. Aquaculture is no exception, and the industry realizes that adapting to the environment is a prerequisite for long-term growth and development. The productivity and economic success of the industry are entirely dependent on fish farming taking place under favourable environmental conditions. This understanding is a prerequisite and a driving force in ensuring that production is based on knowledge and sustainability. Accordingly it is also extremely important that the industry is aware of its own environmental impact and sets itself goals for important environmental areas.

The coastal areas represent a major potential for seafood production, but also demand that commercial operators are aware of their responsibility with regard to the environmental impact of fish farming.

FHL's first environmental report for the aquaculture industry sheds light on the topics that are most relevant to the current debate in society regarding aquaculture, the environment and sustainability. In this edition the focus is on the utilisation of resources, use of marine areas, fish feed, escapes, sea lice, climate accounting and nutrient emissions.

Use of marine areas and fish production: At the end of 2008 96% of coastal municipalities had prepared coastal zoning plans. Such plans are vital in achieving well-considered and structural development in coastal areas. Permission to run a fish farm in a specific location is only granted if it is considered to be an environmentally sound operation. The locations in use are subject to strict environmental requirements. When no longer in use the location will rapidly return to its original status and the operation will not normally leave behind permanent, visible traces.

During the last 10 years there has been a decline in the number of marine locations used for aquaculture, and this trend continued in 2008. During the same period the industry has increased its production volume. The tendency is towards fewer, but larger locations. A continued growth in seafood production is thus not synonymous with increased use of marine areas.

Utilisation of by-products from production:
30% of the total amount of by-products and raw material residuals from the fishing and aquaculture sectors come from production, slaughtering and processing of farmed fish. The by-products and raw material residuals from fish farming are fully utilised

in other production, primarily that of ensilage and fish oil.

Use and production of fish feed: The most important species of farmed fish in Norway, primarily salmon, are predatory fish that subsist on other fish in the ocean. In fish farming, salmon are fed on pellets that consist of around 50% marine raw materials (fish oil and fish meal from wild fish as well as by-products) and around 50% vegetable raw materials. The proportion of marine raw materials is falling.

The significant growth in aquaculture over the last 30 years has not led to an increase in the use of fish in fish oil and fish meal on a global basis. But during this period the application of fish oil and meal has increased in aquaculture. In this way the marine raw materials are to a greater extent used for farmed fish that can retain and pass on the healthy marine protein and fatty acids, instead of these being used in other animal feed or as fuel. Today 65% of fish meal and 83% of fish oil is used in the global aquaculture industry (all species). Norwegian fish farms use 6.8% and 22% respectively (2007).

The suppliers of marine raw materials to the Norwegian feed industry have to document that fish used in the production of fish oil and fish meal was caught in a responsible manner. The feed industry is a driving force in the efforts to make suppliers provide adequate tracing documentation for the species used in production. International producers of fish meal and oil (IFFO) are working on establishing a specific ISO-approved control system through a Responsibility Supply Code that is expected to be in use during 2009.

Escapes: The fish farming industry has clearly expressed its zero-vision for escaping fish. The operative target is to reach a level where escaped farmed fish do not have a negative effect on wild fish. 112,000 salmon, 600 rainbow trout and 259,000 cod escaped from Norwegian fish farming facilities in 2008 according to statistics from the Norwegian Directory of Fisheries.

These figures represent a 61% reduction in the number of escaped salmon from the previous year.

Photo: NSEC

The development was not so positive for cods. An important reason for this was a single episode where a trawler destroyed the mooring lines at a facility and caused an escape that made up 68% of the total escaped fish statistics for cods in 2008.

The industry has worked in a goal-oriented manner to prevent escapes through the investment of billions of Norwegian Kroner in new and robust equipment, training courses in preventing escapes, improved procedures, internal controls and preparedness, and through being a driving force for stricter technical requirements (NYTEK). This has given good results, also in 2008. While 10 years ago some 0.46 per cent of salmon escaped, 0.04 percent of salmon escaped last year. Fish monitoring in many Norwegian rivers has shown that the proportion of escaped farmed fish has fallen significantly over the last 20 years. Primarily with regard to wild fish, but also with regard to economy and framework regulations for the industry, the work in preventing escapes will continue unabated.

Sea lice: Sea lice can be a serious problem for wild salmon and thus represents a significant challenge for the fish farming industry. The main aim for the fish farming industry is that lice from fish farming facilities will not have a negative effect on the wild fish populations. With regard to wild fish and in order to maintain good health and welfare in the fish farming facilities, the industry is using significant resources to keep the sea lice level in the facilities low. The counting of lice in the facilities is regularly carried out and reported to the Norwegian Food Safety Authority, and the results for all districts are publicly available at www.lusedata.no.

Through measures such as coordinated de-liceing, in close collaboration with the administration during the autumn and winter of 2008/2009, the lice situation in the spring of 2009 when the wild smolt migrated out of the fjords was better than in 2008. A national sea lice monitoring system for wild stocks of salmon, sea trout and sea char in 2008, concluded that the pressure of infection had increased along parts of the Norwegian coast. In the majority of locations the situation was better than or equal to 2007, with the exception of Hardangerfjorden where the pressure was particularly high in the outer parts of the fjord. The preliminary findings from monitoring sea lice on wild fish, after wild salmon and trout had mostly completed their migration to the ocean in the spring of 2009, showed far less sea lice compared to 2008.

Preventive measures and the optimal use of de-lousing agents are vital to achieving the desired effect and reducing the risk of developing resistance. In 2008 there were reports of failed treatment for two of the agents in use. In the autumn of 2008 the industry initiated an information campaign aimed at commercial operators to increase knowledge and understanding of how lice can be controlled in the short and long term.

During the last year interest in using wrasse has grown. Commercial and research bodies are also continuing to work on a number of other measures to prevent and combat lice. These measures include vaccine research, breeding, and the use of "health feed" to strengthen the fish' resistance.

Climate Impacts: Documentation of a product's environmental impact through environmental or climate accounting is yet not widespread and not standardised, neither for seafood products or other important product groups. FHL initiated a preliminary study in 2007 to establish a professional basis for comparing studies of selected products from the value chain in the fishing and fish farming sectors and agriculture. The report was completed in 2008 and also included provisional CO_2 accounts for the farming of salmon. The figures showed that the production of 1 kilo of salmon in Norway, delivered to a consumer in Paris, resulted in the emission of 2.9 to 3.0 kilos of CO_2 equivalents (when natural gas or diesel respectively are used to dry the fish feed).

Compared to other studies of greenhouse gas emissions from the production of beef, pork and chicken, salmon comes out well. In 2008 a main project was initiated to compare products from Norwegian fisheries, fish farms and agriculture, to establish statistics for energy consumption and greenhouse gas emissions. The results will give the fish farming industry a basis to document the scale of greenhouse gas emissions and to identify potentials for reductions. The project report is expected to be completed in the autumn of 2009.

Nutrient emissions from aquaculture, predominantly nitrogen and phosphorous, generally represent a minor problem in Norway. However, nutrient emissions and organic materials may have negative local and regional effects if the emissions are on a large scale; the location of the site is unsuitable or lacks sufficient ecological capacity. Access to good locations is important both for the farmed fish and for the surrounding environments. This is why such efforts are put into finding locations with suitable currents and topography.

Ocean currents transport large amounts of nutrient emissions northwards along the Norwegian coast. Man-made emissions of nutrients in Norway, including aquaculture, represent a contribution of around 2% in relation to the combined natural transport of nutrient emissions for the distance between Lindesnes and Stad. In Hordaland, which has the greatest density of fish farming facilities, emissions from aquaculture are equal to 5% of the natural supply of nutrients.

Chemicals that are used in Norwegian aquaculture are cleaning and disinfectant agents, antifouling agents and medicines. Nets need to be cleaned to ensure sufficient water flow and adequate oxygen supply to the fish. Cleaning takes place at sea with regular sea water under pressure. Nets that are to be moved to a different location are taken up, cleaned and disinfected. Boats and equipment are also cleaned and disinfected to prevent the spread of any contagious agents. Increasing emphasis is put on the chemicals being both environmentally friendly and not posing any risk to health, as well as being easily degradable in the environment. In order to limit corrosion and blocking, the majority of aquaculture nets are impregnated with an approved agent containing copper. Impregnation is carried out at a net washing facility where it is not permitted to release water containing copper.

The use of antibiotics has fallen significantly over the last 10-15 years, despite the significant growth in production volume. The reason for this is the development of vaccines and preventive measures. In 2008 the total use of antibiotics for all aquaculture species was 941 kilos. This is slightly higher than 2007, but in relation to the total biomass of aquaculture fish such use is still extremely low.

Waste: Mostly waste from fish farming are paper and residual waste, special waste such as waste oil, batteries, electronics and chemical residuals, discarded packaging and production material made from plastic, metal and concrete, as well as ensilage of dead fish. Waste is handled according to the applicable regulations. The goal is that all waste should be turned from being a challenge to being a resource.

An identification project found that the majority of companies operating fish and shellfish farms take care of discarded equipment in a proper way. But the industry can still do better, and in 2008 FHL helped to start the preliminary study *"Collection and recycling of discarded equipment from the aquaculture industry"*. The aim is to find solutions for Trøndelag and Nordland, and then build upon these experiences to find good solutions for the entire coast.

The topics above are covered thoroughly in the different chapters of the report.

Photo: Crestock

1 Sustainable food production

Efficient food production in harmony with nature. A prerequisite and a challenge
Norwegian aquaculture depends on natural resources. As an extremely efficient and important producer of good and healthy food the industry aspires to continued growth and development. There is also broad political agreement on this. It is thus both necessary and an important goal for the aquaculture industry to act in harmony with nature.

According to the UN's food and agriculture organisation FAO, in a global perspective there is a scarcity of seafood. The Norwegian Scientific Committee for Food Safety says that for the health of the population, Norwegians should eat more fish (1). Demand for attractive seafood that the consumer wants to and can eat is therefore indisputable. This provides the seafood industry in Norway with an important and future-oriented role.

Norway is the second-largest exporter of seafood in the world in value terms and exports 27 million portions of seafood every day. Of this, salmon makes up some 11 million meals (2008). With Norway's natural conditions and expertise in seafood through fishing and aquaculture, seafood production through aquaculture can be increased significantly without

Adapting to the environment is a prerequisite for long-term growth and development. The productivity and economic success of the industry are entirely dependent on fish farming taking place under favourable environmental conditions.

unacceptable negative consequences for the environment (2). This is dependent on production based on sustainable principles. It is thus important to understand the term sustainable. The UN convention on economic, social and cultural rights (established in Norwegian law on 21 May 1999) stipulates that access to food is a human right and that *"...food must be obtained in a socially,*

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All activity affects the environment. This is why the seafood industry takes responsibility

All human activity has an effect on the environment. Producing food for a growing population results in an environmental cost, regardless of whether it is harvested directly from natural resources on land, in freshwater or in the sea – or if it is to be produced and processed.

Aquaculture is no exception, and the industry realizes that adapting to the environment is a prerequisite for long-term growth and development. The productivity and economic success of the industry are entirely dependent on fish farming taking place under favourable environmental conditions. The first to suffer if production has a negative impact on the environment is the fish farmer himself. The environment and the fish farmer thus have the same interests.

This understanding is a prerequisite and a necessary driving force in ensuring that production is based on knowledge and sustainability. Accordingly it is also extremely important that the industry is aware of its own environmental impact and sets itself goals for important environmental areas. Several feed companies and fish farming operators already produce annual environmental reports and some report information as part of their environmental certification.

The use of the precautionary principle also entails that any measures taken must be proportionate and cost-effective.

In accordance with the Aquaculture Act, aquaculture must be established, operated and closed down in an environmentally responsible manner. In the government's "Strategy for environmentally sustainable development" (2009) it is again stressed that the precautionary principle must be used as the basis for evaluating whether an undertaking is environmentally sustainable. It further states that *"The principle entails that if there is a risk of serious or irreversible damage to natural diversity, a lack of knowledge must not be used as grounds to delay or avoid implementing proportional and cost-effective measures"* (2).

This principle and its use are thus extremely important in cases concerning aquaculture and environmental impact. The Ministry of Fisheries and Coastal Affairs has clearly stated that it has a goal of increasing production of seafood through aquaculture.

In order to ensure that primary environmental policy aims and strategies can be implemented in a predictable manner and with proportional measures on the operational level, it is thus important to note that the principle also assumes the presence of a threat of serious or irreversible damage, and that measures that are considered must be deemed both proportional and cost-effective.

References:

1. ***Norwegian Scientific Committee for Food Safety (2006) An overall view of fish and other seafood in the Norwegian diet.***
2. ***The Ministry of Fisheries and Coastal Affairs (2009). Strategy for an environmentally sustainable aquaculture industry.***

2 About FHL
2.1 About FHL and its members

The Norwegian Seafood Federation (FHL) is a nationwide industry policy employer organisation that at the end of 2008 had 509 member companies within the fishing industry, aquaculture sector, feed and marine ingredients industries.

The general meeting chooses the Board of Directors which is the FHL's decision-making body between general meetings. The Board consists of eight members and also has associated advisory members' bodies – industry groups, sector groups and working committees in the regional aquaculture sections. The advisory bodies are delegated decision-making authority by the Board of Directors.

Some of FHL's tasks

- Safeguard members' common interests with regard to national and international authorities and institutions and society as a whole
- Work to provide the companies with framework conditions and development opportunities that strengthen competitiveness and profitability and thus provide good and secure jobs
- Work to strengthen the industry's development of expertise and for a good and stable relationship between member companies, their employees and their organisations.
- Contribute to the fishery and aquaculture industry being represented through participation in a number of arrangements, councils and committees.
- Contribute to the industry being seen in a uniform and effective manner with regard to the authorities, administration and public opinion.

Own environmental section

The seafood industry is dependent on the environment and has some of its most important prerequisites related directly to nature and the environment. The figure below shows the administrative structure in FHL where the professional work on environmental aspects is rooted in one of four departments:

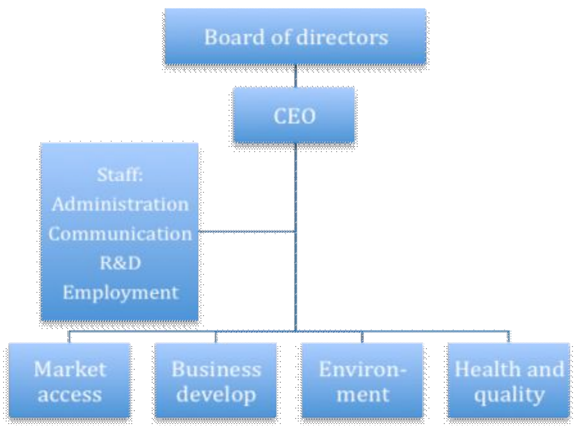


Figure 2.1: Administrative structure in FHL.

Member companies in FHL

Member companies in FHL comprise companies from fisheries and aquaculture to industry, fishmeal, fish feed, marine ingredients and export. There was a small increase in both the number of member companies and in the number of full-time equivalents from 2007 to 2008.

County	Companies	FTEs
Østfold	2	3
Akershus	2	9
Oslo	6	109
Hedmark	1	0
Telemark	1	8
Aust-Agder	2	7
Vest-Agder	1	0
Rogaland	37	497
Hordaland	72	1948
Sogn og Fjordane	50	651
Møre og Romsdal	100	1077
Sør-Trøndelag	50	728
Nord-Trøndelag	28	164
Nordland	92	1549
Troms	41	632
Finnmark	24	732
Total number of members	509	8114

Table 2.1: Distribution of member companies by county in FHL as at 31.12.2008 (Source: FHL/ NHO).

Sectors within FHL	Total for 2008		Total for 2007	
	Companies	FTE's	Companies	FTE's
FHL Total	509	8114	498	7957
Aquaculture	304	3135	280	2929
Trading companies	47	534	*	*
Shellfish	13	29	**	**
Industry and export ***	123	3629	181	4252
Fishmeal	9	199	9	197
Fish feed	13	588	16	554

*Table 2.2: Overview showing the distribution per sector of FHL membership in 2007 and 2008. The overview shows a small increase from 2007 to 2008 both in the number of companies and in the number of FTEs. * Trading companies were placed in a separate group in 2008, but previously were part of FHL industry and export. ** FHL shellfish was also placed in a separate group in 2008 but was previously part of FHL aquaculture. *** Covers also companies that work with the utilisation of marine by-products and residual raw materials (Source: FHL / NHO).*

2.2 FHL and environmental work

Policy

FHL's environmental policy goals are two-fold and cover both the industry's own impact on the environment and the environment's impact on the seafood industry; seafood production shall be environmentally sustainable and environmental contamination shall not restrict the potential to produce safe seafood.

Both of these aspects are important and necessary for safe and future-oriented food production. This is also in line with the government's strategy plan for aquaculture:

"The environmental status in the industry is generally good, and with regard to the growth in production the environmental effects have been less over the years in relative terms. This is a result of extensive work within administration, research and in the industry. Sustainable aquaculture production is a fundamental prerequisite for further growth. This is the responsibility of both the industry and the authorities and where collaboration is important to achieve continuous improvements."

In dialogue with politicians, the authorities and organisations

The conditions for this collaboration are often found in the regulations and permits for fish farming, whether this be for hatchery-produced fish for stocking on land or fish farming facilities at sea. Other important conditions are laid down through central measures for limiting production, through protection and protection plans and in work on the local coastal plans.

On behalf of the industry FHL thus has important tasks when these frameworks are to be drawn up

Seafood production shall be environmentally sustainable and environmental contamination shall not restrict the potential to produce safe seafood.

FHL's environmental policy goals

and determined. These are achieved through dialogue in various cooperation fora, through information and statements from the industry, but also through informing the industry about important regulations and decisions made. Work with politicians and political bodies is therefore important and the organisation emphaises dialogue with the government, members of parliament and other national, regional and local representatives for political parties regarding relevant and principally important cases. The organisation also contributes actively in relevant international organisations and cooperation fora. In the same way FHL has dialogue and collaboration with important administrative bodies such as the Directorate of Fisheries, the Norwegian Food Safety Authority, the Norwegian Pollution Control Authority, the Directorate for Nature Management and the County environmental departments.

FHL also has dialogue with environmental protection organisations and wild fish interests as well as other fishery organisations.

Dialogue and collaboration is just as important in work with regard to environmental contamination from other human activity not being permitted to pollute rivers, coastal and marine areas and thereby restrict the opportunities for continued safe food production or catching safe seafood.
So far Norway and Norwegian nature is in the fortunate and unique position that the majority of our long coast can offer clean and fresh sea water for safe harvesting and production of food. The same applies to the opportunities for access to clean fresh water for hatcheries.

On behalf of the industry it is therefore important that FHL is also involved in and influences cases where there is a risk of contamination from other industry undertakings, leaks from wrecked ships, negative impact form seismic activities or other conditions that can negatively affect the industry.

Research and Development (R&D)
Knowledge and research are important prerequisites for the continued knowledge-based and sustainable development of the aquaculture industry. Through the industry's own research fund, FHF, the industry itself contributes with funds and expertise in many areas directly and indirectly related to the environment's impact on the industry, and to aquaculture's impact on the environment.

An important principle given priority is that it is more important to prevent negative environmental impact than merely to describe it. In addition to joint measures many of FHL's member companies contribute to various research projects.

Photo: Tom Haga/NSEC

3 Use of raw materials and natural resources

3.1 The use of marine areas

Efficient seafood production depends on good production areas

Norway's rich nature with clean water, rivers and a long coastline with a large area within the sea boundary combine to create an extremely good basis for being able to operate efficient food production through aquaculture. For more than 30 years the fish farming industry has proved its legitimacy through being able to produce plentiful healthy food from a relatively small area. Through experience and increased knowledge the industry has also recognised the decisiveness of such production being carried out in good and sustainable locations.

Efficient production is completely dependent on a good environment for the fish. A good environment for the fish is only achieved at locations that are environmentally adapted to fish farming and tolerate high production without an unacceptable impact on the area. This is the key to success for the industry. The availability of good production areas creates the preconditions for the continued efficient production of healthy seafood.

The government's "Strategy for an environmentally sustainable aquaculture industry" points out that efficient land use are land use that can provide the biggest possible production within a limited geographical area without unacceptable negative environmental impact.

Status and challenges

Norway has fantastic conditions for aquaculture

Norway's coastal marine areas make up around one third of the surface area of mainland Norway. The Norwegian coastline is 21,000 kilometres long. This is equal to a distance longer than half way around the equator. If all islands are included this coastline is an incredible 57,000 kilometres. This is almost one and a half times around the equator.

276 of the country's 430 municipalities border on these marine areas. And as many as 80% of the Norwegian population live less than 10 km from the coast (2003). This means that the coastal zone has always been heavily affected by human activities. In other words the coast is not untouched nature. People live, work and travel here (2).

The coastal zone has always been of major significance to the Norwegian society as a source of food and basis for development and welfare, not least because of the resources in the ocean and in the coastal zone. With 90,000 km2 of marine area within the sea boundary, Norway has access to a potential food production area that is the same size as the current agricultural area in Norway, Sweden, Finland and Denmark put together (2).This provides huge opportunities but of course also major challenges. There are many different interests related to the coastal areas. These range from protective interests and recreation to important industrial interests such as traditional fisheries, aquaculture, oil and gas extraction, windmill parks, transport and tourism.

> **With 90,000 km² of marine area within the sea boundary Norway has access to a potential food production area that is the same size as the current agricultural area in Norway, Sweden, Finland and Denmark put together.**

Good coastal zone planning gives predictability and control

According to the Directorate of Fisheries 96% of the coastal municipalities had drawn up their own coastal zone plans at the end of 2008. These plans are important to classify interests and achieve planned, considered and orderly development in the costal areas. Through good plans based on knowledge and through the early and active involvement of relevant interests, conflicts can be avoided between different user interests, and the basis for co-existence can be created.

The fact that a municipality has allocated approved areas for aquaculture enables long-term and optimal production planning, and provides predictability in case processing regarding locations and production areas for aquaculture. It is decisive for the future of Norwegian aquaculture that steps are taken to ensure that the most suitable areas for aquaculture, and thus for the environment, can be put into use. Furthermore it is vital that such plans are regularly updated and followed up and that the development within the aquaculture industry is taken into account; with fewer locations in well suited areas with high capacity. This will be an advantage for everyone, including the environment.

Protection and use in coastal areas

In recent years a number of fjords and coastal areas are protected or are planned to be protected. The protected areas have very different protective aims and any conflict with aquaculture activities will thus vary. If all provisional preservation plans are implemented, major parts of the coast will be off limits.

It is therefore very important that protection plans are coordinated and the consequences are examined in both professional and political terms. The need for and effect of the plans must be thoroughly assessed, protective measures must be in proportion to the protective aim, and the opportunity for concurrent use and protection must always form part of the assessment. The best protection often takes place through a sensible use of our many and rich resources. Co-existence increases understanding of and support for protection, and secures jobs and continued, vigorous settlement along the coast.

It is fundamentally important that protective measures are followed up and evaluated. The aquaculture industry is also concerned that society takes special care of the ecosystem and areas in the coastal zone if these areas are threatened or require special follow-up action in order to survive. But it must be possible to remove specific restrictions if it is found that that the measures are not working, or new knowledge dictates that such protection is unsuitable or no longer necessary. However this does not mean a reversal of preservation but a knowledge-based follow-up and administration of protected areas.

There are several examples of areas close to protected areas being subjected to the same restrictions that apply within the protected area. FHL believes that this is unnecessary, incorrect and unacceptable.

Many of the important points stated above are covered in White Paper no. 43 (1998-1999) "Protection and use in the coastal zone. Relationship between protective interests and the fishing industry". In practice however, it has been found that the intentions in the white paper are not followed up. The industry finds it thus highly positive that a larger programme has now been set in motion in the Research Council of Norway that has been given the name "Value creation programme for our natural heritage". The main goal of the programme is to contribute to protected areas and other valuable natural areas being important resources in the development of society. Marine business interests must also be included in this programme.

Statistics from Midt-Norge (Central Norway) show that during the period from 2003-2007 production increased by 38% at the same time as the number of active locations fell by 17%.

The Ministry of Fisheries and Coastal Affairs has clearly expressed its goal to increase the production of seafood through aquaculture. Good production areas are required to achieve this. In this regard it is also important to remember that *areas* used in fish farming at sea can quickly be returned to their original status, and after they are no longer used there will not normally be any permanent, visible traces left behind. With the monitoring of the seabed beneath the fish farming facility available today, and knowledge of the impact on it, we also know that in the majority of cases conditions on the sea bed rapidly return to their original status.

Use of marine areas by aquaculture

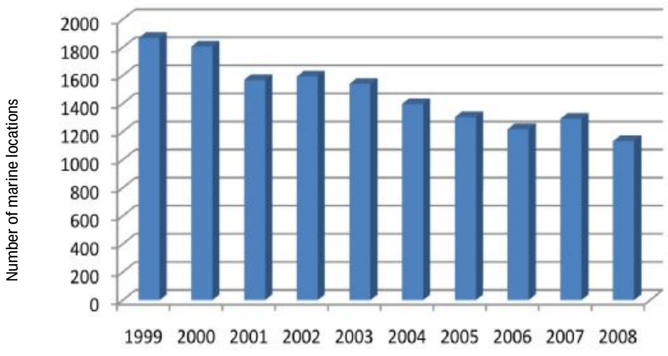
Strict assessment procedures

Areas to be used by aquaculture undertakings are assessed carefully and by several bodies before approval is granted. The locations for aquaculture can only be approved if they are considered to be environmentally suitable. The authorities balance the area's interests with special emphasis on the applicant's requirements, whether other undertakings or aquaculture undertakings are planned for the area, or whether there are special protective interests in the area. Furthermore the applicant must have the required permits related to food production legislation, pollution and waste management. The laws regarding ports and waters (marine facilities) and for rivers and groundwater, must also be assessed. Furthermore the position of the location must not be in breach of approved land use plans and protective measures.

Increased production yet fewer locations in use

At the end of 2008 there were a total of 1038 approved locations for the production of salmon and trout in Norway. There were 342 locations approved for other farmed fish species, while the shellfish industry had 520 locations (this figure is declining in 2009).

The trend shows a clear decline in the number of locations used compared with previous years. The development for shellfish and marine species is due to a real decline in activity, while for salmon the development is a consequence of a restructuring of the industry with fewer, but larger locations as a result. This development is taking place at the same time as we see a clear increase in the production of salmon.



Salmon and trout

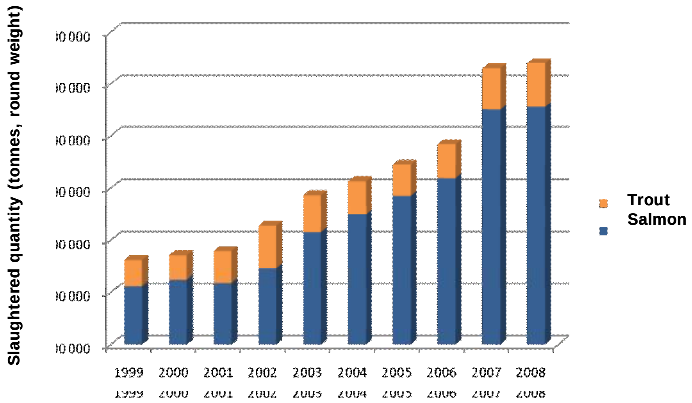


Figure 3.1: Overview of the development in the number of locations and production of salmon and trout in Norway. The figure at the top shows the development with regard to the number of locations for salmon and trout at sea in the period 1999-2008. The figure underneath shows the development of production for the same species in Norway for the same period. (Source: Directorate of Fisheries and FHL).

Statistics from Midt-Norge (Central Norway) show that during the period from 2003-2007 production increased by 38% at the same time as the number of active locations fell by 17%. The fact that the industry generally combines production at larger and more suitable locations is a positive development with regard to the industry's goal of environmental sustainability, but also with regard to area use.

In practice fewer, but larger locations lead to less average area being used for each licence, and to the area used being monitored even more closely to prevent negative effects on the fish and the environment. Negative environmental impact on a location generally affects the fish and thus the fish farmer first. Being pro-active in choosing the most suitable locations is thus an important pre-requisite.

On the right there follows an overview over permits granted for marine locations. Not all of these locations are in use at the same time. In accordance with the regulations, all locations must have a rest period or fallow time of at least 2 months between the end of production and new fish being released. This is both with regard for the environment under the net cages and to reduce any pressure of infection in an area before new fish are let out. "All in – all out" is also a recognised production principle from animal husbandry in agriculture in order to prevent the transfer of infection between generations. In some cases it is also desirable for the fish farmer to be able to have an alternative area for newly released fish cleared if the infection conditions in another area mean that it should not be used for a time. The number of active locations will thus be lower than that shown in the figure.

	2008		
	Laks/ørret *Salmon/trout*	Andre arter *Other species*	Skalldyr *Shellfish*
Fylke *County*	Antall *No.*	Antall *No.*	Antall *No.*
Finnmark	74	27	10
Troms	103	17	15
Nordland	192	102	120
Nord-Trøndelag	76	13	41
Sør-Trøndelag	91	12	32
Møre og Romsdal	110	62	28
Sogn og Fjordane	106	37	66
Hordaland	211	39	111
Rogaland	63	31	46
Vest-Agder	9	2	14
Aust-Agder	3	0	23
Øvrige fylker	0	0	14
Totalt/*Total*	**1 038**	**342**	**520**

Table 3.1: Overview of the number of approved sea locations at the end of 2008 divided by county. The table shows the distribution of the number of locations as at 31.12.08. The majority of locations were then found in Nordland County that had a total of 414 registered locations. Hordaland had the second most with a total of 361 locations. Not all locations were in use. This is due to factors including the fact that all locations must have a fallow or rest period between fish being released. In some cases it is also desirable to have areas already cleared that can be put into use if the infection conditions in another area mean that it should not be used for a time. Some locations are no longer active and the Directorate of Fisheries is working on clarification of this issue and removal from the register.

Emphasis is put on organising the facility so that all net cages have good water flow. In practice this has resulted in more standardised facilities where there is equal distance between the net cages and more uniform equipment.

Development is of significance for land use

The trend in salmon production in many areas is for fewer and larger locations. The general development is that fish farming net cages have become larger. This has led to fewer net cages in the locations, even if the number of fish and thus production has increased.

Emphasis is put on organising the facility so that all net cages have good water flow. In practice this has resulted in more standardised facilities where there is equal distance between the net cages and more uniform equipment.

In total this provides a positive and "tidy" visual impression of the fish farming location. Since in many places the locations are also moved out from land with feed silos in compact facilities right by the net cages, an increasingly smaller area is used on land for land bases and feed storage

This, together with the restructuring and coordination of locations both internally in the companies and between different companies will lead to the planned continued growth in seafood production in Norway not being synonymous with greater area use. However this is dependent on good costal area plans where aquaculture also has access to the best suited locations in the future.

References:

1 *The Ministry of Fisheries and Coastal Affairs (2009)Strategy for an environmentally sustainable aquaculture industry. Interim edition.*

2 *Sandbæk R (2003) Coastal zone planning – terms, planning, processes ISBN 82-8090-001-2 Juul forlag 2003*

3.2 Release and production of fish

Number of permits for fish farming, fish release and production at sea

Below is a brief overview of the number of permits granted for fish farming for various species, as well as an overview of fish released to the sea and over standing biomass in the sea at the end of 2008.

The number of permits for salmonids, which are by far the most important species in Norwegian aquaculture, has remained unchanged since the previous concession allocation round in 2004.

All the same there has been an increase in the production of salmonids within the existing system for production restrictions (MTB, Maximum Permitted Biomass) and during the same period of time. There is a tendency towards releasing fewer rainbow trout, which means that the majority of salmonid concessions are used to release Atlantic salmon. The production of other species showed a decline in 2008.

County	Number
Finnmark	3
Troms	14
Nordland	31
Nord-Trøndelag	17
Sør-Trøndelag	23
Møre og Romsdal	36
Sogn og Fjordane	24
Hordaland	59
Rogaland	17
Total	224

Table 3.2: Overview of the number of permits for the production of fry as at 31.12.08. The overview covers all permits for commercial hatcheries and fry production centres (saltwater and fresh water). (Source: The Directorate of Fisheries and FHL.)

County	SALMONIDS	COD	HALIBUT	OTHER	SHELLFISH	TOTAL
Finnmark	84	42	0	3	27	156
Troms	87	11	1	2	27	128
Nordland	146	142	13	8	158	467
Nord-Trøndelag	64	11	6	0	49	140
Sør-Trøndelag	82	13	1	4	47	147
Møre og Romsdal	109	61	17	12	34	233
Sogn og Fjordane	82	49	2	4	66	103
Hordaland	155	54	14	14	106	343
Rogaland	58	42	12	5	46	163
Aust-Agder	1	1	1	1	26	30
Buskerud					2	2
Vestfold				2	2	4
Akershus					1	1
Østfold					10	10
Total	868	426	67	55	601	2017

Table 3.3: Number of permits for fish farming at sea as per 14.04.08. Divided by county. The overview shows the distribution of different permits by county for commercial aquaculture at sea for fish for human consumption and breeding stock and for shellfish as at 14.08.08. (Source: Directorate of Fisheries and FHL).

	2007			2008		
Fylke *County*	Laks *Atlantic salmon*	Ørret *Rainbow trout*	Totalt *Total*	Laks *Atlantic salmon*	Ørret *Rainbow trout*	Totalt *Total*
Finnmark	8 196	2 592	10 788	12 800	1 600	14 400
Troms	23 666	1 238	24 904	27 100	1 400	28 500
Nordland	36 312	3 675	39 987	38 800	800	39 600
Nord-Trøndelag	15 592	0	15 592	21 400	0	21 400
Sør-Trøndelag	24 402	42	24 445	25 500	100	25 600
Møre og Romsdal	27 109	4 679	31 789	26 600	3 000	29 600
Sogn og Fjordane	15 137	4 075	19 212	19 800	2 700	22 500
Hordaland	37 565	9 455	47 019	40 100	9 000	49 100
Rogaland	16 224	22	16 246	23 800	0	23 800
Øvrige fylker	2 777	77	2 854		127	127
Totalt / *Total*	**206 981**	**25 856**	**232 836**	**235 900**	**18 727**	**254 627**

Table 3.4: Released (smolt purchased and received internally) fish divided by country. Amounts in thousands. This overview shows smolts of salmon and trout released in 2007 and 2008 divided by county. (Source: Directorate of Fisheries and FHL).

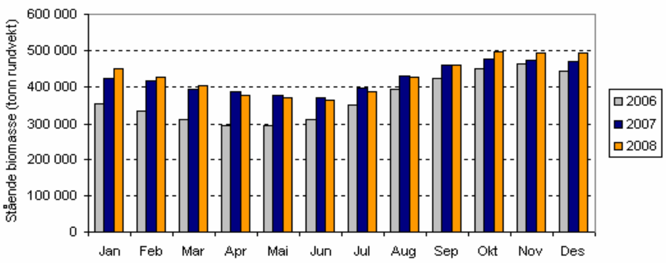


Figure 3.2: Standing biomass in sea 2006-2008: **The overview shows the standing biomass of Atlantic salmon in the sea throughout the year. (Source: FHL)**
(Left axis: Standing biomass, round weight in tonnes)

3.3 Utilisation of by-products and residual raw materials from production

Major value creation potential in marine by-products and residual raw materials

In connection with the production, slaughter and further processing of seafood, parts of the fish that cannot be used as the main product will remain. These are divided into by-products and residual raw materials. By-products consist of dead fish from fish farming facilities, or innards and offal from slaughterhouses and fish processing sites that are not used in food production.

Residual raw materials from Norwegian fisheries and aquaculture undertakings consist of innards (livers, roe, stomachs, entrails etc.), heads, discarded fish etc. Important products from residual raw materials include ensilage, proteins and oils for foodstuff and feed production, in addition to other highly specialised products for use in pharmaceutical and cosmetics, amongst others.

According to the Rubin foundation, whose aim is to contribute to the complete use of fish and increased value creation of by-products and residue raw materials in Norway, marine by-products and residual raw materials from fisheries and aquaculture make up a total of well over 600,000 tonnes per year. This is the equivalent of around 20% of all fish caught and farmed in Norway.

Around 450,000 tonnes of this is used mainly as feed raw materials for animal feed, and some is used as ingredients and consumer products. A proportion of residual raw materials is not used and is returned to the marine environment.

FHL Maring is an independent industry group for the biomarine ingredients industry in Norway, which covers a variety of production based on fisheries' residual raw materials.

By-products and residual raw materials from aquaculture are used in their entirety

By-products and residual raw materials from aquaculture are used in their entirety. The majority of these (around 77%) go to ensilage, but there is now a positive development in the direction of increased utilisation for human consumption. Right from the beginning the aquaculture industry has had close collaboration with the ensilage industry concerning an effective utilisation of dead fish and other by-products which has led to a positive financial contribution to the industry.

The result is the hygienic and quality assured processing of the resources that by-products from fish farming facilities and slaughterhouses represent. At the fish farming facilities such by-products are immediately ground, preserved and stored until they are collected by the ensilage industry.

Effective ensilage methods and logistics have been developed, and the end products such as fish protein hydrolysates and fish oils have been found to be valuable in the feed industry and as raw materials in the production of biochemicals and biodiesel. In value terms this makes up around NOK 1.3 billion per year.

Challenges and further development

The potential for the use of by-products and residual raw materials has changed as a result of the changes to EU regulations. FHL is focused on achieving the safe and appropriate use of these resources. It is important to create the best conditions possible for value creation from the sea at the same time as safeguarding the health of animals and humans alike.

The processing and use of by-products is regulated by the EU's By-products Regulation. The By-products Regulation regulates an important part of the framework conditions for this value creation. As Europe's biggest seafood nation, Norway must be a premise and knowledge provider and ensure that the by-products decree's provisions are proportional with regard to risk and do not create unnecessary restrictions on the processing of by-products

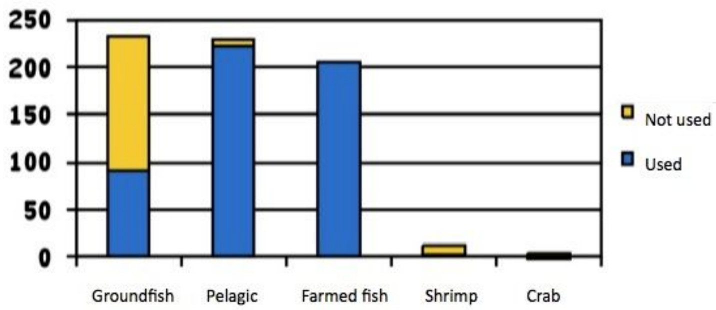


Figure 3.3 By-products and residual raw materials used in 2008.
The diagram shows the size of the proportion of by-products and residual raw materials from fisheries and farmed fish used stated in 1000 tonnes / year. Both salmonids and cod are included for farmed fish. (Source: Rubin)

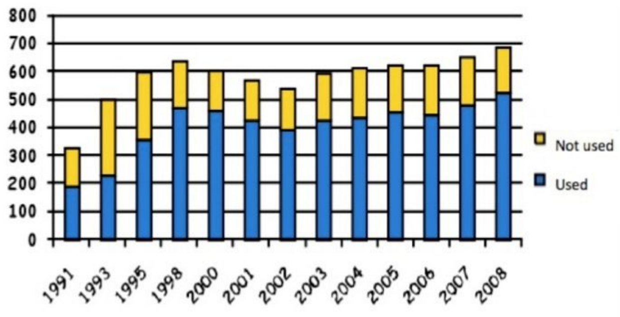


Figure 3.4: Development in amounts and use of by-products 1991-2008 (thousands of tonnes per year). The overview shows development with regard to the use of by-products from fisheries and aquaculture in the period 1991-2008. Amounts are given in thousands of tonnes / year. (Source: Rubin)

Used for	*Aquaculture*
Ensilage	*158,500*
Raw ensilage for fur-bearing animals	*400*
For fur-bearing animals (fresh/frozen)	*1,000*
Oil (fresh)	*21,900*
Consumption etc	*7,000*
Hydrolysates / oil	*17,500*
Rounded total	*206,300*

Table 3.5: Specification of use of residual raw materials from aquaculture 2008. The overview shows how by-products and residual raw materials are used from farmed fish. Usage is given in tonnes / year. (Source: Rubin)

from aquatic animals. The goal must be that the regulations accept that by-products from aquatic animals can be processed, including using methods that Norway has experienced as well suited over many decades. Furthermore the possibility must be allowed for processed material to be used for as many purposes as possible within the regulations.

For example, the By-products Regulation requires high-pressure sterilisation of dead fish before these can be used in biogas production. This requirement is disproportionate with regard to potential risks and expensive; it destroys the nutritive value and prevents other usage areas. FHL, together with the ensilage industry has therefore sought approval of the existing method for the ensiling and heat treatment of dead fish so that it can be included in the By-products Regulation. At the same time new research is underway to document that the method is adequate. So far the results have been positive.

All residual raw materials that arise during the slaughter of farmed fish such as offal and innards can be used in food production. There is a trend and a desire in the industry to exploit the potential for the production of salmon oil and hydrolysates etc. for human consumption. There are currently 4-5 well-established companies that produce over 20,000 tonnes of fish oil, the majority of which is for human consumption. There are also several projects underway with the purpose of utilising a greater proportion of residual raw materials for human consumption.

References:

1. *Rubinnytt, July 2009*

By-products and residual raw materials from aquaculture are used in their entirety.

3.4 Feed and feed raw materials Status and challenges

Increased production with reduced feed consumption

In 2008 1.2 million tonnes of feed was sold for fish farming in Norway. Of this, 1.18 million tonnes was produced in Norway while 18,000 tonnes was imported. For many years the aquaculture industry has experienced production growth without proportionate growth in consumption of feed. This is due to farmed fish being fed under strictly controlled conditions today, having a better adapted feed, utilising the feed better and thus requiring less in order to grow.

Today, salmon is the most efficient “meat producer”. Compared with pigs and chicken it is more than twice as efficient at converting feed to meat.

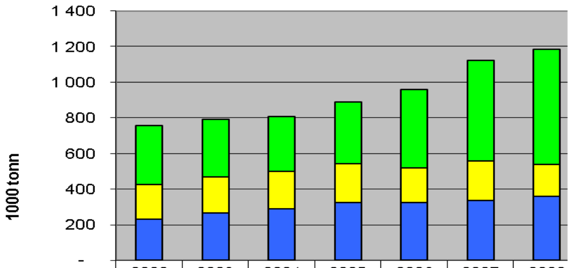
Sustainable harvesting of raw materials

Along with fish, feed is the most important input factor in aquaculture. In assessing whether fish farming is environmentally sustainable, the aquaculture industry must therefore also assess whether the production of fish feed is sustainable. This requires a clear division between two aspects: The first is whether the raw materials are harvested in a sustainable manner. The second is whether the use of the marine raw materials is correct with regard to the best utilisation of the catch, in the light of the fact that the lack of seafood on a global basis will increase with a growing population.

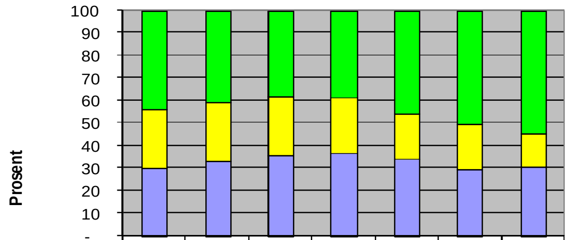
What do farmed fish eat?

Increased proportion of vegetable raw materials in fish feed

The most important fish farming species in Norway are by nature predatory fish that subsist on other marine fish. In fish farming the fish are fed on pellets consisting of both marine and vegetable raw materials. The marine raw materials in fish feed are fish oil and fishmeal. Fishmeal producers are important recipients of offal and by-products



	2002	2003	2004	2005	2006	2007	2008
Vegetabiler	331	322	309	344	440	564	649
Fiskeolje	196	206	212	219	193	225	178
Fiskemel	229	264	288	325	325	334	360



	2002	2003	2004	2005	2006	2007	2008
Vegetabiler	44	41	38	39	46	50	55
Fiskeolje	26	26	26	25	20	20	15
Fiskemel	30	33	36	37	34	30	30

Figure 3.5: The composition of Norwegian-produced fish feed during the period 2002 – 2008:
The figure on the left shows the content of vegetable raw materials, fish oil and fishmeal in Norwegian-produced fish feed in tonnes per year. The figure on the right shows the percentage distribution of the same, and clearly illustrates how there has been a decline in the proportion of marine raw material in the feed since 2004. (Source: FHL)

The suppliers to the Norwegian feed industry must document that the fish used in the production of fish oil and fishmeal was fished in a responsible manner, without depleting fish stocks or damaging the marine environment.

(innards, heads, skin and bone) from the consumer fish industry that on average only uses around 50% of the fish directly in food for human consumption.

Traditionally fishmeal and fish oil have been the main ingredients in feed. Concerns about sustainable development have led to only about half of the ingredients in a pellet being marine raw materials today. The remainder are various types of vegetable raw materials. An overview of the composition and division of vegetable and marine raw materials in fish feed used in aquaculture in Norway is given in the figures (left).

Whilst in overall terms the aquaculture industry has increased its production both nationally and globally over the last 30 years, the production of fishmeal and fish oil has not grown proportionately. (See figure 3.6 and 3.7) When whole fish are used in fishmeal, it is almost exclusively pelagic species with many bones that are also small and have a low fillet yield; this has traditionally made them difficult to use directly in food for human consumption. However, improved technology and greater acceptance of new fish products has led to species that previously were used in fishmeal and oil being increasingly sent to a consumer market ever more willing to pay for them.

Another important driving force in this development is a desire to optimise the use of resources and to ensure sustainable harvesting in a time presenting challenges both with regard to the ocean’s resources and with regard to the demand for healthy food for a world with a growing population.

Feed producers and fish farmers are thus being encouraged to use the available feed raw materials as efficiently as possible. At the same time industry operators are also looking at the potential for using alternative raw materials without this being at the expense of the health, welfare and quality of the fish.

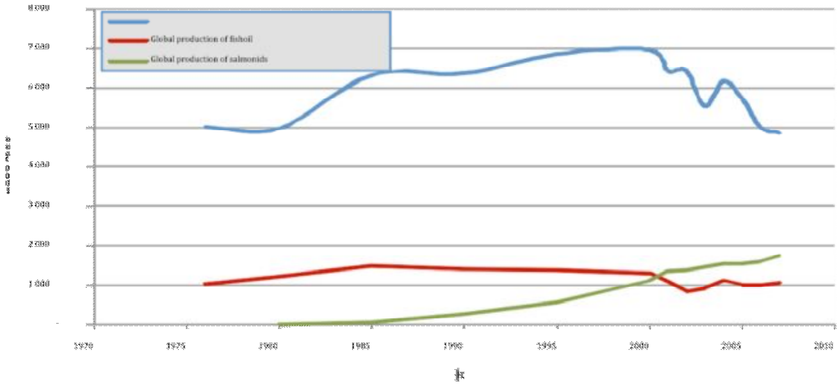


Figure 3.6: Production of fishmeal, fish oil and salmonids.
The figure shows how the global production of salmonids has increased without an increase in the production of fishmeal and fish oil. (Source: IFFO nad FHL)

This development is well underway. Not only through better composition and digestibility of the feed, and through the increased use of fish offal and vegetable ingredients, but also through improved feeding systems and feeding methods. In total this has led to a reduction in the feed factor (the amount of feed needed to produce 1 kg of fish) of at least 15-20% over the last 30 years.

Less dependence on marine raw materials
While in 1990 around 4 kg of wild fish was required to produce 1 kg of salmon, only just over 2 kilos of wild fish are currently required to produce 1 kg of salmon. Dependence on wild fish has thus fallen dramatically. Research is also underway to find alternative marine sources of feed. This revolves around finding opportunities to utilise surpluses at a lower level in the food pyramid (krill, copepods), the production of marine fatty acids in plants and the use of single-cell protein.

It is only partially correct to say that 2 to 2.5 kg of wild fish is required to produce 1 kg of salmon. This figure only indicates how much wild fish is needed to meet the requirement for marine oils (fish oils) in a standard diet. This amount of wild fish thus also provides a large amount of the “surplus” fishmeal. This raw material can be used by other industries in the production of other goods. A parallel can be drawn from another agricultural industry to explain this: You need an entire sheep to make a lamb’s head dish, without one thereby saying that one “uses” a whole sheep.

Based on an average feed pellet in Norway, the actual consumption of marine raw materials for 1 kg of farmed fish is some 1.5 kg and can vary somewhat depending on the fat content and quality of the wild fish used (1). The International Fishmeal and Fish Oil Organisation (IFFO) states on its website that the average global FIFO ratio (Fish In – Fish Out) for salmon is 1.7 – 1, and is continuously falling (2). This is no less impressive when one also knows that both cod and salmon require many times more wild fish to grow 1 kg.

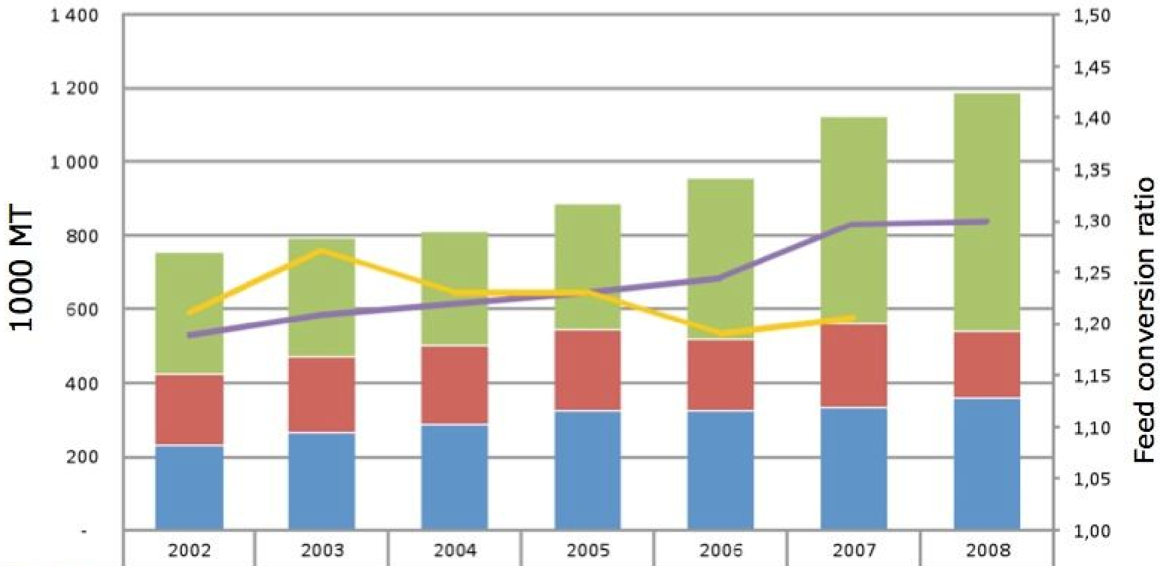
Is fish feed based on sustainable raw materials?

Norwegian feed companies set sustainability requirements for their suppliers
The suppliers to the Norwegian feed industry must document that the fish used in the production of fish oil and fishmeal was fished in a responsible manner, without depleting fish stocks or damaging the marine environment. These raw materials are required to come from regulated fisheries that are administered and approved in accordance with national fishing authorities and in line with international agreements. Furthermore the feed industry is a driving force behind enabling suppliers to offer adequate and systematic tracing documentation for the species used in fishmeal and fish oil production. The feed producers regularly carry out audits of their suppliers to ensure that the information received is correct and complies with the requirements stipulated.

The feed industry’s goal is that the species used in production shall come from sustainable fisheries. Today this is a challenge as there are many and varied opinions on the requirements that must be made for a fishery to be considered sustainable. In recent years there has been an increased focus on this with regard to species fished directly for human consumption. It has only recently become more relevant for fisheries that traditionally participate in the production of fishmeal and fish oil.

The feed industry wants openness about the fish species used in the production of raw materials for the industry, to thereby contribute to a constructive process to define sustainability criteria for the fisheries that can produce raw materials for Norwegian feed production.

Confusion about the definition of the term sustainable fisheries has also led to the producers of fishmeal and oil (IFFO – International Fishmeal and Fish Oil Organisation) working to establish a specific ISO – approved control system through a Responsible Supply Code that is expected to come into effect during 2009.



	2002	2003	2004	2005	2006	2007	2008
Vegetables	331	322	309	344	440	564	649
Fish oil	196	206	212	219	193	225	178
Fishmeal	229	264	288	325	325	334	360
Slaughtered qty	528	586	613	645	684	830	840
Feed factor	1,21	1,27	1,23	1,23	1,19	1,21	

Figure 3.7: Feed consumption in Norwegian production of salmon and trout.
The figure shows the feed consumption in Norwegian production of salmon and trout. One can also see how the proportion of marine raw materials has not grown as a consequence of increased production of salmonids. The figure also shows the economic feed factor (amount of feed used per kg of slaughtered fish) during the period. The biological feed factor (amount of feed used to produce 1 kg of meat) is not shown in the figure, but has fallen 15-20% over the last 30 years. (Source: IFFO and Directorate of Fisheries)

Different mechanisms regulate the utilisation of industrial fish

On a global basis fishmeal and fish oils are produced from an average of approximately 33 million tonnes of fish each year. Of this around 5 million tonnes come from by-products (innards, skin, bone etc.) from fish that are caught for human consumption. The rest are so-called industrial fish. With a few exceptions all fish are nutritionally suitable as food for human consumption, but in today's situation with the increase in welfare in many large markets, demand for meat and fish of what is seen as higher quality than that offered by industrial fish is growing. If industrial fish is to end up as food for human consumption on a larger basis, demand will have to increase so that the production of such fish becomes financially sustainable.

Another result of the market situation is also the fact that now and again mackerel, herring and capelin are ground up into fishmeal when the price in the consumer market is not much higher than in the meal or oil industry, or if fish are landed in countries that do not have the facilities to process these fish species further into food for human consumption. In larger seasonal fisheries that fish for anchovy off the west coast of South America, the production of fishmeal and fish oil helps to conserve the catch and spread sales over a longer period (3). This gives the fishermen better prices and is thus in certain cases an important prerequisite for the ability to maintain activity so that this renewable resource can be utilised in the food value chain, including in the production of consumer fish.

Important fish species used in Norwegian fish feed

In geographical terms aquaculture has primarily been dependent on fisheries in the northeast Atlantic Ocean and the south-eastern Pacific Ocean (Peru and Chile). For global salmon fish farming around 60% of fishmeal comes from the southern hemisphere. Tracing the origins of fishmeal has shown that 90% comes from six species of fish. In the northern hemisphere it is herring (only when the consumer market cannot absorb all catches), blue whiting, capelin and sprat, as well as offal from edible fish production. In the southern hemisphere anchovy and Pacific mackerel are the most important (4).

Norway produces around 200,000 tonnes of fishmeal each year and imports around the same amount. The biggest suppliers of fishmeal to Norwegian feed production are Peru, Iceland and Denmark. With regard to fish oil, Norway produces around 55,000 tonnes, and imports around 17,000 tonnes. Denmark is the biggest supplier, followed by Peru and Iceland. Table 3.6 shows an overview of the fish species mostly used in fishmeal and fish oil in feed produced in Norway for 2008.

At the same time it is important to be aware that according to the IFFO on a global basis some 22% of the marine raw materials for the production of fishmeal come from offal and by-products from the consumer fish industry (2). This is a good and positive contribution with regard to effective utilisation of harvested resources.

Does salmon fish farming utilise feed in a sustainable manner?

Increased aquaculture operations, unchanged production of fishmeal and fish oil

While production of salmon both globally and nationally has grown significantly over the last 30 years, the production of fishmeal and fish oil has been almost constant during the same 30 years with around 5-7 million and 1 million tonnes per year respectively (see figure 3.8 – 3.10). This means that aquaculture in Norway has not contributed to increased exploitation of fish for fishmeal and fish oil.

Fish species		Fishmeal		Fish oil		Fishmeal and fish oil	
English	Norwegian	2007	2008	2007	2008	2007	2008
Anchovy	Ansjoveta	23 %	23 %	21 %	22 %	22 %	23 %
Blue whiting	Kolmule	37 %	27 %	14 %	8 %	27 %	21 %
Capelin	Lodde	4 %	1 %	2 %	1 %	4 %	2 %
Herring	Sild	16 %	17 %	26 %	23 %	20 %	19 %
Sandeel	Tobis	2 %	14 %	7 %	7 %	4 %	11 %
Herring cuttings	Sildeavskjær	3 %	4 %	4 %	12 %	4 %	6 %
Sprat	Brisling	5 %	4 %	14 %	9 %	9 %	6 %
Trimmings	Avskjær	2 %	1 %	5 %		3 %	1 %
Mackerell	Makrell	1 %	1 %	<1%		<1%	<1%
Horsemackerel	Hestemakrell	1 %		<1%	1 %	<1%	<1%
Jackmackerel		5 %	6 %	<1%	1 %	3 %	
Pilchard				3 %	5 %	1 %	2 %
Menhaden				4 %	7 %	2 %	3 %
Norway pout	Øyepål						<1%
Boar fish	Villsvinfisk						<1%
Other species	Andre arter	<1%	2 %		3 %	<1%	1 %
Sum		99 %	100 %	100 %	99 %	99 %	100 %
Meal		331 365 462	355 656 674			331 365 462	355 656 674
Oil				233 925 592	189 178 273	233 925 592	189 178 273
Total meal + oil						565 291 054	544 834 947

Table 3.6: Fish species used in feed in the Norwegian aquaculture industry
The table shows a simplified fusion of the fish species used in fish feed; i.e. an adjusted species distribution based on the volume of fishmeal and fish oil, based on statistics from the 3 biggest feed companies in Norway. (Source: Ewos, Skretting, Biomar, FHL)

Global and Norwegian production of fishmeal over the last 30 years

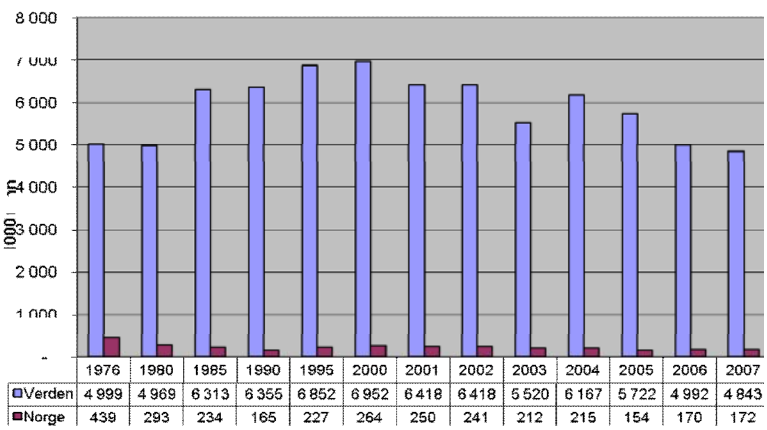


Figure 3.8: Global and Norwegian production of fishmeal over the last 30 years
Global production (blue columns) of fishmeal (left axis, thousand tonnes) is almost unchanged over the last 30 years. From increasing in the 1980s and 1990s there has been a decline in the last 10 years so that the level of production is now in line with that of 30 years ago. Production in Norway (red columns) has shown a downward trend over the entire period. (Source: IFFO, FAO and FHL)

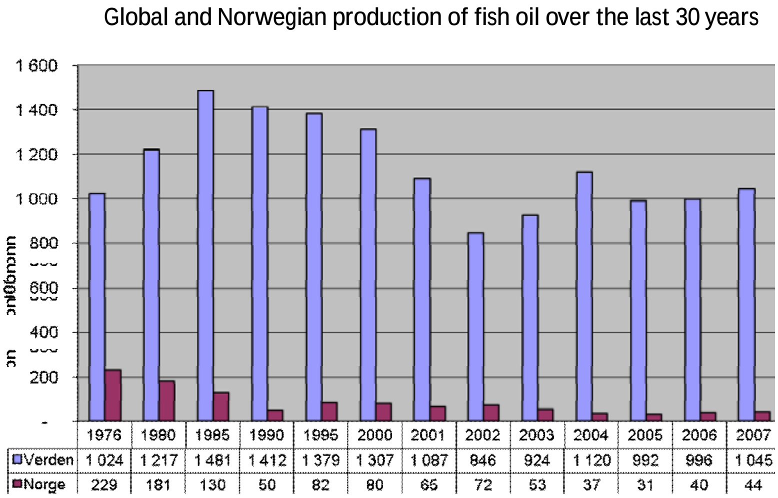


Figure 3.9: Global and Norwegian production of fish oil over the last 30 years
The figure shows the development in the production of fish oil both globally(blue) and in Norway(red) over the last 30 years. The trends are the same as for the production of fishmeal. (Source: IFFO, FAO and FHL)

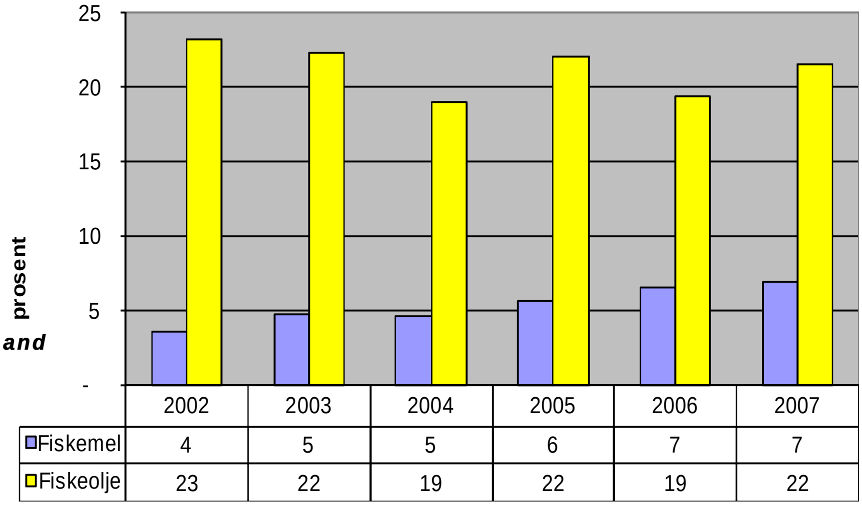


Figure 3.10: Norwegian aquaculture industry's use of globally produced fishmeal and fish oil, in %
The figure shows the proportion of the world's production of fish oil (yellow) and fishmeal (blue) used in feed for the Norwegian aquaculture industry. (Source: IFFO, FAO and FHL)

Salmon is a highly efficient meat producer

In 2008 around 2 million tonnes of salmonids were produced on a global basis. During the same period 50 million tonnes of chicken and 90 million tonnes of pork were produced. Total feed consumption for this production was at least 500 million tonnes, of which 2.3 million tonnes (0.44%) was used in salmon farming (5).

On this basis one can see that while salmon represented 1.41% of meat by weight, it consumed just 0.44% of the feed (6). This means that compared with the averages for chicken and pork, salmon is 2-3 times more efficient in creating meat. In other words salmon is a particularly efficient meat producer.

If comparisons are made of the biological feed factor (how much feed must be used to grow 1kg) for salmon, chicken and pork, this will on average come to 1.2 for salmon, 2.5 for chicken and 3.0 for pork.

But it is also important to look at protein utilisation and energy utilisation. Salmon also show good results here (see figures). Knowing that around 34% of fish feed produced on a global basis is used to feed chicken, pigs and farmed animals, the conclusion must be that to the extent that we catch fish to feed animals, salmon is a very efficient alternative; not least because the fish proteins with their positive nutritional benefits for the population are transferred.

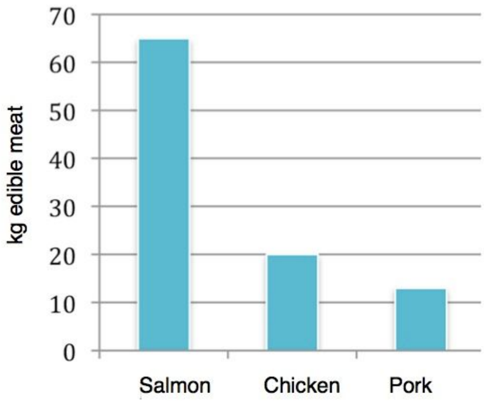


Figure 3.11: Meat production from 100 kg of feed for different farmed animals
The figure shows that assuming dried feed is used; 100 kg of feed give 65 kg salmon fillet, 20 kg chicken fillet and 13 kg pork fillet. Also compared with wild fish farmed fish is extremely efficient. A wild salmon or a wild cod will have eaten around 10 kg of fish to grow 1 kg (5). Farmed salmon eat around 1.1 kg of feed containing raw materials from around 1.5 kg wild fish to grow 1 kg (Norwegian Fish Farming no. 4 2009)(Source: Trygve Berg Lea and Mugaas Jensen, Norwegian Fish Farming no. 4 2009)

Table 3.7: Protein retention in the edible parts of pigs, chicken and fish
The figure shows that the edible part of salmon is extremely high, the feed factor is low and the utilisation of protein (retention) in the feed is very good. This means that if there is a limited amount of a feed resource that can be used by different types of animals, it is efficient to use this to feed salmon. (Note: The feed factor for round (not gutted) salmon at a normal slaughter weight is calculated on average in Norway in 2008 to be around 1.2, but will wary somewhat). (Source for figure: Åsgard, Berge, Mørkøre, Refstie in Norwegian Fish Farming no.2 2008)

Animal species	Salmon	Chicken	Pig
Edible part of animal In %	65	50	50
Proportion of protein (grams/kg)	190	200	165
Feed factor	1,0	2,5	3,0
Protein retention	31	21	20

The Norwegian aquaculture industry use less than 10% of the world's fishmeal
When examining the utilisation of fishmeal and fish oil on a global basis, one finds that the aquaculture industry (all species) uses around 65% of fishmeal production and 83% of the production of fish oil (Figure 3.12). Of around 5 million tonnes of fishmeal produced on a global basis from 2006-2008, the Norwegian aquaculture industry used less than 10% of this (6.8% in 2007). By way of comparison pork production used 24%, chicken 6% and other animals 4% of fishmeal on a global basis.

Through its use of fishmeal and fish oil the aquaculture industry is necessarily an important part in the market for these products. This is precisely why both the feed industry in particular and the aquaculture industry in general take the issues of sustainability and resource utilisation so seriously. This is achieved through not only being a driving force for the effective regulation and tracing of raw materials and through the auditing and control of the producers, but also through further research to reduce dependence on marine raw materials and to find good alternatives.

Farmed fish utilise and carry forward the health benefits from marine feed resources
Farmed fish are not only an extremely efficient provider of meat but also the one that takes by far the best care of the unique and extremely important health benefits of fish proteins and fatty acids.

Salmon is today our most efficient "meat producer". Compared with pigs and chicken it is more than twice as efficient at converting feed to meat.

Around 44%, or almost half of the marine protein used in feed for salmon is preserved in the form of salmon meat (4). Equivalent calculations have not been made for the marine omega-3 fatty acids, but analyses show that the content and composition of the marine oils in feed are preserved and mirrored in the salmon. It is therefore a sensible way to preserve and utilise the important marine fatty acids and to make them available in attractive food for human consumption.

When plant oils, that generally contain shorter chain fatty acids, replace marine oils in feed this does not mean that the proportion of long-chain omega-3 fatty acids are reduced in proportion in the fish meat. NIFES (the National Institute of Nutrition and Seafood Research) have shown in studies that when salmon is fed with plant oils in addition to marine oils, the proportion of marine omega-3 fatty acids that are used in the energy consumption of the fish are reduced. Salmon "save" the important fatty acids and use a greater proportion of the other fatty acids for energy.

This means that by reducing the amount of omega-3 fatty acids EPA and DHA in the feed, the valuable omega-3 fatty acids are better utilised and more of the omega-3 fatty acids found in the fish feed benefit the consumer (7).

Given salmonids' good effects on health and the authorities' signals that consumption of fish ought to increase it is highly positive that Norwegian consumption also shows an increase.

It is proper to redirect fish oil from use as fuel to use as healthy and good food.

Previously fish oil with omega-3 was mainly used to harden margarine (see the figure at the bottom right) but also for paint and fuel. The hardening process destroys the omega-3 and thereby the good health effects on human beings.

When fish oil is cheap, such as is the case in the spring of 2009) fish oil is still used for fuel (biofuel). It is difficult to defend such use of this valuable resource when it could be used in the production of healthy food.

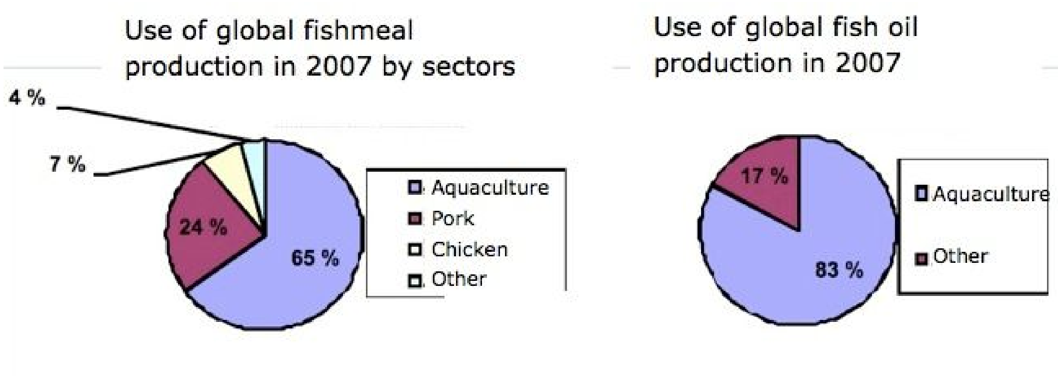


Figure 3.12: Use of global production of fishmeal and fish oil.
On a global basis in 2007 the aquaculture industry used around 65% of fishmeal and 83% of fish oil. The Norwegian aquaculture industry's share of this was 6.8% and 22% respectively. (Source: IFFO)

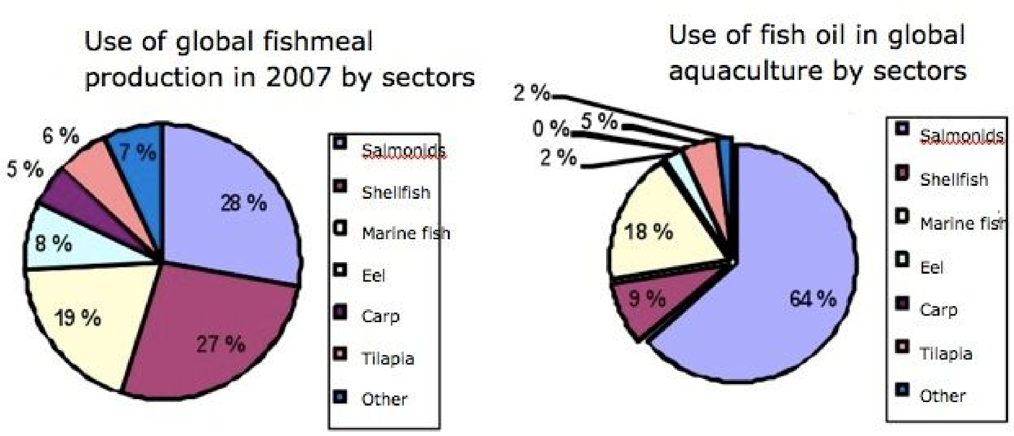


Figure 3.13: Use of global production of fishmeal and fish oil in the aquaculture industry.
The figure shows how the consumption of fishmeal and fish oil is divided into the various farmed fish species on a global basis. Consumption for shellfish was mainly for shrimps. (Source: IFFO)

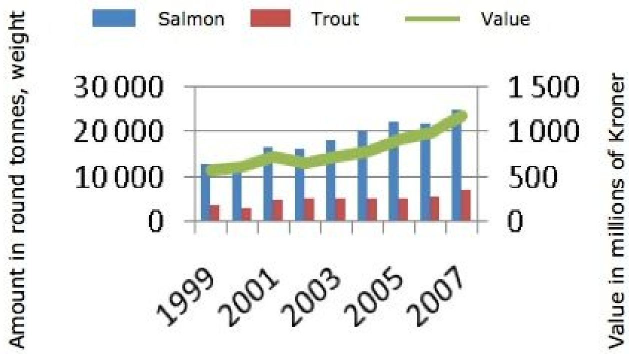


Figure 3.14: Norwegian household consumption of salmon and trout
Given salmonids' good effects on health and the authorities' signals that consumption of fish ought to increase, it is highly positive that Norwegian consumption also shows an increase.
(Source: GFK-Norge/EFF Norwegian Seafood Export Council)

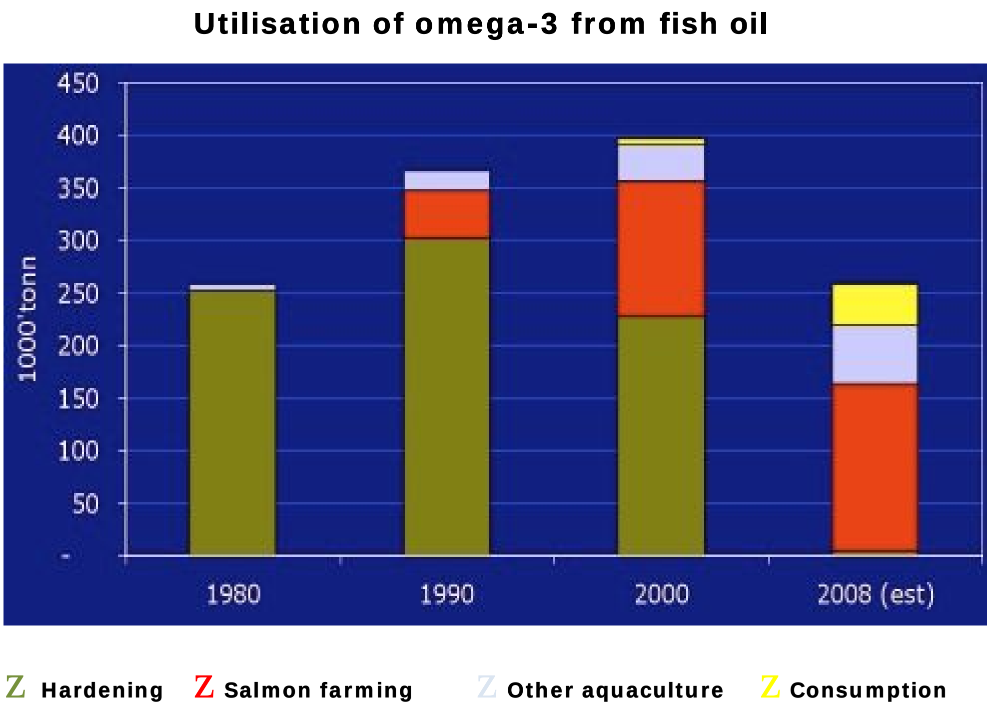


Figure 3.15: Utilisation of omega-3 from fish oil
The figure shows how the use of omega-3 from fish oil in recent years has changed from having been used in paint, fuel and hardening margarine (which destroys omega-3) to use in salmon farming that makes the healthy oils available in food for human consumption. (Source: Chr. Holtermann and EWOS)

Measures and goals

The industry will continue to contribute to the sustainable utilisation of marine resources
The industry is preparing itself for a continuing, relatively minor reduction in dependence on fishmeal and fish oil with increasing production and demand. This has led to the proportion of marine raw materials experiencing a steep decline in recent years, with the proportion of vegetable raw materials growing from 12% in 1995 to 38% in 2007. However an increase in the proportion of marine raw materials can occur periodically, for example during times when the price for fish oil is low compared with vegetable oils. The majority of people would agree that it is better to use fish oil in aquaculture than to use this nutritionally important oil for fuel or biofuel.

FHL also fully supports the government's work in the fight against illegal fishing and to reduce and prevent fish being discarded. FHL believes that it is vital that such discarding is stopped as it has been in Norway, and that the resources are taken onto land and utilised. The Norwegian authorities are carrying out an important international job in aiming to change the regulations.

Discarded fish are estimated to make up around 20 million tonnes every year. This amount that is currently dumped in the sea would itself provide enough marine raw materials to expand the volume of the Norwegian fish farming industry by ten times, without increasing today's regulated fish quotas (8).

For many years the industry has, through research, increased knowledge and dissemination of knowledge regarding feeding strategies, worked to ensure that the feed produced is utilised as effectively as possible. Better feeding equipment and good feed monitoring are also important contributions to this work.

One of the goals is to achieve the knowledge of how to make salmon into a net producer of marine protein
Research is already well underway in developing expertise to make salmon into a potential net producer of fish protein. The opportunities for utilising other resources as a source of the important marine fatty acids (EPA and DHA) are also being evaluated (using zoo plankton or through changing the genetics of plants).

Furthermore another goal is to increase the use of by-products form other fish species to an even greater extent. If this is successful the need for fishmeal and fish oils from industrial fish will be further reduced. However it remains to be seen if the results that have already been achieved in study conditions can be achieved in practice in fish farming. In connection with the EU-funded Aquamax project ("Sustainable AquaFeeds to maximise the Health benefits of Farmed Fish for Consumers") in which NIFES is a participant, 1 kg of salmon has been produced in which 70% of the oil and 80% of the protein was from plants, and in which the consumption of marine raw materials was reduced to the equivalent of 0.9 kg wild fish.

References:

1. ***Laksefakta.no and Kyst.no, based on figures from Ewos and Skretting (2009).***
2. ***Dr Jonathan Shepard (2009) IFFO re-appraisal of transformation efficiency of fishmeal***
3. ***FKD (2009) Strategy for an environmentally sustainable aquaculture industry***
4. ***Skretting (2008). SEA 2007***
5. ***Åsgard, Omholt, Venvik (2009). IntraFish. Article: Our most efficient meat producer***
6. ***Mugass Jensen (2009) Kyst.no: Salmon farming does not result in less fish in the sea***
7. ***NIFES. Factsheet. How marine omega-3 is better utilised by salmon. Part of the project "Researching Alternatives to Fish Oil in Aquaculture".***
8. ***Molvik, Ewos (2009)***

3.5 Use of energy

Developments towards reduced use of oil and diesel in aquaculture.
Energy consumption in aquaculture varies widely depending on the type of facility at sea and on land and the facility's location. Energy is mainly used to operate the feeding system and other technical equipment, for transport (boats), for lighting and heating the premises. Where possible, many companies have chosen to switch from using oil and diesel to operate the feeding platforms, to using electricity. There is also a tendency towards more companies switching from using feed storage facilities on land and feeding boats, to larger feeding fleets at sea with a central feeding facility. Over time this results in savings for both the environment and for the fish farmer.

The energy-saving project governed by FHL has produced good results
EnergiForum was established by FHL to direct focus on energy economisation and new technology in the Norwegian seafood industry. The forum will contribute to the exchange of experience and be a link between technical professional environments and the Norwegian seafood industry. It is also to be a useful arena for follow-up work and spreading the results of energy-saving projects in FHL.

In 2004 Energy network – fisheries (Energinettverk fiskeri) and Energy network – hatcheries and fry production (Energinettverk settefisk) were started. The goal was to implement new methods to reduce

energy consumption, and to document a saving of 10% in energy consumption. In 2005 the project resulted in an energy saving of some 29%. This was followed up by including more companies in 2006, and for the period 2006-2008 a new project was initiated with a target figure for the period for a total of 57 companies. In addition to hatchery and fry production facilities, participating companies have also included various facilities for the slaughtering, reception and processing of fish. The goals varied among the participating industries but in total the aim was to achieve a robust saving of 11.6% for the companies. This is the equivalent of an average of 559,000 KWh per company. The project was financed by Enova, with Cowi as FHL's professional consultant.

Hatcheries and fry production facilities in the energy network have achieved energy savings of over 30%

In hatchery fish facilities energy is mainly used in the pumping of water (and fish) through the facility, for heating the water, heating the premises and for lighting, but also for oxygenating the water. The first hatchery and fry producers that participated in the Energy network in 2006 had saved between 26% and 34.3% energy as of January 2007, which is the equivalent of an annual saving of between NOK 307,000 and NOK 673,000. With this excellent result more facilities were brought into the Energy network in 2007 and 2008. In 2008 there were a total of 15 companies in the network. Of these, 3 of the facilities had reconstruction work carried out and a partial stop in operations, and the results for these were thus not representative and were therefore taken out of the overview below. For the 12 remaining facilities in total during the project period a reduction in energy consumption of some 11% was achieved. This is the equivalent of a saving of 5.22 GWh. (1GWh = 1 gigawatt hour, the equivalent of 10^9 kilowatt hours).

The most important measures that led to the savings were a switch from the purchasing of liquid oxygen in tanks to the production of oxygen using a generator, the use of heat recovery and air-to-air heat pumps, switching from oil boilers to heat pumps, lighting management, use of energy-saving light fittings and improved specific energy use; with higher production based on unchanged energy consumption

	Energy consumption	Saving						
	Before project	2006		2007		2008		
	kWh/tonne	GWh	Reduction	GWh	Reduction	GWh	Reduction	
Company 1	15 552	1,30	34 %	1,05	30 %	1,25	31 %	kr 598 243
Company 2	8 975	0,61	26 %	0,74	31 %	0,59	27 %	kr 294 547
Company 3	20 625	-		1,70	19 %	1,25	15 %	kr 612 527
Company 4	12 525			0,25	12 %	0,33	15 %	kr 200 953
Company 5	8 153					0,01	1 %	kr 4 845
Company 6	10 624					(0,16)	-10 %	kr (76 699)
Company 7	13 904					0,72	20 %	kr 367 004
Company 8	5 564					(0,07)	-2 %	kr (40 452)
Company 9	27 352					(0,25)	-7 %	kr (144 576)
Company 10	23 325					1,07	23 %	kr 673 889
Company 11	11 471					0,13	5 %	kr 111 845
Company 12	11 482					0,35	15 %	kr 218 637
Total	14 129	1,91	30 %	3,74	23 %	5,22	11 %	kr 2 820 763

Table 3.8 Overview of the results from hatcheries and fry producers that took part in the Energy network 2006-2008

The overview shows energy consumption in 12 hatcheries and fry facilities before and after reviewing the companies and implementing energy-saving measures. The total consumption increased for 3 of the companies for various reasons from 2-10% during the project period. 7 of 12 companies achieved a saving in consumption of 15% or more. In total for all companies a saving of 11% was achieved, representing a reduction equivalent to over 5 GWh. (Source: Cowi AS.)

4. Escaped fish

The industry's own attitude to escaped fish
The aquaculture industry is quite clear that escapes of fish is undesirable; both with regard to the environment and to avoid financial loss. In 2007 the annual general meeting of the FHL declared a zero vision for escaped fish. This is also in line with the authorities' vision.

The adopted operative goal is to reach a level where escaped farmed fish do not have a negative effect on wild fish. This means that the number of escaped fish and the scope of individual escapes must be reduced to a minimum. Many aquaculture companies have an equivalent vision and goal within their own companies.

Why is it so important for the industry to prevent the escape of fish?
1. With regard to wild fish

a) Salmon: The breeding material for Norwegian farmed salmon is obtained from Norwegian rivers. However, avoiding any possible negative impact on the local wild fish in our salmon rivers is the most important reason for the industry's powerful actions to prevent escapes over the last 5-10 years. This is also reflected in the industry's operative goal repeated above.

b) Rainbow trout: The escape of rainbow trout is not a recognised problem with regard to the genetic influence on the local, wild stocks of fish in Norway. However it is not desirable that the species establishes itself in Norwegian fauna. Preventing escapes is thus treated just as seriously for the rainbow trout as for the other species of farmed fish.

c) Cod: It is considered that escapes of cod may have a negative impact on the local cod stocks in the fjords through genetic influence. However this concept must be limited to the cases where it is farmed fish that escape, and cannot be used in the same way for locally caught and fed wild cod. Cod is otherwise different to salmon and trout due to the potential for "escapes" in connection with spawning in the net cages.

Both escapes and premature maturity are expensive for the industry and several research projects have been initiated to find solutions to these challenges. At present little is known about the spread of eggs from fish farming facilities for cod. Nor has the effect of escaped fish and eggs on wild cod stocks been documented (1). However, researchers at the Institute of Marine Research found in studies in the spring of 2009 that cod can spawn in the net cages, that eggs survive and that some of the cod larvae survive and grow. The remaining question with regard to these studies is whether the farmed cod also cross-breeds with wild cod (2). Given the potential for negative impact, the work to prevent escapes should be intensified to turn around the negative trend in the escape statistics for cod in the same way as for salmon and rainbow trout. This will be a major priority in the future.

The aquaculture industry has a clear zero vision for escaped fish. The operative goal is to reach a level where escaped farmed fish do not have a negative effect on wild fish.

2. Financial considerations
Escapes are unprofitable. Each escaped fish has a negative effect on the fish farmer's net profit, which will of course be an important incentive to continue work on preventing escapes.

3. The reputation of the industry
The escape of fish is naturally enough seen in a negative light by the general public and is an oft-used argument against the industry and the sustainability of the industry. As long as the sustainability of the industry can be questioned on this point, fish farmers will do all they can to continue the positive overall development that escape statistics have shown in recent years.

4. Framework conditions
The industry's framework conditions will be affected by its ability to show that it can safeguard the resources it is entrusted with and the regulations it is subject to. Further growth and future frameworks will depend on sustainability and environmentally responsible operations.

Effects on wild salmon
The world's stock of wild salmon has been significantly reduced over the last 30 years. Fortunately the trend has not been as negative in Norway. Norway has fantastic natural conditions for both farmed and wild Atlantic salmon, and around 1/3 of Atlantic salmon has its spawning grounds in Norway.

In Norway salmon has disappeared from around 45 river systems, and around 100 of the remaining 400 Norwegian stocks are vulnerable. The construction of hydropower stations, acidification of river systems and mortality due to the parasite *Gyrodactylus salaris* are the three most important reasons that stocks have been wiped out or threatened by extinction (3). However, historical catch data in Norway shows natural fluctuations and that the trends are different in different regions over time.

There are many reasons for the decline in stocks of wild salmon over the last 30 years. Among the most important are natural fluctuations in access to nutrition and the water temperature in the ocean, pollution and acid rain, river interference, overexploitation and the parasite *Gyrodactylus salaries*, but also influence form aquaculture (4).

In its report “Stock status for salmon in Norway 2007” the Directorate for Nature Management provides an overview and categorisation of Norwegian river systems that have or have had a self-reproducing salmon stock. Furthermore it provides an overview of influential factors that determine placement in categories. The overview is reproduced in the figure below.

There appears to be a high level of mortality among escaped farmed fish. The survival rate for farmed fish has been found to be somewhat higher for salmon that escape in the spring (6.6%) compared with escapes in the autumn (2.6%) (5). There is also a large degree of uncertainty about how fish migrate. Research shows that fish escaping in Norwegian fjord and coastal areas may be found in river systems very far from the point of escape. Despite the low survival rate of escaped salmon, studies show that farmed salmon that survive and reach maturity can go up the rivers to spawn. Those who reach the spawning area may influence the wild salmon stock through competition for food and in the spawning area, and through genetic influence on the local salmon in the river.

A high level of farmed salmon in a river is assumed to have a negative effect on the local wild salmon stock. However, enough is not currently known on the extent to which farmed salmon negatively influence wild salmon, or the proportion of farmed fish a river can tolerate without negative influence. There are also no good procedures and guidelines for determining the level of farmed salmon in a river.

Results from fish sampling in rivers suggest that the choice of fishing area and fishing tackles can affect the estimates for the intermingling of escaped farmed fish (6). More research is therefore required and suitable monitoring procedures are needed. Everyone must be interested in these statistics being as correct as possible.

Figures from NINA’s monitoring programme show that the level of escaped farmed fish in Norwegian rivers has fallen significantly over the last 20 years (see figure 4.2). Although the methodology concerning monitored fish is not sufficiently standardised, the figures available show a clear decline and that the fish farmers’ engagement and efforts to prevent escapes have an effect.

Even though the different rivers have unique and local salmon stocks, these are not static in genetic terms from nature’s point of view either. Researchers estimate that 5-10% of salmon in a river have mistakenly migrated from other river systems. This is nature’s way of preventing in-breeding. Furthermore salmon have been released in Norwegian rivers since the end of the 1800s. Wild salmon interest groups moved salmon between river systems in the 1900s.

Furthermore, in Norwegian river systems salmon have been released since the middle of the 1950s to compensate for lost spawning and growing areas in connection with river system regulation.

Physical cultivation measures may also lead to genetic effects. Fish traps can change the stock structure by new river sections being available for size groups of fish that previously were excluded. When electrical power is regulated through the transfer of water between river systems, many species and stocks are spread further to new areas. All such intervention changes the direction of the natural selection.

Regardless of the assessments made in research environments the most important contribution from the fish farming industry is to continue to have its primary focus on preventing escapes.

Salmon has disappeared from around 45 river systems, and around 100 of the remaining 400 Norwegian stocks are vulnerable. The construction of hydroelectric power plants, acidification of river systems and the parasite *gyrodactylus salaris* are the three most important reasons that stocks are threatened by extinction.

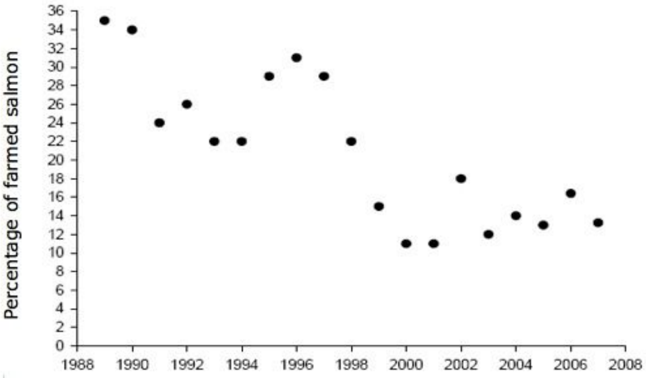


Figure 4.2: Level of escaped farmed salmon
Calculated percentage (non-weighted average in rivers) for the level of escaped farmed fish in sampled fish/stock fish just before spawning in the autumn during the period 1989-2007 (Source: Nina. Memo from May 2008)

Escape statistics

Escape statistics are official and readily available
Official escape statistics for farmed fish are recorded by the Directorate of Fisheries based on escape numbers notified by the fish farmers. The statistics are updated with regard to recapture and the number of remaining fish in the net cage, and will thus be subject to change until all fish from the net cage from which fish escaped have been slaughtered. Escape statistics are publicly available on the internet.

Escape statistics for salmonids in 2008
The trend in the number of escaped fish and the number of escape incidents for salmon and trout have been positive and the operative goal has been reached with a good margin. For salmon the number of escaped fish fell by 61% * in 2008 compared with the previous year. The fall for rainbow trout was even larger but has varied somewhat over the last few years.

Looking at the trend in escaped fish and escape incidents compared with production growth, one finds the same positive trend in recent years (see the figure 4.4). While 10 years ago some 0.46 percent of released salmon smolt escaped, only 0.04 percent of salmon escaped in 2008 (7).

To put it another way: 99.9% of salmon do not escape. This is positive for both wild salmon and the fish farmer, and provides inspiration to continue the hard work to prevent escapes and thus continue the positive trend. As shown in figure 4.6 the escape statistics have fallen in recent years while production has increased.
*** Based on corrected figures as at 24.06.09**

Escapes of cod in 2008
The trend is not as positive for the cod industry, where numbers were back at 2005 and 2006 levels, after having declined in 2007. This is extremely regrettable.

An important reason that the escape statistics for cod were so high in 2008 compared with 2007 was a single episode where a trawler destroyed the mooring lines of a facility and caused a major escape that made up 68% * of the total escaped fish statistics for cod in 2008. This was no less unfortunate being aware that cod fish farmers, in the same way as salmon and trout farmers, have worked hard to obtain equipment and implement procedures precisely to prevent escape. At the same time this is a reminder that all activity involves a risk.

The industry shall and must do its best to prevent escapes, but is unable to prevail over all conditions. It is enough to mention here natural disasters, certified equipment with production faults and collisions with boats due to careless skippers. However, the systematic review of the causes of all kinds of escapes will be a positive contribution with regard to risk assessments and preventive measures, also with regard to conditions the fish farmer has no direct influence or control over.
*** Based on corrected figures as at 24.06.09**

Developments in spring 2009
In the first half of 2009 there have unfortunately been escape incidents both of salmonids and marine farmed fish species, even if the total number appears to have been lower than for the same period in 2008. However, it is positive that the number of registered incidents in the same period has almost halved (12 against 21) compared with 2008 (7).

Species	Aquaculture`s industry's operative goal for 2008	Directorate of Fisheries statistics for number of escaped fish 2008
Salmon	200.000	112.000
Rainbow trout	75.000	600
Cod	50.000	259.000*

Table 4.1: Operative goals and results with regard to escapes in 2008
*The table shows the aquaculture industry's operative goal for escaped fish in 2008 compared with the result achieved. The figure was updated as at 24.06.09 (Source: Directorate of Fisheries and FHL). * Around 68% of this is due to one escape incident when a trawler destroyed the mooring lines of a facility*

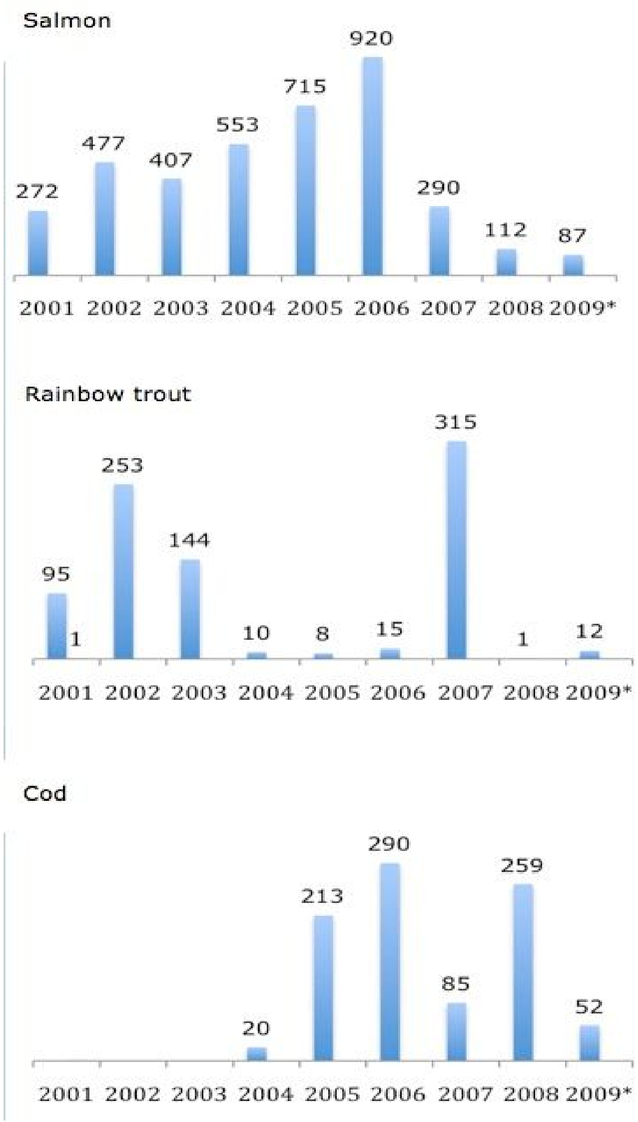


Figure 4.3: Statistics over escaped fish
The figures show the number of escaped salmon, rainbow trout and cod in recent years. Figures in thousands. *) Updated as at 24.06.09

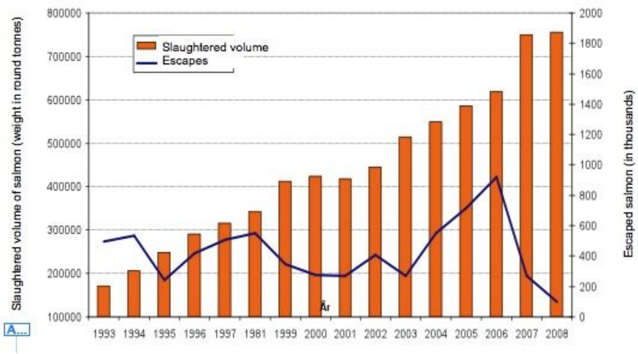


Figure 4.4: Escaped salmon in relation to the production of salmon in the last 15 years

While 10 years ago some 0.46 percent of released salmon smolts escaped, only 0.04 percent of salmon escaped in 2008.

The figure shows how the production of salmon has increased, while at the same time the number of escaped salmon has declined.
(Source: Directorate of Fisheries' statistics and FHL)

"The Namsen Project"

For several years fish have been monitored in many Norwegian rivers to measure the level of farmed fish in the various rivers. Namsen is one of these rivers in which fish have been monitored. As in many of the other rivers the proportion of escaped fish in Namsen appears to be declining.

Due to the major uncertainty in the basis of the figures, the initiative was taken to implement a collaboration project between the aquaculture industry, wild salmon interests, various organisations, researchers and the authorities (FHL, NVGF, NTGS, FMNT, NTFK, NINA, HI* (*8)) where classification of the fish made up part of the project.

In the autumn of 2008 classification of fish using wedgeshaped weir during the period of 21 August to 26 September, which was supposed to be the most important upward period for escaped salmon in Namsen, was carried out in addition to the ordinary monitoring fish programme.

This was a success in the sense that the nets seemed to work well, it can be assumed that wild salmon and farmed salmon had the same chance of being caught and that the majority of salmonids that travelled up the river during the period were actually caught in the nets. Furthermore it provided the opportunity to handle the fish with care. All salmonids were visually assessed and in addition scale samples were taken of all fish that were classified as farmed fish.

The result was that around 11% of the salmon caught was classified as farmed fish. Only 1% of the total of 363 fish that were caught with the net was rainbow trout, 341 were salmon (9).

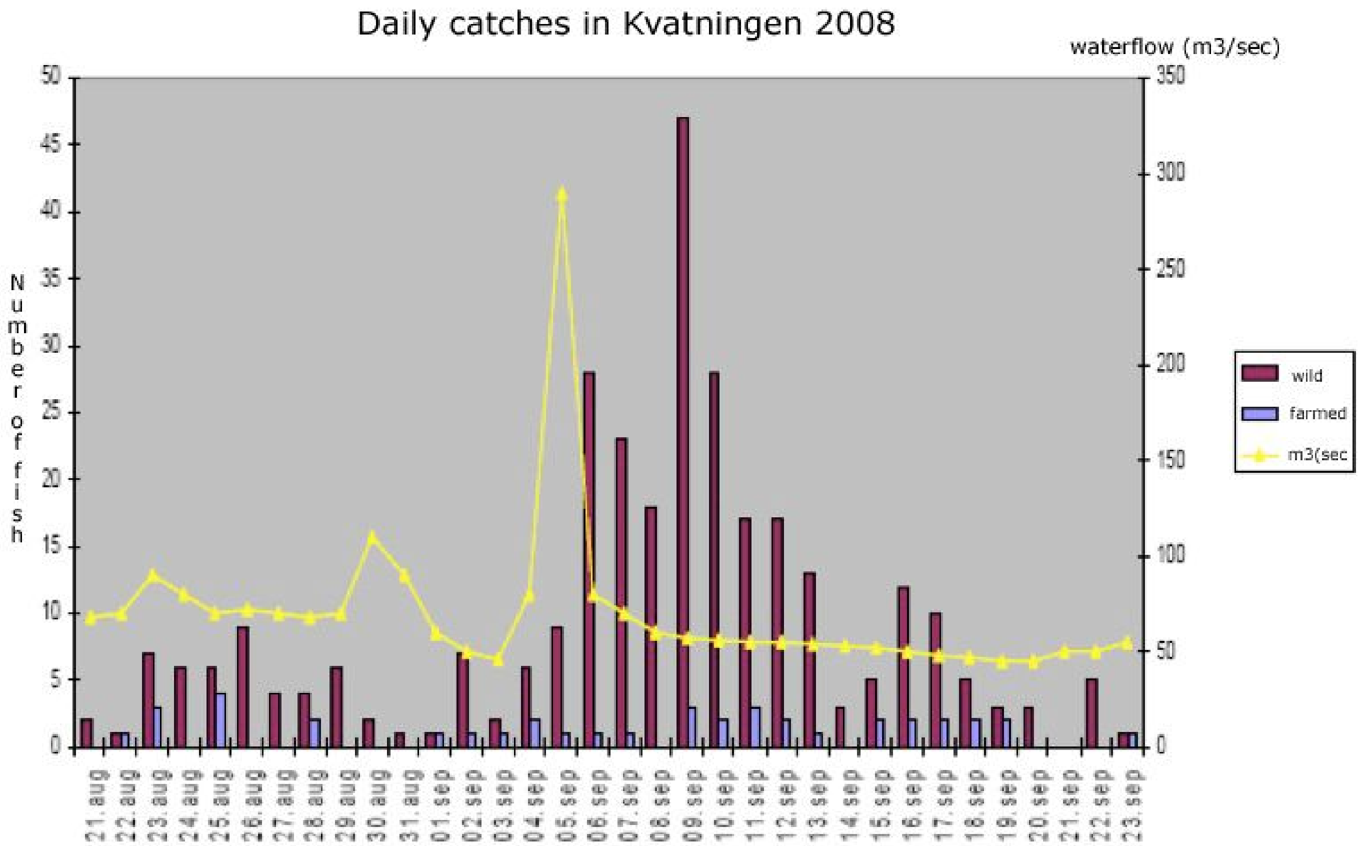


Figure 4.6: Daily catches in Kvatningen 2008
The figure shows purse seine net catches by Kvatningen(Namsen) fall of 2008. Wild salmon are assessed based on external characteristics, farmed salmon also by characteristics caused by vaccination of smolts (n = 333). Sea Trout and "uncertain" is omitted. The yellow curve indicates the flow of water in the river. (Source: Namslaksen 2008. Report No. 7 - 2008.)

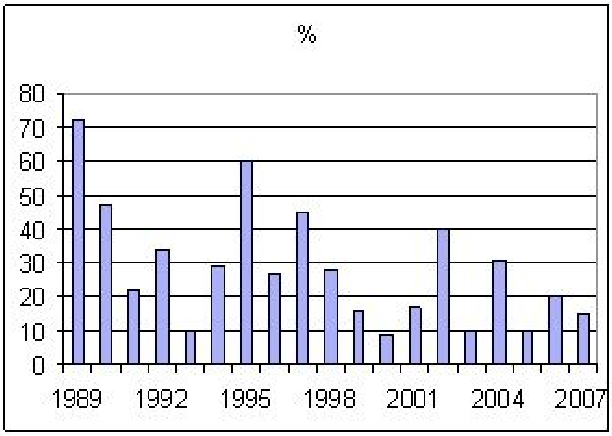


Figure 4.5: Fish monitored in Namsen river system
The figure shows the results of monitoring fish in the salmon-leading sections of Namsen river system from 1989-2007. The trend over the last 20 years is clearly positive in the available basis for the figures. However it is important to continue to work towards creating procedures and guidelines that ensure the most accurate basis for the figures as possible.
(Source: KLV, Information centre for salmon and the aquatic environment)

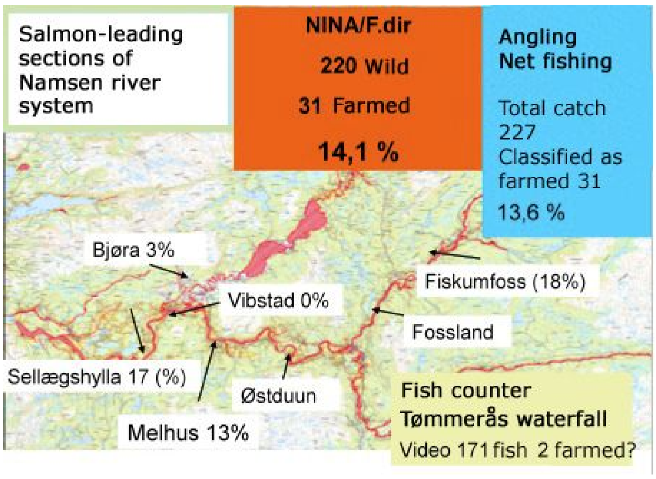


Figure 4.7: Distribution of escaped farmed fish found during monitoring of fish in Namsen in 2007
The figure shows the catch results and proportion of farmed salmon at different catch locations in the Namsen river system in 2007. The level of farmed fish varied from 0-18% depending on where the monitoring of fish took place. This shows how important it is that good guidelines are developed for how to measure the level of escaped salmon in river systems.

Important reasons for escapes

Old escape incidents are reviewed to gain new insight into reasons behind escapes
No official statistics are available detailing the reasons for escapes. However a review and investigation of the reasons behind escapes were initiated in the aftermath of escapes in connection with two storm periods in January 2006 (10). In addition SINTEF Fisheries and Aquaculture is carrying out a project called SECURE funded by the Norwegian Research Council where it goes through known escape incidents and summarises the reasons that escapes took place (11). The purpose of the investigations is of course to find out the underlying reasons, learn from mistakes and to find effective measures to avoid escapes happening again.

After the Escape commission appointed by the authorities was established in the autumn of 2006, work in finding causal connections has improved. Several studies have also been carried out of a selection of escapes. The results of the studies have been and will continue to be spread in various ways, including courses in escape prevention for fish farming companies, for equipment suppliers and other relevant parties.

Causes are often complex
Escapes can occur as a result of a critical individual incident, but are just as often due to a combination of multiple incidents. These will often not have led to escape on their own but combined with other incidents can lead to a risk of escape. A summary is now available of the total of 115 notifications about escapes or suspected escapes registered in the period autumn 2006 – autumn 2008. 20% of these escapes are categorised in the study by SINTEF as major escapes, i.e. escapes by more than 5,000 fish. In total these major escapes cover 95% of the escaped fish during the period.

44% of the escapes are categorised as minor escapes, and cover incidents where 0-200 fish escaped. In total these "minor" escapes make up just 0.2% of the escaped fish. However this shows that the industry also cares about and reports incidents where the escape covers relatively few fish. This is important, not just because the regulations state that each escape or suspected escape must be notified and followed up, but also because each escape, regardless of the cause or scope, is the basis and opportunity for continuous improvement provided it is followed up.

The figures below show that in total for all species the majority of the escape incidents investigated were caused by various operational faults (38%), while the most fish escaped as a result of technical errors (44%). While 6% of these escape incidents occurred from fry production facilities, escape incidents from fry production facilities made up 18% of the total escaped fish.

The most important reason for these escapes was holes in the nets; 51% of *the number* of fish escaped in connection with the fact that holes was made in the nets, while 65% of the escape *incidents* were related to holes in nets.

Since holes in nets are the most important reason for fish escaping from a facility, and since escapes related to holes in nets also represent over half of the total amount of fish that escaped, it is important to look more closely at what causes holes in nets. For the escape incidents from autumn 2006 – autumn 2008 it was found that the majority of incidents (22%) were due to predators or pests. Rubbing from other equipment against the nets was the next most important reason (18%). Not unexpectedly most fish escape in connection with breakdowns (21%). Regarding the *number* of escaped fish predators are also an important single reason.

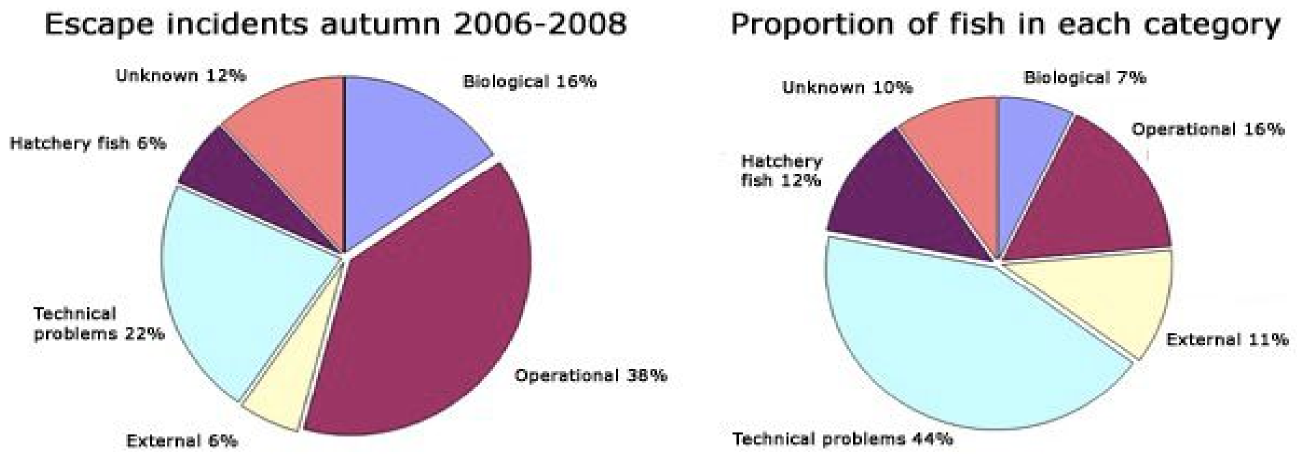
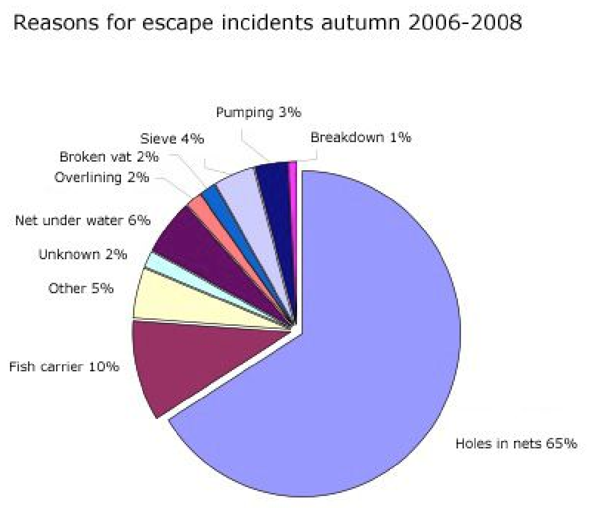


Figure 4.8: Escape incidents; categorised with regard to main types and proportion of fish in each category.
The figure shows different categories of escapes with regard to incidents and number of fish. (Source: Østen Jensen, SINTEF Fisheries and Aquaculture)



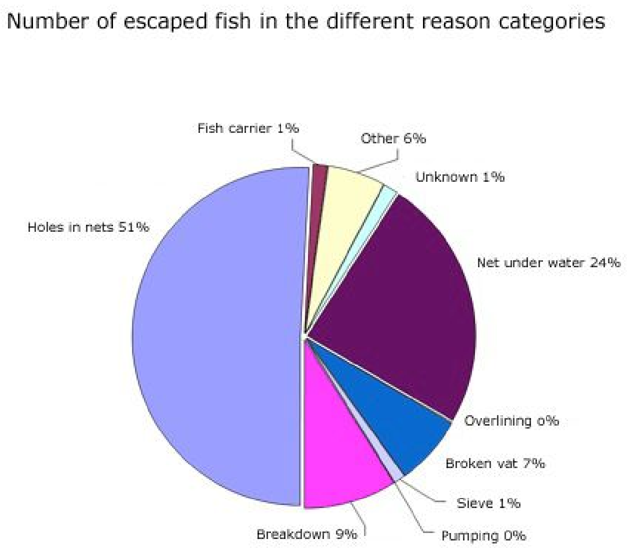


Figure 4.9: Reasons for escapes and number of fish in the different reason categories
The figure shows the different reasons for escape from autumn 2006-2008 obtained from sea facilities and hatchery fish facilities. (Source: Østen Jensen, SINTEF Fisheries and Aquaculture)

Measures to prevent escape

NYTEK: Focus on safety and correct equipment in the right location

The NYTEK regulations (Regulations on the requirements for a technical standard for installations related to aquaculture) with the related standard (NS 9415) are perhaps the most important regulations specifically aimed at preventing escapes. FHL has been a driving force and actively contributed to both the original design in 2004 and in connection with the revision that is underway. With NYTEK the industry and equipment suppliers have standardised requirements for location classification and the certification of new equipment adapted to the class of location. A capability certificate is required for existing equipment.

Through the implementation of NYTEK the aquaculture industry has made a significant step in work to prevent escapes. In recent years the industry has invested billions of Norwegian Kroner in new, more secure equipment, location classification, the testing of equipment and monitoring procedures. There is reason to believe that this, together with work on creating the right attitude has been the most important contribution with regard to the positive development in the escape statistics. FHL sees the opportunity to develop an equivalent standard for hatcheries and fry production facilities as positive, and wants also to be active in such development.

Internal control in all parts of operation based on risk assessments

Risk = probability x consequence.

In 2008 a total of 6 nationwide courses in escape prevention were held under the direction of FHL, in which around 250 operators from aquaculture and hatchery fish production took part.

With increased production and larger net cages it is reasonable to assume that both the probability (number of escapes) and consequence (as a result of more escaped fish) will increase and give an increased risk of escapes in total for the aquaculture industry. So far the statistics show that this has not taken place. Through the Internal Control Regulations to meet the requirements of aquaculture legislation, all fish farming companies are obliged to have an internal control system based on risk assessments. This has resulted in a review of operation, and an implementation of risk assessments also with regard to escapes in all

companies. Procedures have been created and much work has been put into the system for monitoring and maintenance with the intention to preventing escapes during normal operation, and during special operative routines.

Double protection of outlets in hatcheries and fry production facilities

The requirement for double protection of outlets in hatcheries and fry production facilities has led to a new review of risk assessments in many facilities, and major efforts to protect outlets and outside areas. Thus significant work has also been carried out and many millions of Norwegian Kroner invested in these facilities in recent years to ensure that fish from the facilities do not escape in connection with operations. Courses and training have been part of the process.

New marking regulations have been followed up

There has always been a requirement for the marking of facilities at sea so that they are well visible to shipping traffic. These requirements were changed with effect from 01.02.08, and resulted in the replacement of marker buoys and lights for all facilities. The aim was that the new marking should make the facilities even more visible than before.

The work and costs related to this reform have been extensive, but if this can help in avoiding collisions from boat and shipping traffic these are good investments. However this does still depend on the responsible behaviour of those who travel by sea so that collisions and escapes that result from damage after such incidents can be avoided.

Fish farmers want to learn from mistakes after escape incidents

In the government-appointed Escape Commission (created in June 2006) in which fish farmers are also represented, relevant escape incidents are reviewed. FHL's own escape committee (established at the end of 2005) that consists of various fish farmers has also contributed to the review of previous escape incidents in connection with the storm "Narve" (2006).

Possible reasons are examined so that knowledge can be obtained and that learned can be communicated to equipment suppliers, fish farmers and other operators in the industry. Furthermore these committees contribute by initiating new research projects and through their input to the authorities when regulations are to be drawn up or revised.

Training is important. Many fish farmers have taken part in courses in escape prevention

In 2008 a total of 6 nationwide courses in escape prevention were held under the direction of FHL, in which around 250 operators from aquaculture and hatcheries and fry production facilities took part. These were followed up in February 2009 by a new course specifically for hatcheries and fry producers that also gathered around 80 participants. Furthermore escape prevention has been an important subject in internal company meetings, and fact-based information has been passed on from research projects and the Escape Commission.

Research has contributed to more secure fish farming equipment and special knowledge of escapes

The aquaculture industry itself has been a driving force in the accumulation of more knowledge about escape prevention, but also to get more information of the behaviour of salmon that escape to thereby gain greater knowledge about recapture and preparedness. It has also been important to obtain improved escape statistics on the way.

In connection with the storm "Narve" in 2006 a detailed evaluation was carried out with a review of the reasons and communication of preventive measures through escape prevention courses afterwards. Research was carried out to improve location classification and strength calculation for fish farming facilities. Furthermore several different research projects have been initiated with a view to developing fish farming facilities in which the different parts of the facility and the use of the equipment are in focus.

Methods for tracing fish are also tested, and other researchers are looking into the possibilities for farming sterile fish in a way that safeguards both animal welfare and production-related conditions in the industry. FHF has contributed with significant funds for projects dealing with escape prevention, and for the communication of the results through FHL.

Good preparedness is vital if an incident occurs.

All facilities are obliged to have preparedness plans with regard to escapes and recapture. These plans shall ensure that all employees at the facility must know how escapes can be discovered, limited and reported and how in practice to secure the facility and start recapture as soon as possible after an escape has taken place.

FHL's website has templates for agreements with fishermen in connection with recapture. Many fish farmers have also taken the initiative to collaborate on preparedness, recapture nets, receipt of fish etc. in different regions to ensure sufficient capacity in the event of an accident.

In 2009 FHL will continue the work in clarifying requirements for preparedness plans, and also wishes to look at the possibility of developing templates for preparedness drills in collaboration with the Directorate of Fisheries.

To be able to help fish farmers with advice and information if an incident should occur is also high priority work from FHL's point of view. FHL's own

employees in the environmental and communications departments may contribute or they can assist through hired legal experts when required.

Goals and focus areas for 2009

Work continues every day. All year long.
The aquaculture industry has a clearly stated zero vision for escaped fish. The operative aim is to reach a level where escaped farmed fish do not have a negative effect on wild fish. This means that the number of escaped fish and the scope of individual escapes must be reduced to a minimum.

In 2009 the industry will strengthen its focus on keeping the figures for escaped salmon and trout low and preferably even lower than last year. The goal for cod is no less than a drastic reduction. Based on an overall assessment it has been decided to also keep the 2008 target figures for 2009, but at the same time to continue the intensive work in preventing escapes.

In the coming year FHL will particularly focus on reducing the number of incidents that lead to, or can lead to escapes. The securing of hatcheries, fry producers and fish farming facilities for cod will also be important focus areas.

An increased focus can improve the results further. The number of escaped salmon and number of escapes shall be reduced to a minimum. To reach this goal the good work carried out by the industry every day, all year long, must continue unabated.

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7. Directorate of Fisheries' website, escape statistics.
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9. Nord-Trøndelag County Administrator, Namsen salmon 2008, Report no. 7/2008 and Staldvik F., personal report
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11.Jensen Ø (2009) Personal report

5. Sea lice

Status and challenges

Sea lice – not a health problem for farmed salmon, but taken very seriously by the aquaculture industry

Due to strict regulations and good follow-up from fish farmers, in general sea lice do not represent a health problem for farmed fish in the Norwegian aquaculture industry today.

At the same time the industry must recognise that sea lice represent a challenge related to safeguards with regard to wild salmon and sea trout. Both for this reason and in order to maintain good health and fish welfare in the fish farming facility, the industry uses significant resources to keep the louse level low in the facilities.

The aquaculture industry carries out regular controls on the amount of lice on fish and therefore has sufficient background knowledge to implement measures. In collaboration with the administration and scientists the continuous development of the methodology with regard to controlling the sea lice situation is underway and treatment strategies are improved in line with new expertise. The overall goal for the industry is that sea lice from fish farming facilities will not have a negative influence on the wild fish population.

Through measures such as coordinated treatments, in close collaboration with the administration, in the autumn and winter 2008/9, the lice situation in the fish farming facilities in the spring of 2009 is good. This shows that through focus and collaboration the industry can succeed, which provides inspiration for continued hard work to ensure control with the lice situation and thereby achieve the goal for the benefit of both wild salmonids and farmed fish.

The majority of fish species in the sea are hosts for one or more types of lice

The majority of fish species in the sea naturally have one or more species of lice. For salmonids in our waters two species have been described; sea lice (*Leptophteirus salmonis*) is specific to salmonids and the one that represents the greatest challenge, while fish lice *(Caligus elongatus)* can prey on more than 80 different species and is of limited significance in our waters (1).

Cod is also mainly a host to two different types of lice. These are cod louse (Caligus curtus) and fish lice *(Caligus elongatus).* Cod lice are found on both cod and other codfish such as ling, pollack, coalfish, cusk etc. Studies of fish caught in nets from Tromsø to Stavanger show minor incidences of cod lice. Experiences show that this louse does not sit well on the fish and quickly disappears from fish that are released into net cages and vats. Cod lice is thus seen to have completely different behaviour to sea lice, and it is therefore open to question whether cod lice will thrive on fish in net cages and thereby contribute to increased pressure of infection for wild fish and other farmed cod. So far cod lice have not caused any known problem in cod farming, but the incidences, ecology and behaviour of cod lice and fish louse are not generally well researched (2). Cod fish farmers report that there is very little lice on farmed cod. The following information will thus mainly cover sea lice (*Leptophteirus salmonis).*

> **The overall goal for the industry is that sea lice from fish farming facilities will not have a negative influence on the wild fish population.**

Sea lice are also the only directly health-related subject covered by this report. The health situation of Norwegian farmed fish is otherwise covered in reports from the National Veterinary Institute, and reference is therefore made to these for more information regarding health and farmed fish.

Sea lice are an old challenge with new relevance

Sea lice are not a new salmon parasite, and are mentioned in old literature right back in the 1600s. The first time a lice epidemic was reported in wild salmonids was in Canada in 1939 (1). Sea lice are widespread in the northern hemisphere and are found in both the northern parts of the Atlantic Ocean and in the Pacific Ocean. No genetic differences have been found between sea lice from different parts of the Atlantic Ocean, while it is possible to observe clear genetic discrepancies between sea lice in the Atlantic Ocean and the Pacific Ocean (1, 5).

The number of salmonids, and thus the number of potential hosts for sea lice in the sea has increased as a result of fish farming. Many are therefore concerned that the locations of fish farming facilities in fjords and along the coast exposes the migrating salmon smolts to a greater pressure of infection than previously. Even though the incidences of lice are also seen to follow natural fluctuations, sea lice are an important challenge given major emphasis from the aquaculture industry.

About sea lice
Sea lice (*Lepeophtheirus salmonis*) are crustaceans that grow by changing their shell between the different stages of development. The lice have three free living stages and during these stages the lice can spread over large areas through the waters. When attaching itself to a salmon, it develops further through four fixed stages and three mobile stages, and ends up as an adult louse that breads on the fish. A female releases the fertilised eggs in two sacks, "egg strings". A female can produce up to 10-11 pairs of such sacks, each containing several hundred eggs, during her lifetime (3).

The growth and development depends on the temperature. Development occurs rapidly if the sea water temperature is high, but can take longer in lower temperatures. Free living lice larvae do not eat, and its food reserves are gradually used up. The louse will die if it does not find a host in time, and death occurs sooner the higher the temperature (1, 4).

Sea lice are a marine parasites, which means that a salmonid can only be infected in the sea. The lice generally fall off the salmon after a short time in fresh water and cannot breed or infect other fish in freshwater. It is believed that wild salmon bring the source of new lice with them from the ocean when in springtime they travel into the coastal areas towards the rivers to spawn. Since it takes time to develop infectious lice, there is not always an overlap between smolt migration and infectious llice from adult fish that are headed for the rivers. However, sea trout live in the fjords and coastal waters all year round and like farmed fish they can help to maintain the continuous production of sea lice all year. Thus in practice it is possible for lice to travel from wild fish to other wild fish or farmed fish, and from farmed fish to other farmed fish or to wild fish.

The incidence and spread of sea lice varies according to many factors. The salt content in the water, temperature and current are important conditions. But the concentration of hosts for sea lice, i.e. the number of salmonids in an area, of course plays an important part. This is precisely why it is so important that the industry has good routines to keep control of the level of sea lice in net cages; and particularly at times as the risk of infection of wild salmon is enhanced.

Challenges related to sea lice
In salmon fish farming lice levels are continuously monitored according to legal requirements, by having the number of lice counted every 14 days. The results of all counts are reported to the Norwegian Food Safety Authority. Furthermore the regulations have provisions regarding defined limits for when

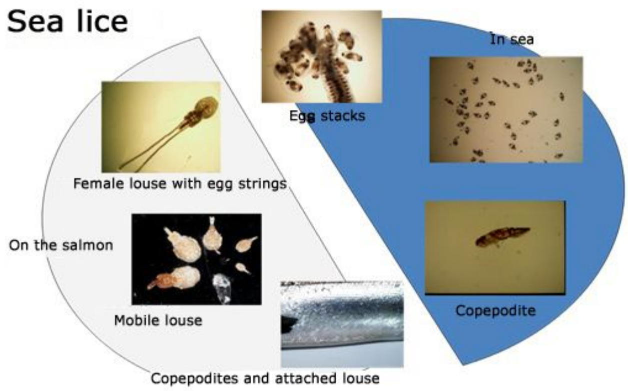


Figure 5.1: Development of sea lice
The eggs hatch from the egg strings and directly into the sea where they are subject to both passive and active movements. Sea lice fasten to salmonids as either fixed (4 stages) or mobile (3 stages). (Source: K.K. Boxaspen, Institute of Marine Research.)

treatments must be initiated. At the same time the number of farmed fish, and thus the number of potential hosts for sea lice has increased. This is the reason for the strict regulations and for a number of measures that the aquaculture industry has put in place to reduce the pressure of infection on smolts migrating from the rivers in the spring and early summer, and to reduce the pressure of infection on salmonids that feed in the fjords.

Effective treatment measures against sea lice have existed for several years that have led to lice not generally representing a problem for farmed fish. During 2008 certain areas along the coast reported that lice showed reduced sensitivity to some of the anti-parasite preparations. This has caused new and serious challenges for fish farmers, and potentially for wild fish, but at the same time has resulted in a number of new measures to prevent a reversal of the positive development also seen in the lice situation for wild fish in recent years. Based on lice counts and the situation in the fish farming facilities in the spring of 2009 it appears that the measures implemented during the winter 2008 / 2009 have had the desired effect.

Openness regarding the lice situation in the fish farming industry
The counts of sea lice in the fish farming net cages are reported each month to the Norwegian Food Safety Authority and the results are published at www.lusedata.no. The situation can be followed from month to month, for the entire country and for each individual county. Because natural fluctuations along the coast and in the different fjords in our long country represent different challenges, it is important to continue to look at the different regions individually to achieve the best adapted measures possible, while at the same time in principle measures must be coordinated and nationwide.

The effect of the fight against sea lice is measured on wild fish

Back in 1997 a national working group with representatives from the industry and administration presented a national action plan against lice on salmonids. The long-term goal for this (1997-2002) was to reduce the damage caused by lice to farmed and wild fish to a minimum through coordinated de-lousing and preventive measures in the aquaculture industry. A knowledge summary (7) from 2005 concluded that the effect of a reduction in total sea lice production must be measured on wild fish. This is also in line with the government's Strategy for sustainable development from 2009, where it states that "*In addition to an acceptable level of lice in the fish farm that satisfactorily safeguards the farmed fish, in the future a lice level on wild stocks of salmonids that does not lead to an unacceptable negative influence must be achieved".*

Since 1992 various bodies have sporadically and using different methods in different parts of the country registered sea lice on wild fish in rivers, fjords and along the coast. Over time scientists have obtained results for a longer period of time in some regions and can thus better follow development. The conclusion is that the level of sea lice is lower now than early in the 1990s, but that the results can vary from year to year (1). For many years NINA (Norwegian Institute for Nature Research) has documented the situation particularly from the Trondheim fjord and northwards (1, 6). They found a tendency that the southern areas had been infected earlier than the northern areas, and at a higher level of intensity. This is probably an effect of higher sea temperatures in the south. Other monitoring projects have also been carried out where the conclusions vary not only from region to region, but also from year to year (1).

A national sea lice monitoring in 2008 for wild stocks of salmon, sea trout and sea char along the Norwegian coast, concluded that the pressure of infection in 2008 had increased along large parts of the Norwegian coast. In the majority of wild fish locations that were studied the situation was still somewhat better or the same as in 2007, with the exception of the Hardanger fjord where the pressure of infection was particularly high in the outer parts of the fjord (8). The preliminary conclusion from the monitoring of sea lice on wild fish after wild salmon and trout had mostly completed their migration to the sea in the spring of 2009 showed that so far in 2009 there were clearly fewer lice than after the same monitoring in 2008. (9)

In the coming years it will be important to both ensure the effective methodology for the monitoring of and fight against sea lice in the fish farming facilities, but also to ensure that we have sufficient knowledge regarding the effect and tolerance limits for sea lice on wild fish, dispersion patterns and not least sufficient certainty and consistency regarding the monitoring methods used to determine the level and negative influence on wild salmon.

Measures

In the fight against sea lice a large number of measures have been implemented

Given the fact Norway has important wild salmon stocks and a major aquaculture industry it is important that measures are put in place that safeguards these. The degree of risk that sea lice represent to wild fish populations alone or in combination with other risk factors is unknown.

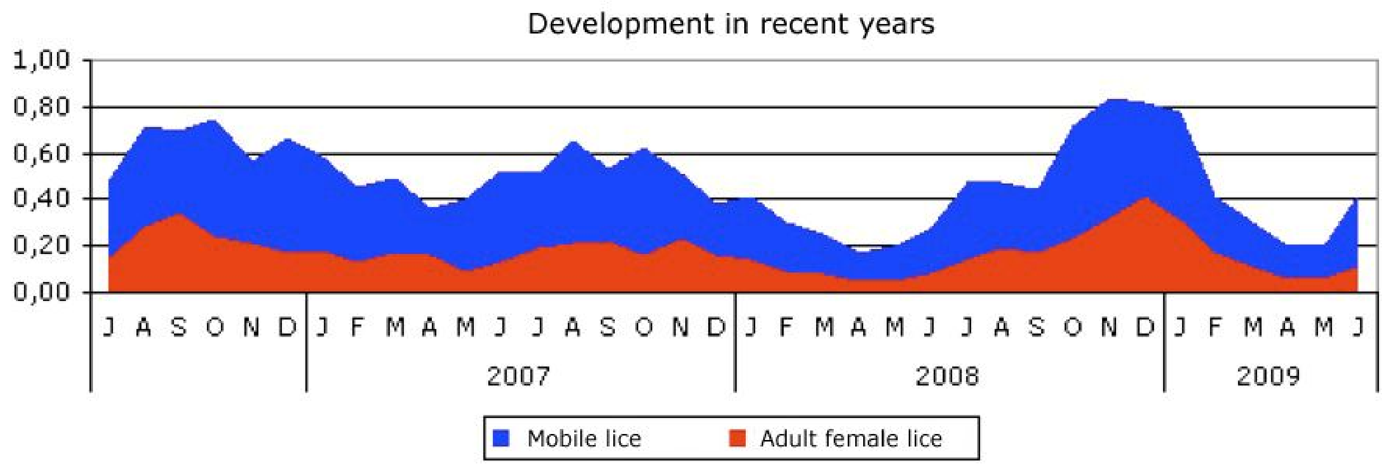
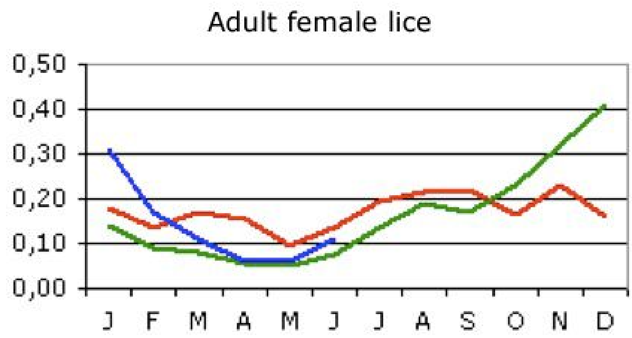


Figure 5.2: Sea lice statistics for the last 3 years
The figure shows the development in the situation for sea lice based on counts carried out in all fish farming facilities. The action levels for treatment are in accordance with the applicable regulations at 0.5 female lice per fish, or 3 mobile lice perfish. Furthermore the figure shows that the national average is under the action levels, with a highly positive development in 2007 and the first 3 quarters of 2008. Thereafter the counts show an increase in the final months of 2008. The results for the first six months of 2009 show that measures including coordinated winter de-lousing around the country have given the desired and positive effect, but at the same time there was a slight increase again towards the summer. (Source: Lusedata.no)



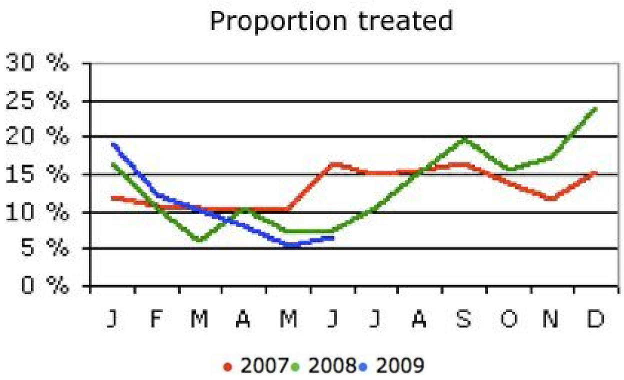


Figure 5.3: Salmon lice statistics for the last 3 years
The figure at the top shows the development in the number of adult female salmon lice over the last 3 years, and the figure at the bottom shows the proportion of fish farming facilities that have had to use anti-parasite treatments during the period. (Source: Lusedata.no)

However there is general acceptance that controlling and restricting sea lice in fish farming facilities must be more comprehensive than that which is strictly necessary with regard to the health and welfare of the farmed fish, and value creation in aquaculture in general. Therefore the industry, in collaboration with the administration and researchers has initiated a number of measures and put many different methods into use to prevent increased production of salmon from leading to a proportionate increase in the production of sea lice. The industry has succeeded in this. However, in some areas there are still challenges that must be solved to ensure that the level of sea lice does not have a negative influence on wild salmon. The industry has therefore taken action.

Fighting sea lice entails both preventive measures and treatment

In order to succeed in the fight against sea lice it is important that all known measures are put into use, are used optimally and by everyone along the entire coast. Basic knowledge about a comprehensive action strategy (IPM; Integrated Pest Management) and how this can be used in the industry is beginning to gain increased attention. This control strategy entails a need for even greater focus on preventive work, and is in line with the development in many regions and with guidelines in new regulations that are being prepared in the spring of 2009.
Sea lice can spread in flowing waters and locations in large areas are influenced by each other. Preventing lice thus requires not only good cooperation between fish farmers, but also between fish farmers, fish health services and the administration. In this area there has been a highly positive development.

Important preventive measures already put into place or that are under implementation entail an increased focus on area considerations with the use of larger locations. Attempts are made to position the facilities optimally with regard to each other and in respect of current conditions and the topography of the area. There is a focus on separating generations and joint resting of larger areas where this is possible. These measures have given a positive effect in many cases, also with regard to sea lice.

Interest in the use of wrasse has increased again. There are particularly two species ballan wrasse (*Labrus bergylta*) and goldsinny wrasse (*Ctenolabrus rupestris*) that have been used in fish farming. Wrasse eat sea lice that have attached themselves to fish and thus carry out a continuous fight against sea lice in the net cages. The use of wrasse is naturally limited by low temperatures in the sea (5-20°C) but there is a documented effect all the way up to Lofoten (10). This means that wrasse can potentially be used by around 80% of the licence holders in Norway. Access to sufficient wrasse is currently a problem and limits its use. The same applies to a degree to the lack of experience and knowledge about the use of wrasse. However the farming of wrasse on a minor scale has been initiated in Norway which provides both hope on the greater use and greater spread of knowledge regarding the use of wrasse in the fight against sea lice.

The use of “health feed” can also be a possible preventive measure. Initial studies indicate that health feed can have an effect on the incidence of sea lice. Such feed has substances added to it (beta glucan, nucleotides or “biomousse” (from yeasts)) that appear to be able to strengthen the fish's unspecific immune system, strengthen the fish’s outer mucus layer and can give a healthier intestine. New studies and research is underway to better understand the mechanisms behind this (11).

In the long term vaccines and breeding can be good supplements for sea lice prevention. Studies and vaccine research show that it can be possible to develop a vaccine against sea lice but this is complicated and requires long-term research efforts.

All anti-sea lice measures are based on monitoring and control

Treatments using medicine is only used when necessary. A systematic monitoring of the level of sea lice with regard to stipulated regulations and procedures forms the basis for each treatment.

Wrasse. Photo: Villa Organic

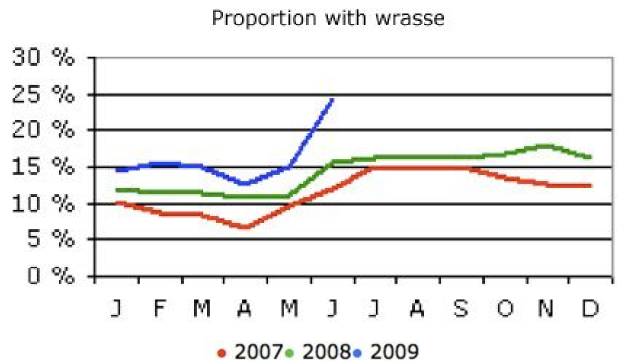


Figure 5.4: Use of wrasse
The development in the use of wrasse in Norwegian aquaculture over the last 3 years. The trend shows the increased use of wrasse once again, and an increasing interest from more operators to use this measure in the fight against sea lice.
(Source: Lusedata.no)

Monitoring and counting before and after treatment is a key factor in an overall strategy to fight sea lice, and correct counting is therefore decisive for evaluation of the effect of treatments.

Treatments areundertaken through the use of medicine feed or through bath treatments. In 2008 a total of 218 kg of active substance was used divided into various anti-sea lice treatments. This represents an increase compared with 2007, which is assumed to be related to the changed threshold levels, repeated treatment in connection with some cases of resistance and probably more coordinated area treatments. Medicines used were prescribed by fish health personnel and are approved for use in farmed fish. It is not permitted to slaughter fish before the retention time for the medication has expired. All use of anti-parasite preparations is reported and slaughter reports and prescriptions are controlled by the Norwegian Food Safety Authority. Food safety is therefore also well safeguarded.

Coordinated winter and spring de-lousing is a good example of overall area considerations and collaboration between fish farmers, fish health personnel and the administration. Such action that results in respective facilities within a defined area carrying out treatment at the same time in order to reduce the level of sea lice in a whole area have been carried out with great success in many regions and has resulted in all parts of the country being well under the regulatory requirements for the maximum permitted number of lice per fish as of April 2009.

Increased knowledge and optimum use of treatments reduces the risk of resistance

The correct use of medicines is decisive not only in the achievement of a good treatment result, but also to reduce the risk of the development of resistance. This applies both to the use of substances in feed and those used in bath trestments. In the final months of 2008 treatment failure was reported for two types of substance. Previously resistance had been experienced with other types of substances used. Resistance may occur sooner or later, but non-optimal treatments and unilateral and increased use of medicines can hasten such development. This is why in the autumn of 2008 the industry initiated an information campaign about and against sea lice. This was a communication project whose purpose was to contribute to increased knowledge and understanding for how the fight against lice can be carried out in cooperation with medicine and feed producers, the industry, fish health services and researchers.

In order to avoid resistance it is important to have good control on the amount of lice in the net cages, administer treatment when the threshold limit is reached and ensure that all treatments are carried out in as optimal a manner as possible. Treatment via feed is only for healthy fish with a good appetite.

Preventing lice requires good cooperation between fish farmers and also with fish health services and the administration.

After treatment it is important to control that the treatment has had the desired effect. If not the reason for the reduced effect must be clarified and new treatment with a different method must be started. Sensitivity testing of lice must also be carried out before new treatment. In this way it can be ensured that a medicine that the lice is sensitive too is used. This method has had a good effect in cases where resistance has developed, and the principles will probably be used in new regulations.

The industry continues to focus on R&D to reach its goals

The aquaculture industry is a growing and developing industry. This entails that equipment and operations change, and the need for new and updated knowledge demands research and development. "Sea lice in the Hardanger fjord" is one of several ongoing research projects financed by the Norwegian Seafood Federation's Research Fund (FHF) and the Norwegian Research Council. The project documents the connection between the number of sea lice on fish in Hardanger and uses advanced statistical and epidemiological techniques for further studies of the influence of physical factors such as salt content and temperature.

"De-lousing in large net cages" is another project in which FHF is involved with part funding. In this project the effect is of different medicines and treatment methods for fish in large net cages. In collaboration with the Institute of Marine Research and suppliers of different preparations the spread of treatment substances in the water is evaluated along with the reaction of the fish to changed environmental conditions and the effect of treatment in closed and semi-closed (i.e. with the use of skirting (a tarpaulin with and open base that is fixed around the net cages)) treatment systems.

An "Information campaign – about and against sea lice 2009" was started in the autumn of 2008. This project is also funded by the industry's own research fund, FHF, but is carried out in cooperation with the medicine and feed producers, the industry, fish health services and researchers.

The industry has a strong belief that these projects, together with several other ongoing regional and national action plans and projects that look at the development of vaccines and breeding, among other subjects, will bring us further in the fight against sea lice and the goal of a lice level in wild stocks that does not lead to an unacceptable negative influence.

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6. Emissions from aquaculture

6.1 Climate accountings for the aquaculture industry

There is an increasing focus both nationally and internationally on being able to document a product's environmental impact. Environmental analyses and a quantification of the environmental impact through climate accounting or environmental accounting*, is still relatively little widespread and non-standardised for the fisheries and aquaculture sector or for other important sectors. With increased focus on the environmental effects of food production in general it is increasingly important to be able to document the extent to which fish farming also affects the environment.

Emissions of greenhouse gases for different products are currently often calculated or quantified in climate accounts for production, achieved through calculating the production stages' emissions of different greenhouse gases. These are converted into CO_2 equivalents, and calculated for an entire production cycle from fjord to table – a so-called lifecycle analysis. For the aquaculture industry it is appropriate to calculate this for all production stages from roe to the product in the store. Together these calculations will represent climate accounts for the respective product from the aquaculture industry.

** Environmental accounts are more comprehensive and consider even more possible impact factors than climate accounts. Complete environmental accounts will therefore also be far more complicated both to create and standardise.*

Knowledge of our environmental impact provides the opportunity for continuous improvement

There are several reasons why we wish to evaluate the environmental impact in this way. The producer can find out where in the production process the emission of greenhouse gases is greatest and which measures that should or can be put into place to reduce the emissions as much as possible. The producer will also be able to follow trends in the development and be able to document emissions cuts, and to give the consumer credible and verifiable information about the climatic impact of production. On his part the consumer can receive information about the foodstuffs that have low emissions and thereafter use this in an evaluation of which products he wishes to purchase.

Product	Unit	CO2 equiv./kg	Comments	Source
Meat (pigs)	1 kg	6.4	Emissions are mainly methane (from ruminants and laughing gas (from the production of feed).	(Future in our hands, 2008)
Meat (cattle)	1 kg	15.8	Applies to the farm gate. CO_2 from slaughtering, storage and transport of meat, packaging, cooling	
Chicken	1 kg	4.6	and in the store not included.	
Farmed fish	1 kg	4.1	Trout fillet, Danish dam farmed. Frozen	
Fish, caught	1 kg	3.0	Barents Sea, trawler, hand-filleted in China, 30% offal	
	2.8		Barents Sea, trawler, machine-filleted in Norway, 45% offal	
	1.3		Coast, net/line, hand-filleted in China, 30% offal	
	0.7		Coast, net/line, machine-filleted in China, 45% offal	
	0.5		Coast, net/line, hand-filleted in China, 30% offal	
Meat (cattle)	1 kg	14.5		(Sunde, 2007)
Meat (pigs)	1 kg	4.9		
Chicken	1 kg	1.9		
Salmon (farmed, Canada)	1 kg	4.5		
Cod fillet (40% net, 60% trawler)	1 kg	7.5		
Salmon (Norwegian farmed)	1 kg	3.0	Fillet to consumer in Paris. Drying of feed using diesel oil	(SINTEF 2008)
Salmon (Norwegian farmed)	1 kg	2.9	Fillet to consumer in Paris. Drying of feed using natural gas (LNG).	

Table 6.1: Overview over greenhouse gas emissions from the production of fish and meat in different studies
The table shows an overview of the emissions of CO2 equivalents for different products found in various projects. Based on a comparison of these results it can be seen that the production of fish products is on a relatively moderate level compared with meat products in general. However it should be emphasised that the results in the report from SINTEF are provisional. Furthermore the table also underlines the need for standardised methods to be able to make good comparisons. (Source: SINTEF Fisheries and Aquaculture AS(1)).

All production affects the environment in different ways. With increased knowledge of how different products affect the environment it will be possible to push production in the direction of products and production methods that are beneficial to the climate and thus the environment. This will also help to ensure effective use of measures by the authorities and by politicians who are faced with a double challenge; to be able to ensure food supplies at the same time as having to reduce emissions of greenhouse gases.

Results from the preliminary study

In order to be able to calculate greenhouse gas emissions in the various stages and to be able to compare different production or types of foodstuffs with one another, it is essential that standardised methods of calculation are found.

To obtain a professional basis for starting comparable studies and analyses of selected products from Norwegian fisheries, aquaculture and agriculture, and to obtain figures for energy consumption and greenhouse gas emissions, a preliminary study was carried out under the direction of FHL.

The final report from SINTEF was presented in March 2008 (2). Through the project the work that which had previously been carried out within environmental accounting for the seafood industry was documented; the methods used and the research environments that worked on this type of problem as well as the opportunities found to prepare environmental accounts and trends.

Through the preliminary study, provisional CO_2 accounts (climate accounts) were prepared for salmon farming. Depending on whether the feed for the salmon was dried using diesel oil or natural gas, the production of 1 kg of salmon fillet in Norway resulted in the emission of 3.0 and 2.9 kg of CO_2 equivalents respectively. The entire lifecycle from roe to finished fillet for a consumer in Paris was taken into consideration.

The report also concludes that comparing the results with other available studies, "*it can appear as though the energy consumption related to the production of fish products is on a relatively moderate level compared with meat products in general.*" Other literature states that around 90% of greenhouse gases from farmed fish are emitted in connection with the production of feed (2).

Real comparisons of greenhouse gas depend on good and standardised methodology

The preliminary study also concluded that it appears to be both useful and realisable to continue work on climate accounts for the fisheries and aquaculture industry.

In the autumn of 2008 a main project was therefore initiated with the aim of carrying out a comparative analysis of selected products from Norwegian fisheries, aquaculture and agriculture to obtain figures for energy consumption and greenhouse gas emissions.

The analysis shall use comparable methods based on international standards and the analysis is to be able to show where in the value chain energy consumption and greenhouse gas emissions are greatest. In this way the aquaculture industry can achieve a basis to put in place relevant measures based on documented analyses as well as the opportunity to give customers and consumers objective and appropriate information and documentation on greenhouse gas emissions in the production of various seafood products and other sources of protein (3).

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6.2 Emissions of nutrients and organic materials

Status and challenges.

Emissions from aquaculture generally represent a minor problem in Norway

In the Ministry of Fisheries and Coastal Affairs' "Strategy for sustainable aquaculture" (April 2009) it is stated that "In general terms the emission of nutrients and organic materials from fish farming is a minor problem in Norway." The Government substantiates this by the fact that Norway has a long coastline and extensive use of fish farming locations with high water exchange and good water quality. Aquaculture takes place in regions with relatively deep fjords and in coastal areas with good recipient conditions where capacity and self-cleansing properties are relatively good. Production takes place in complex ecosystems with high biodiversity and tolerance (21).

In its report "Coast and Aquaculture 2008", under the title "Challenges in the administration of Norwegian aquaculture" the Institute of Marine Research says that "The man-made supply of nutrient emissions can lead to the over-fertilization of certain areas. However, measurements and models show that this is not the case for the majority of regions, and that the natural distribution of nutrient emissions is much greater than our contribution to the environment" (1)

Emissions from aquaculture mainly contain substances that are a natural part of the ocean ecosystem, that are included in the natural cycle and that the fjord system therefore has a "tailor-made" capacity to absorb and utilise. Nutrient load from aquaculture mainly dissolved nitrogen and phosphorous, are necessary nutrients for algae production in water. They are thus important as fertilizers for algae which again function as food for more superior organisms in the sea.

Nevertheless, nutrients and organic loads from fish farming may have a negative local impact if the emissions are too large in proportion to the recipient capacity; if the location is unsuitable or has insufficient ecological capacity. Even regional effects cannot be completely excluded if the water exchange is too low in proportion to the activities in the area. However, areas with local, negative effects from fish farming do not provide good conditions for the farming of fish. Such areas are thus not considered desirable for use by the fish farmers themselves. In order to assess the effect of emissions from the aquaculture industry it is not enough to know much about local conditions. A fjord is not a closed area, but part of an open ocean system. It is therefore necessary to put emissions from the industry in a larger perspective.

Status and tolerances for fjords and coastal areas

Water transport between coast – fjord; an important prerequisite making Norway so suitable for aquaculture

The illustration at the foot of the page shows a cross-section of a typical Norwegian fjord in which the water transport between coast and fjord is shown. The Norwegian coastal current along Østfold, Vestfold and further along the entire coast of Southern Norway will be composed of waters from Jyllandstrømmen, Østersjøstrømmen and Skagerakvann. The coastal current is supplemented on the way from Norwegian rivers. Gradually more and more salt water is mixed in from the North Sea, and further north salty and warm Atlantic Ocean water is also added. The coastal current can be traced all the way up to the Barents Sea area.

In order to illustrate the significance of these water currents and the extent to which these help to affect the conditions in our fjords, it can be noted that each second around 8 million tonnes of warm salt water runs from the Atlantic Ocean into the Norwegian Sea. This transport is the equivalent of 8 times the total of all the rivers in the world (2).

The majority of fjords have a relatively deep sill (often 100 m or more) and are in open contact with the water in the coastal stream beyond. Water exchange in Norwegian fjord systems is generally good, with retention periods from several days to weeks for most fjords (3). It is these conditions that make the Norwegian coast so suitable for aquaculture.

At the same time it is also true that there can be important local variations. There may also be found enclosed fjord basins and trapped lakes with shallow sills and narrow inlets that restrict local water exchange.

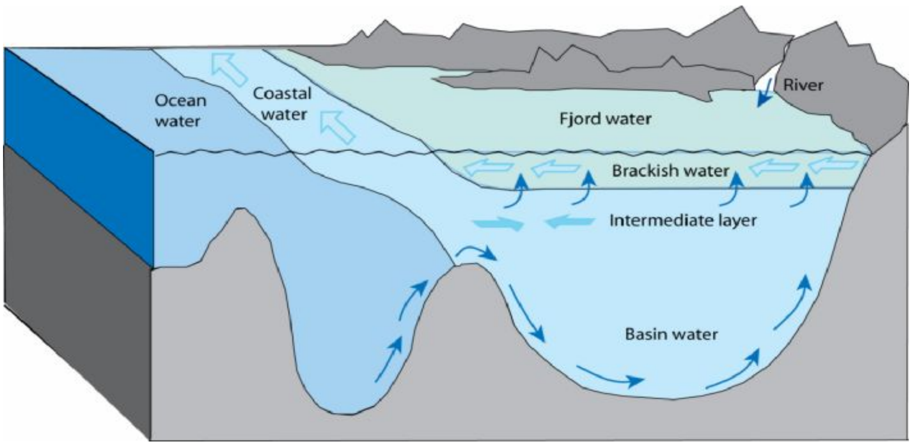


Figure 6.1: Water transport between sea, coast and fjord
The figure shows how the coastal and fjord waters are in open contact with ocean water in a Norwegian fjord with a sill. Ocean water will typically have a higher salinity than the water in the fjord that receives freshwater from rivers and land run-off. The ocean water flows into the deeper layers of the fjord as shown in the figure, and is later mixed with the upper and more brackish layers. The major freshwater supply within the majority of Norwegian fjords contributes to a marked layering of the waters; typically in a surface layer with low salinity that gradually increases in an intermediate layer between the surface water and the deeper, more salty waters. Freshwater running into the fjord mixes with the underlying ocean water, forming the thin brackish upper water layer that flows out of the fjord. The result is that a greater water volume (often many times greater) is transported out of the fjord than that constituting the added freshwater.
The water exchange between the different ocean currents that enter along the Norwegian coast contributing to the Norwegian coastal current, and between fjord and coastal waters, is dependent on different conditions of temperature, wind and salinity at all times. (Source: Institute of Marine Research)

The fjord's ecosystem is influenced by both local conditions and conditions in the major ocean currents

The currents and water flow mentioned above are of major significance to the water quality and life in the fjord and the outer coastal areas. It is also important to be aware that the natural occurrence of nutrients in the deep water layers in the ocean is extremely high. In the same way that there is a stirring of the waters in freshwater areas every spring and autumn, in the ocean highly nutrient-rich water flows from the bottom to the upper water layers in the winter time. Adding light, this is the condition required for new algae production in the summer time. Thus there is not only a major horizontal transport of the waters but also a significant and equally important vertical transport with the replacement and mixing of waters (4).

The substantial water exchange entails that conditions far from our coasts, both natural and man-made, may influence conditions here. Conditions are also significantly affected by major natural variations caused by changes in temperature, wind, precipitation, salinity, tides and the season. These conditions are thus also completely definitive and decisive for the significance of both natural and man-made local supplies of nutrients to the Norwegian fjord systems. The ecosystems in the fjord are in other words not only influenced by local conditions but also significantly by the much larger water currents that come from far away.

It is worth noting the results from the Institute of Marine Research's modelling of primary production in Skagerakk and the North Sea in 2008. Despite the substantial reduction in the emission of man-made nutrient emissions into the North Sea in recent years, there has been no reduction in total primary production (algae production). The reason for this is that the biggest amounts of nutrients (85-90%) required in primary production are transported to the North Sea from the Atlantic Ocean (5).

The degree of fertilization in the fjord is closely related to the water exchange

Fertilization is the supply of nutrients to plants. All plants, including algae in the sea, require nutrients to grow. In nature fertilization takes place through the stirring and supply of nutrients from the reservoirs in the deep water layers and up to the upper water layers.

The degree of fertilization is calculated as the total supplies of nitrogen from man-made sources in relation to the natural transport of nitrogen in coastal waters that receive the supply (6). The degree of fertilization determines whether algae production will be adequate and "controllable" for the ecosystem, or whether overfertilization (eutrophication) takes place with negative changes in the ecosystem as a result. The degree of fertilization is mainly determined by two amounts: the volume of nutrient emissions supplied and the area or volume that receives this amount. In exactly the same way as the degree of fertilization on land will be completely different depending on whether a small patch of garden or a huge field is supplied with the same amount of fertilizer. There is also a connection between dose and response in nature. In a procedure under the OSPAR Convention, an international environmental agreement for the Northeast Atlantic, a 50% increase in the algae concentration in the summer or in nutrient emissions in the winter is used as the criterion for over fertilization.

Water exchange in Norwegian fjord systems is generally good, with retention periods from several days to weeks for most fjords. These conditions make the Norwegian coast very suitable for aquaculture.

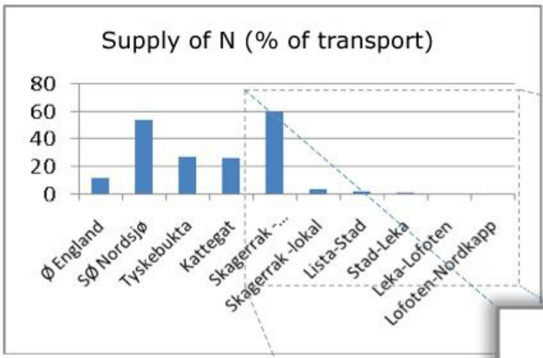
The total man-made Norwegian nutrient emissions from all sources, including aquaculture, represent a contribution of some 2% in relation to the natural transport of nutrient emissions for the distance from Lindesnes to Stad. The contribution from man-made activity falls the further north one travels along the Norwegian coast from Lista to Nordkapp (6). On this basis it can be concluded that the emission of nutrients cannot result in the overfertilization of this stretch of coast.

What is emitted and what happens to emissions from fish farming facilities?

Emissions from aquaculture cannot be compared with sewage from towns

Emissions from production in fish farming facilities are mainly metabolic products, excrements and feed waste (7).

Emissions from aquaculture are often incorrectly compared directly with sewage and emissions from larger towns. Excrements from fish, whether from wild fish or farmed fish, is not in itself harmful to the environment. Nor can it be directly compared with sewage from humans, since both the composition and bacterial flora will be completely different. Unlike



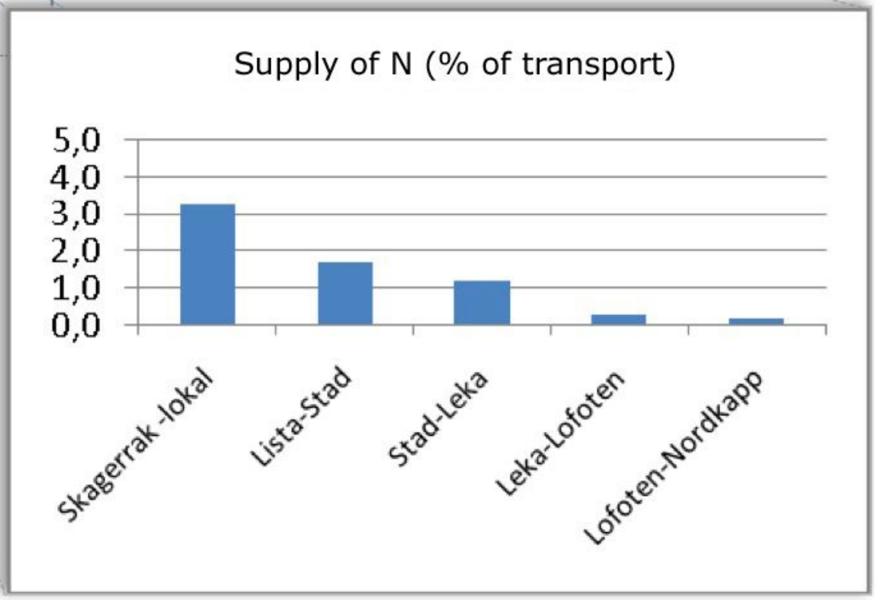


Figure 6.2: Degree of fertilization for the supply of nitrogen to different coastal sections of the southern part of the North Sea and various parts of the Norwegian coast.
The degree of fertilization is calculated as the total supply of nitrogen from man-made sources (agriculture, population, aquaculture etc.) in relation to the natural transport of nitrogen in the coastal waters that receive the supply. (Sources: North Sea Quality Status Report 1993. OSPAR, London: Aure, J., Skjoldal, H.R. 2004. OSPAR Common Procedure for the identification of eutrophication status. Application of the screening procedure for the Norwegian coast north of 62°N (Stad-Russian border). SFT report, and Coast and Aquaculture 2008, Institute of Marine Research.

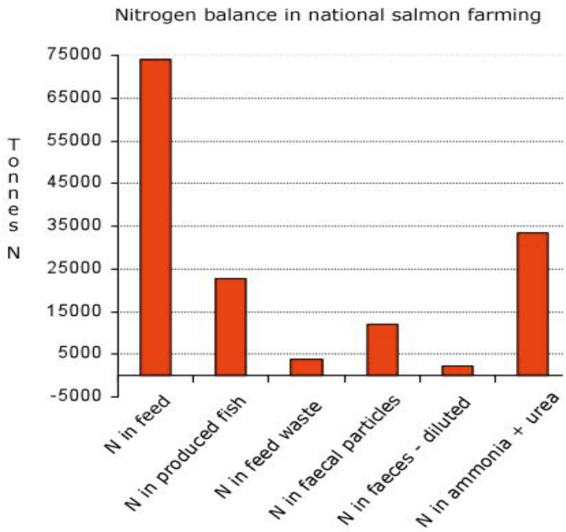
excrements from humans, pets and many farm animals, excrements from fish do not represent any hygienic risk for humans or fish.
By way of comparison one uses animal fertilizer in agriculture to grow vegetables and corn, berries and fruit – not least in connection with organic growing.

Optimum fertilization has a positive effect
The incidence and supply of nutrients are essential for life in the sea and these so-called biogenic substances are therefore naturally present. However in excess they can still cause undesirable changes to the ecosystem. Optimum concentrations promote and maintain a healthy ecosystem. This can be compared with fertilization in traditional agriculture. Without fertilization the soil is impoverished and gives reduced harvest.

Calculated nutrient emissions from aquaculture
Based on the mass balance the total emission of nitrogen and phosphorous from fish farming facilities is calculated from total production (slaughtered) and knowledge about the digestibility and composition of feed (7, 10). Around 42% of the protein nitrogen eaten by the fish will be separated through the gills as ammonia (NH4) and as urea in dissolved form, and around 30% as excrements (7). Emissions of nitrogen from salmon and trout have declined significantly over the last 10 years because an increasing proportion of the protein has been replaced by fat ("high energy feed").

In salmonids around 19% of digested phosphorous is separated as phosphate, and around 47% as faeces (7). Thus normally only a smaller proportion of separated phosphorous will exist in dissolved form. Figure 6.3 shows the calculated emissions of nitrogen and phosphorous from Norwegian fish farming facilities in 2008. The calculations were carried out by Yngvar Olsen, Trondheim biological station, NTNU.

Aquaculture does not lead to the increased concentration of nutrient emissions in a fjord system
Measuring and monitoring nutrient emissions in water is far more difficult than measuring the impact from organic materials that sink down to the sea bed right by the facility.
The Institute of Marine Research carried tout rials in the summer of 2008 for measuring nutrient emissions in the Hardanger fjord both in and outside the net cages. The trials showed that in the net cages an increase in dissolved nitrogen, ammonia and phosphorous could of course be noted, but that it was not possible to measure increased concentrations 2-3 net cage lengths away from the facility. It was concluded that it was impossible for concentrations of nutrient emissions to build up in a fjord system as a result of aquaculture (15).



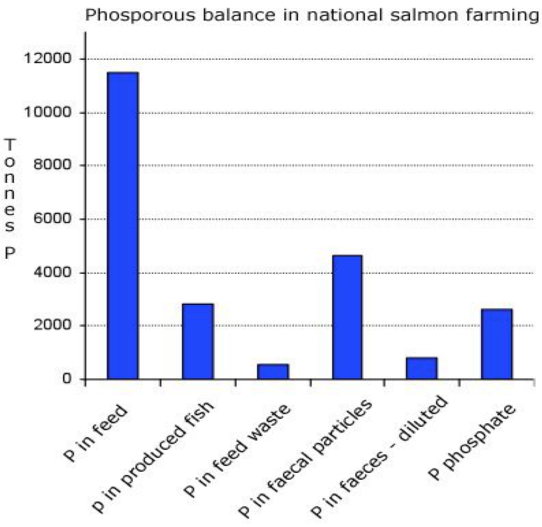


Figure 6.3: The nitrogen and phosphorous balance in Norwegian salmonid aquaculture
The figure shows the calculated total emissions of nitrogen and phosphorous from Norwegian fish farming facilities (trout and salmon) in 2008. Although aquaculture represents a large proportion of the local supply of nitrogen and phosphorous along the Vestland coast and northwards, this only makes up a total of 2-5% of the total compared with that which naturally comes with the coastal current (15). (Source: Y. Olsen, NTNU)

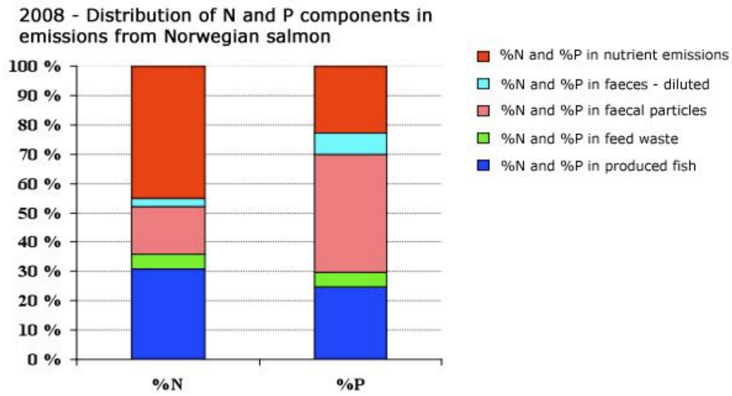


Figure 6.4: Distribution of nitrogen and phosphorous components in emissions from Norwegian fish farming of salmonids
The figure shows how phosphorous and nitrogen in feed are distributed in produced fish and emissions from Norwegian salmon and trout farming in 2008. (Source: Yngvar Olsen,2009)

One of the reasons for this is that emissions of excess nutrients from a net cage will be rapidly available for absorption by plant plankton in the water column. Afterwards it may take 3-7 days from the emission occurs until algae growth can be observed in the form of an increased biomass. At this time both nutrient emissions and plankton have been spread over great distances, and the concentration is significantly diluted and normally tolerable in the ecosystem. Thus it is the hydrodynamic conditions in the fish farming facility and downstream of the facility that are significant. It is only in stationary or almost stationary water that the availability of nutrient emissions can be so high that local algae growth occurs at the point of emission (10, 8).
Three important conditions determine the influence of salmon farming on nutrients in the water column, water quality and the pelagic system (8):
1. Supply of nutrients per unit of time, hydrodynamic conditions and depth conditions
2. Geography and topography (degree of openness) where fish farming is carried out and in nearby areas
3. Fish density in the fish farming facility and the distance between different fish farming facilities.

The fish farmer therefore increasingly takes these conditions into consideration in planning, establishing and operating the fish farming facility. When such prerequisites are safeguarded nutrient emissions are no longer a pollutant but a resource that helps to stimulate marine production in a positive manner. A research project carried out at Hopvågen in the far reaches of the Trondheim fjord has shown that both scallops and mussels achieve better growth with a supply of nutrients (16, 17). It is desirable that over time one can find suitable methods to be able to exploit this in a good way, for example through shellfish farming.

The aquaculture industry contributes with nutrient emissions, but not to over-fertilization

The aquaculture industry is responsible for a large part of the man-made local supply of nutrient emissions along the Vestland coats and northwards (18). Yet compared with the amount that arrives naturally with the coastal current this represents just 2-5 percent of the total. Total Norwegian emissions from all sources, including aquaculture, represent a contribution of some 2% for the distance from Lindesnes to Stad (6).

Through a number of examples research has shown that today's aquaculture activity only affects the eutrophication or oxygen content in sill fjords to a minor extent, and a good localisation strategy can provide the basis for a major increase in today's production (9, 11). In order to assess the effect of nutrient emissions the Institute of Marine Research has calculated average primary production (i.e. algae production) resulting from nutrient emissions from fish farming from Rogaland to Finnmark.

The greatest density of facilities is currently found in Hordaland, where emissions from aquaculture are around 5% compared with the naturally supplied nutrients. This is well under the OSPAR criteria (see page 47). Nutrient emissions and the stimulation of algae growth are thus so far a minor problem along the Norwegian coast (6) In another report researchers from the Institute of Marine Research summarised the effects of nutrient emissions from aquaculture by stating that "the greatest future potential for fish farming with regard to tolerating nutrient emissions is in Northern Norway, but there is also potential for a significant production increase in Southern Norway." (11).

The Minister of Fisheries and Coastal Affairs Helga Pedersen gave the following summary of the results of research concerning the significance of aquaculture's contribution of nutrient emissions in an article in BT 27, February 2008:

"I find that the majority of researchers now seem to agree that the aquaculture industry only contributes to a small part of the total supply of nutrient emissions. The development in the supply of nutrient emissions and the consequences of this must be followed closely. The FKD will follow this up with the Institute of Marine Research who are already obliged to increase their research activity related to the relationship between aquaculture and fjord and coastal ecology in 2008."

The situation for the Hardanger fjord

The Hardanger fjord has often been presented as a problem area where aquaculture is claimed to have contributed to over-fertilization. The Institute of Marine Research carried out a study of the capacity of fjords from 2003-2006 by studying emissions from fish farming in the Hardanger fjord. With the help of a numerical model (NORWECOM) simulations showed that the algae concentration was little affected by emissions from fish farming facilities. By comparing concentrations with and without fish farming, the model gave a maximum increase of 2%. By multiplying emissions from aquaculture by ten times the increase in plankton production would still remain no more than 13%.

The localisation of the facilities can affect the results. The conclusion of this study is that the Hardanger fjord is little affected by today's aquaculture activity with regard to nutrient emissions from fish farms, and can tolerate more aquaculture (19).

Aquaculture is not the direct cause of the disappearance of the kelp forest

The aquaculture industry has previously been blamed for being an important cause of the decline seen in the sugar kelp forest in many places along the coast. In the report from the Sugar kelp project 2008 it is stated that there is probably no isolated and responsible factor for the disappearance of sugar kelp seen in many places along the Norwegian coast, at its worst in Skagerrak and Vestlandet, but rather an interaction between several factors.

Among the most important contributory factors are temperature, nutrients, light, substrate and feeding. High temperature is the single factor that is most likely to have caused regional tangle death (20). The decline has been particularly major following extremely warm summer months, which there have been unusually many of in the past 10 years (1997, 2002 and 2006) (15). The report from the Sugar kelp project 2008 also concludes that increased nutrient emissions cannot explain the loss of sugar kelp, since these are not poisonous and can only affect sugar kelp indirectly through reducing light conditions and the stimulation of thread eel growth. It is also worth noting that in some places along the coast sugar kelp has returned, and that the situation both in Skagerrak (that has no aquaculture) and Vestlandet (that has seen a rise in aquaculture activity) has actually improved compared with equivalent studies carried out in 2004-2006 (20).

What is the aquaculture industry doing to reduce emissions and prevent negative consequences?

Good feeding control has resulted in reduced emissions

In general feed waste is often stated to represent around 5% (7). But this will wary somewhat from facility to facility, between aquaculture companies, between countries and with the seasons (8). Since feed is the most expensive input factor in fish farming (it represents around 60%) the growth and feeding of the fish as well as the water quality are closely controlled to avoid feed waste, and to ensure the best possible conditions for good appetite and feed utilisation. This includes good control of the temperature and oxygen conditions in the net cages. Today feeding takes place under detailed visual controls, through the extensive use of underwater cameras, dosage equipment and through continuous control of actual and expected feed consumption and growth.

Good environmental and feeding controls form the basis for financial success for the fish farmer. Feed waste has therefore been significantly reduced in recent years. Studies show that feed waste is mostly eaten by wild fish, and that the extent of feed waste therefore normally will have little influence on the emissions of the various nutrient fractions at the location (9).

It is generally positive and a direct environmental benefit that feed is actually eaten by fish rather than gathering on the sea bed beneath the facilities. With regard to the amount of fish normally present in a fjord system the intake of feed waste will necessarily only make up a small proportion of the wild fish's total feed intake. Nevertheless there are many different views as to how this can affect wild fish. Some claim that wild fish eating feed waste may become fatter and that the meat will get a soft texture and a different flavour as a result of increased nutritional intake. Others want to be permitted to fish near the facilities precisely to catch these fish that they believe to be extra fat and good quality. Fish farmers will continue to work to have all feed eaten by fish within the net cages.

Good farming locations and reconstruction of the farming areas is a priority

In recent years the aquaculture industry has been heavily involved in finding good criteria to optimise both the individual fish farming facility and facilities with regard to each other within the individual fjord systems. The background for this development is the recognition of how important this is in minimising the consequences of fish farming on the surrounding environment, but also to achieve the best possible production conditions for the fish farmer. These considerations are closely related.

The result is that old and environmentally poor locations are no longer in use. Permits are increasingly merged together into larger facilities in locations that are well researched and more environmentally suitable. Major emphasis has been put on finding locations with beneficial current conditions and suitable topography, in placing the facilities so that strain on the local area is avoided as far as possible and at the same time so that all net cages have good water flow. Furthermore regional considerations must be taken so that larger areas can have fish released at the same time, be rested at

If a location's carrying capacity is exceeded the seabed conditions can be negatively affected. Such negative effects are today significantly reduced by positioning the facilities in well-researched locations with optimal conditions for the fish and the environment.

the same time and de-loused at the same time. Important conditions that must be examined at the location are waves and wind, temperature, current conditions at several depths, water exchange, seabed topography and seabed sediment (see the section covering MOM surveys). Furthermore today work is underway in several different aquaculture and research environments to find good simulation models that can provide even more information not only about how the positioning of a facility will affect the surrounding environment, but also about interactions with other facilities in a fjord system or coastal area. These are important data that have already been used as the basis for the restructuring that has taken place within the aquaculture industry in many regions.

Good monitoring of local effects; results of MOM monitoring

Larger faecal particles and feed waste that is not eaten by fish around the net cages sinks to the seabed and will mostly affect the seabed conditions right under the facility (7). Normally this leads to a change in the form of increased life and biodiversity on the seabed under the fish farming facility (12). The results of attempts to trace organic emissions from aquaculture show that different seabed animals and fish exploit the emissions from farmed fish and that there are more and larger animals close to the facilities compared with samples taken further away. These animals are included in a food chain in which spineless animals eat faeces from salmon and thereafter become prey for other animals (11).

The MOM-B study is a study of the seabed conditions beneath a fish farming facility with regard to the Norwegian standard (NS 9410) where a minimum of 10 dredging samples from the seabed are examined with regard to animal life, sensory parameters (smell, appearance etc.) and chemical parameters. The study is obligatory and is carried out before the fish farming locations are put into use, and during maximum production. If the results are unacceptable during maximum production (condition 3 or 4) new fish cannot be relased before the seabed conditions are once again acceptable (condition 1 or 2).
In a summary of 24 MOM-B studies carried out in locations in Sør-Trøndelag during maximum production of fish released in the spring and autumn of 2007, it was concluded that there was no clear connection between the MOM-B result and the amount of fish produced in a location. Furthermore the report confirmed that over the last five years in Sør-Trøndelag a trend has been established where the studies have given increasingly better results. The region has experienced this trend while simultaneously increasing the production of farmed fish.

The main explanation for this positive trend is stated to be that new locations have been put into use that are more exposed to currents and waves. At the same time there has been a development towards less compact facilities. The industry has invested in new equipment that is strong enough to be placed in exposed areas (13).

Result of MOM-C: no influence in the remote zones of the facilities

Through the MOM-B studies the industry is regulated mainly according to the effect it has on the ecosystems on the seabed underneath the facilities. The same standard also describes a method (MOM-C) that was developed to provide information about the seabed conditions in the remote zones of the facility, i.e. from the facility and to the deepest part in the local area/fjord. MOM-C is relatively little used today, partly because it is difficult to find sufficient and approved expertise in Norway to carry out these analyses on a large scale. Results from studies carried out in Trøndelag show no negative influence in the remote zones (12, 14).

Aqua Kompetanse AS has monitored the inner basin of the Jøssund fjord in Flatanger and Indre Follafjord in Nærøy with quantitive animal life surveys (MOM-C) since 2000. Both fjords are sill fjords with shallow inlet sills (50 m and 12 m respectively) where aquaculture is in operation. The samples were taken from the deepest parts of the fjord where there may be a collection of organic material over time. In the Jøssund fjord fish farming has been carried out for 20 years, and in 2008 there were 3 permits there. Neither of the fjords showed signs of negative influence and had normal environmental conditions according to SFT’s classification system (14).

Knowledge about the coast’s ability to utilise nutrients in useful production has been thoroughly investigated in research projects within the European ELOISE programme, in which researchers from Trondheim biological station took part. NTNU was the coordinator for the project. Methods were established for the diagnosis of the environmental conditions, and a method that can predict some of the ecological effects of the emission of nutrients. Together with the knowledge about ecological criteria for water quality this knowledge can contribute to the optimum placement of fish farming facilities in areas with good natural preconditions.

A survey of a facility in Hordaland showed a clear increase in organic compounds under the facility itself and in the nearby zone within a 250 m circumference. However, due to the depth and intermittent good current, sediments under the facility were only moderately affected by operations. The equivalent change was not found 3 km away from the facility, and no gradient with regard to sinking plankton was found when the distance from the facility increased. In other words there were no indications of stimulated eutrophication or influence in the remote zone as a result of facility operation (9).

Aim for further work
The aquaculture industry agrees with the government's goal of environmentally sustainable development, and will continue to work so that all fish farming locations that are in use remain within an acceptable environmental condition and do not have greater nutrient emissions and organic material than the recipient can tolerate.

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Yngvar Olsen, Trondheim biological station, NTNU, has contributed through a review of the professional content in this chapter.

6.3 Use and emissions of chemicals

Strict customer requirements and certification schemes ensure a strong focus on chemical handling.
To a great extent the aquaculture industry is an export industry with the world's biggest foodstuffs chains and processing facilities as important and demanding customers. With this type of customers there are strict specifications and detailed requirements that often far exceed the requirements in the regulations with regard to HSE, animal welfare, the environment and food safety.

Some customers have developed their own manuals and requirement specifications, and many set requirements for various certifications with regard to these important aspects of production. And major resources are used to control that the requirements and specifications are genuinely complied with. This has led to increased awareness regarding the use, storage and handling of chemicals in the aquaculture industry in recent years. Many fish farmers are certified according to the environmental standard ISO 14001, and even more according to GlobalGap, which is a standard that includes safeguarding the production of salmonids from roe to customer. This is one of several standards that has extremely detailed requirements for the use and handling of chemicals and to the following up of the health and welfare of both the fish and the fish farmer.

The most important chemicals used in Norwegian aquaculture today are cleaning and disinfection agents, antifouling agents for nets and medicines.

Use of cleaning and disinfection agents
In order to ensure a good flow of oxygen-rich water to fish in the aquaculture net cages it is important that nets are regularly cleaned; especially at times of the year when there is a large amount of seaweed,

hydroids etc in the sea. Today the majority of nets are cleaned at sea using pressure and clean sea water. Nets that are to be taken out of the sea for later use in a different location or for other fish are taken to a specific net cleaning facility where they are cleaned and disinfected. Today the cleaning water from these facilities is required to be collected and treated.

Boats and equipment used on a daily basis are also cleaned and disinfected with approved cleaning and disinfection agents. This is done to ensure good cleanliness but also to prevent the spread of any contamination between locations. Increasing emphasis is put on cleaning and disinfection chemicals being environmentally friendly, correctly manufactured, handled and used and not posing any risk to health, as well as being easily degradable in the environment.

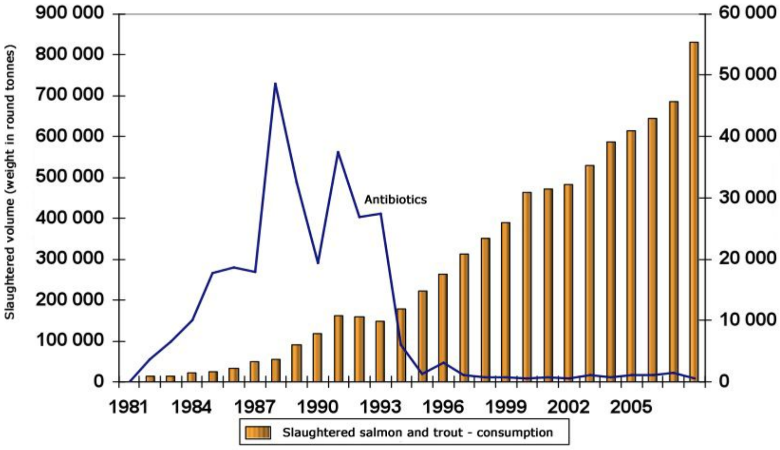

Figure 6.5: Use of antibiotics compared with the production of salmonids in Norway 1981-2008
The figure shows how the use of antibiotics fell in the first half of the 1990s at the same time as we obtained vaccines for important bacterial diseases. At the same time it shows how consumption has remained extremely low from 1995 and until today, despite the biomass and slaughtered volume increasing significantly during the same period. (Source: Institute for Public Health (based on statistics from the Norwegian Food Safety Authority)

Nets are impregnated to prevent fouling and ensure good water flow in the aquaculture net cages

Objects immersed in the sea are constantly subject to fouling by shellfish, algae, barnacles and hydroids. In order to prevent nets becoming blocked and weighed down by fouling, today the majority of aquaculture nets are impregnated with an approved agent containing copper that reduces fouling, but also makes the net lines stiffer and keeps them better tensioned in the sea, prevents UV rays damaging the net lines and reduces space between the filaments so that fouling is prevented.

Fouling will prevent new, oxygen-rich water from flowing through the nets. In order to ensure the best possible conditions for the fish it is therefore (until better measures are found) necessary to impregnate a large proportion of the nets. Work continues in parallel on trying to find other solutions to ensure clean nets. The majority of fish farmers impregnate nets just once per generation in connection with the nets being at a net cleaning facility for cleaning, disinfection and inspection. The net washing facility is not permitted to release water containing copper but has to collect and treat the water and sludge from the cleaning process. This helps to reduce the emission of copper from the aquaculture industry and to prevent the concentration of copper in the sediment near the net cleaning facilities. According to SFT (Norwegian Pollution Control Authority) copper has now been removed from the authorities' list of the around 30 highest priority substances and substance groups with an environmentally damaging effect. There are several criteria to be included in this list: the substances must be able to concentrate in the food chain and give long-term effects, and they must also be toxic (poisonous). It has been found that copper does not concentrate in the food chain and therefore does not meet the criteria. However copper can have poisonous effects, particularly in fresh water. Copper will thus continue to be environmentally monitored by the authorities but measures to reduce the emissions of copper will be based on specific risk assessments in each case in the future.

Good preventive measures have dramatically reduced the use of antibiotics

Given the development of vaccines for known bacterial diseases in farmed fish the use of antibacterial substances has fallen dramatically over the last 10-15 years. Sales of antibiotics were somewhat higher in 2008 than 2007. But in relation to the biomass of farmed fish consumption is extremely low as it has been for many years

According to the Norwegian Institute of Public Health the small variations in the consumption of antibacterial substances in the period 2000-2008 most probably represents only random variations in the incidence of bacterial diseases in farmed fish. In 2008 the total consumption of antibacterial medicines in Norwegian fish farming (all species) was 941 kg of active substances.

This positive development with regard to the use of antibacterial substances in the aquaculture industry has taken place at the same time as major growth in the production of fish. The reason is preventive measures; with the vaccination of fish and increased knowledge about choosing the most suitable locations being by far the most important individual measures. Antibacterial substances are not used in shellfish farming. With regard to the health situation of Norwegian farmed fish refer to reports from the

National Veterinary Institute. This report only covers sea lice (see chapter 5).

7 Waste and waste processing

Status and challenges

Most waste from aquaculture is taken care of in a good way, but the industry can still be better

Good processing of all waste is an important goal for the aquaculture industry as for other industries. A report from a documentation project regarding the recycling of discarded equipment from aquaculture undertakings stated that the majority of aquaculture and shellfish farming companies operate responsibly and that the majority of discarded equipment and waste from the aquaculture industry is taken care of in good way (1).

For the types of waste for which waste disposal arrangements and return schemes already exist these are used by the industry. The challenges are mostly related to dealing with discarded aquaculture equipment of a certain size, and then specifically where the main component is plastic.

This is equipment that may be difficult to handle in a good way, and for which there currently are no well established return and recycling schemes. However the industry wants to take more responsibility for precisely these products itself and together with the producers contribute to the development of robust and permanent return and recycling schemes for plastic from the aquaculture industry.

Certification according to ISO 14001 (environmental certification), GlobalGap and various customer standards with requirements regarding the surrounding environment; including order and waste handling, have contributed to an increased focus on good and safe handling of waste in the aquaculture industry.

The most important waste fractions from fish farming

The most important waste fractions from fish farming are production waste such as paper and residual waste, special waste such as waste oil, batteries, electronics and chemical residue, discarded packaging and production equipment made from plastic, metal and concrete, as well as ensilage of dead fish. The various fractions and the current handling arrangement can be briefly summarised as follows:

1. *Ensilage.* This fraction is referred to as a resource that is fully utilised in other products in the section on utilisation of by-products in this report.
2. *Paper and residual waste.* For most companies this will come under council or private waste disposal schemes. These are generally covered by local regulations with a varying degree of sorting and recycling.

The industry is working towards putting in place robust and permanent return schemes that ensure effective and environmentally correct recycling, collection and re-use.

3. *Chemicals* from fish farming facilities mainly consist of oil and oil products from boats and generators for which various approved reception systems are available. In addition there may be residues from de-lousing agents and disinfection agents, but these are such expensive substances that the industry will try to avoid any waste. Formic acid residue can occur, but this is also normally consumed as are residual cleaning and disinfection agents.
The copper impregnation of nets takes place today at net cleaning facilities and will normally be a waste fraction that is collected and handled by the net cleaning facilities. In addition there may also be residuals from paint etc. In total there are small amounts of chemical residuals that arise in the facilities and chemicals and chemical residuals are delivered through an approved reception system.
4. *Electronics.* This mostly covers PCs, control systems from feeding facilities, cameras and monitoring systems, fluorescent tubes and similar. There are established return schemes for these that the aquaculture industry also uses.
5. *Batteries,* mainly from lighting equipment etc., are covered by an established scheme that the aquaculture industry also uses.
6. *Metal.* According to documentation work that was carried out in 2007 (1) the main component is metal in major parts such as net cages, gangways, and steel floating surfaces. Anchors, chains, shackles, sorting equipment and pumps are the most important minor metal components. The majority are pure metal, with the exception of surfaces that can have housing and

equipment made from other materials. Net cages and gangways are disposed of locally, either in the form of floating stages or are delivered to scrap dealers or local waste collection operators.
The impression from the interviews carried out during the documentation work was that so far it has been easy to dispose of metal, and the majority was through a local waste reception scheme.
7. *Plastic* is a complex waste group. The major components are the main components in plastic net cages, nets and feed hoses, while the smaller components mainly consist of feed sacks, ropes and buoys.
The report that followed the preliminary study from December 2007 (1) states that some of the plastic net cages are disposed of locally for use in mines, waste systems and similar, some are sold on to other fish farmers and some can be used for wharves. The rate of replacement from small net cages to larger net cages has been and will probably remain relatively high for some years. As a result of this several companies have established cooperation with net cage suppliers to try to find a good solution for handling the discarded equipment.

This was one of the reasons why in the autumn of 2008 a new preliminary study was initiated to look at the opportunities for establishing robust and national solutions for the recycling of plastic net cages and other relevant plastic equipment such as feed hoses, nets and ropes. Studies from this project have shown that there are some operators who are able to receive plastic rings, and who are in the process of developing downstream solutions for the recycling of plastic and the other components. This provides hope that it can be possible to achieve good solutions for the entire coast.

Feed hoses are also a waste fraction for which the potential for good recycling solutions is being examined. Currently this is mostly delivered together with buoys to local waste reception centres. For ropes and cleaned nets there is already a market for material recycling. It is important to further develop this and make all fish farmers aware of its existence. Some ropes are still scrapped through the ordinary waste system.

For many years there has been a scheme for feed sacks. So far this is the only industry scheme to have been arranged. This scheme will almost certainly be important for many more years, even though the amount will probably decrease as a result of the fact that more fish farmers have started to use feed silos, and some of the feed companies have started to follow this up through bulk deliveries in 2008. In addition there is a system for the receipt of bottles / cans etc., as well as for EPS (polystyrene) fish boxes, all organised through Emballasjeretur AS (1).

Old mussel facilities are to be removed, preferably in collaboration with other fish farmers

The aquaculture industry has both an obligation and a desire to keep good order around the facilities in operation, and to have good and documented schemes for disposing of all waste during production as well as procedures for cleaning up after operations cease.

Nevertheless the industry is today in a situation where there are a number of old and abandoned mussel farming facilities along the coast. The challenge regarding these facilities is partly that there were previously governmental grant schemes and that permits were granted without any requirements for expertise in the area. These facilities were established before today's guarantee scheme, whereby new mussel farming facilities must provide a financial guarantee for cleaning up.

Some of the abandoned facilities found in the winter of 2008 have already been cleaned up, or agreements for such work exist. For the remaining facilities one solution could be that the Directorate of Fisheries as far as possible gives other industry operators the opportunity to take over the equipment in return for cleaning up. The industry's efforts with regard to cleaning up can also be rewarded through payment, access to the marine area, equipment and/or mussels that could be harvested.

Figure no. 7.1: The waste pyramid
The figure shows the various possibilities for the disposal of waste. The aim is to be able to dispose of waste in a manner that lies as close to the top of the waste pyramid as possible. This gives the greatest benefit for the environment.

Aims and measures

The aquaculture industry has an aim for waste to be turned from being a challenge to being a resource.

The industry has a desire and a goal to be able to establish schemes also for larger production equipment for which currently no good overall schemes exist. Over time the aim is for these schemes to be so good that they can lead to a financial benefit as well as the environmental benefit.

Furthermore the industry wishes to be able to document what happens with discarded equipment, and thereby have control that the equipment actually is recycled, and preferably as far up as possible in the waste pyramid. Good waste processing for the industry thus entails that waste is turned from being a challenge to being a resource, that the cleaning up process does not in itself create new problems, but is safe guards against contamination, and that the return schemes that are established are permanent and robust.

This was also the aim when FHL and the industry itself, together with equipment suppliers and operators from the waste industry and recycling industry, took the initiative of starting the preliminary study "Collection and recycling of discarded equipment from the aquaculture industry" in the autumn of 2008. The project aims to focus initially on solutions for Trøndelag and Nordland, but over time the solutions should be able to be implemented throughout the country.

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