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Theme session Report

Theme Session E – Environmental risk assessment of aquaculture (co-sponsored by PICES)

Conveners: Ellen Sofie Grefsrud (Norway), Liu Hui (China), Monica Solberg (Norway), Nianzhi Jiao (China)

Introduction

A better understanding of the potential cumulative impacts of aquaculture could guide the development of sustainable marine aquaculture. Environmental risk assessment plays an important role in this process by elucidating the main challenges and associated risk factors.

Choice of methodology will affect the management advice; therefore, an appropriate environmental risk assessment should contribute to mutual risk understanding and risk acknowledgement among stakeholders and thus, common perspectives on measures and governance. Risk assessment should also aim to promote fruitful discussions about risk and risk influencing factors across stakeholders with different value perceptions.

Whether an environmental risk assessment can be considered useful should be seen in relation to the specific context of how aquaculture is governed. That is, how the results will be utilized by stakeholders, and whether the risk assessment is structured and displayed in such a way that decision makers in the public administration and other interested parties are able to fully understand and acknowledge risk.

To reach these goals the concept of risk and risk terminology should be guided by the latest thinking in risk science where the characterization of the background knowledge is considered a key component of the risk assessment.

Risk can seldom be described adequately by probabilities alone and advocates an approach that aims at knowledge characterization. Characterization of the background knowledge provides stakeholders an awareness of to what extent the results from the risk assessment carry weight. Strong knowledge means the risk results carry much weight, whilst weak knowledge (i.e., uncertainty) may lead stakeholders to question whether the risk assessment is valid.

This session invites presentations and discussions on what makes an environmental risk assessment valid and reliable and how do we deal with uncertainties and surprises aiming to reach common risk understanding across stakeholders with different value perceptions.

Content

The contributions to this session were mainly on environmental impact of aquaculture and only a couple of the contributors focused on environmental risk assessment. That may reflect that the use of environmental risk assessments is still not widely implemented in aquaculture research and management in ICES countries. The contributions, however, showed that there is a need of developing decision-support tools to assess the environmental impact of land-based and in-sea aquaculture, where risk assessment is considered an important tool. China is in the process of developing and implementing a framework of ecosystem-based risk assessment for mariculture, and a wish of sharing experience and knowledge with ICES countries was expressed. Most contributions focused on negative impact, but also positive impacts like increased biodiversity and habitats being restored below offshore blue mussel farms were discussed.

The presentations and posters covered a range of environmental impacts, including genetic impact from escaped farmed Atlantic salmon on wild salmon populations, negative effects of salmon lice on sea trout populations, impact of organic waste on water body carrying capacity and how marine phycotoxins may impact shellfish mariculture production through accumulation of toxins in cultured bivalves. Multifunctionality in environmental impact assessment and the importance of long-term studies and time series were also part of the discussion.

Highlights:

The presentation “Ecological impacts of farming mussels offshore: The Lyme Bay case study” was rewarded with the ICES “Best presentation by young scientist” reward. Offshore mussel farming was proposed to potentially become one of the most sustainable, large-scale sources of healthy protein, with less negative environmental impact and higher mussel growth potential than inshore mussel aquaculture.

The presentation “Risk of genetic impact from escaped farmed Atlantic salmon from a given farming location” showed how the implementation of a new approach to environmental risk assessment in Norwegian aquaculture has made it possible to connect science and management into a new risk-based supervision tool. This presentation engaged the audience a lot, reflected in many questions to the presenter.

The presentation “Setting up a framework for mariculture risk assessment in China” was highly relevant for the session as China is the world’s leading producer of intensive marine aquaculture. The format of eight-minute presentations was too short for such a broad topic and should be considered a keynote presentation in future Annual Science Conferences.

Conclusions

The topic of the session only covered environmental risk assessments in aquaculture, not the use of such tools in marine sciences in general. That probably limited the number of relevant contributions since aquaculture is still a very small part of ICES. Environmental risk assessments are widely used in marine science, but there is no common risk terminology or common understanding of what defines a useful, valid, and reliable risk assessment. The most frequently used risk assessments in marine science are indicator based, which in most cases has limited value due to the challenge of identifying relevant and data rich indicators in complex systems such as marine ecosystems. With that perspective, ICES should continue the discussion on environmental risk assessments in future Annual Science Conferences, but maybe with more focus on how valid and useful existing methodologies are in a management perspective.

Based on this years’ experience, there seems to be a need for a session on the environmental impact of aquaculture. Such session should include how to support decision-makers implement marine policy, especially regarding the aquaculture licensing and monitoring requirements, in order to support a sustainable growth of the aquaculture industry. This is something that should be relevant to all ICES aquaculture working groups, including the social-economic aspects. Since there are still relatively few working groups on aquaculture in ICES, maybe a full day session, instead of several small and scattered sessions, could help get more attention and engagement into this part of ICES. Involving all aquaculture WG-chairs and inviting them to organize an aquaculture event may also facilitate more interactions and establish a dialogue that will strengthen the bond between the WGs.

Contents

CM 66: Modelling ecosystem assimilation capacity for a sustainable aquaculture in France: the MOCAA project

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In France, there is currently no decision-support tool, accepted by all stakeholders, to predict the impact of fish farm waste and facilitate environmental risk assessment. Thus, planning permission and permit to establish a new aquaculture farm are complicated to obtain. Models are important tools to address sustainability challenges associated with developing aquaculture at farm, regional and global scales (Chary et al. 2022). The objective of the MOCAA project (*Modeling ecosystem assimilation capacity for a sustainable aquaculture*) is to develop a chain of modelling tools to assess the environmental impact of land-based and marine cage fish farming systems, based on the evaluation of the biological waste assimilation capacity of the receiving ecosystem. The MOCAA decision-support tool considers the production systems characteristics (species, production, type and farm management, etc.) and the characteristics of the ecosystem (bathymetry, hydrodynamics, sensitivity of benthic ecosystems, etc.) to simulate the emission, the fate and the impact of aquaculture waste on the environment. The project involves aquaculture stakeholders in France Metropolitan and oversea territories to ensure that the tool will meet multi-stakeholder needs. The project is divided into three phases. For each phase, existing tools are reviewed and benchmarked. Workshops are organized in collaboration with fish farmers, public authorities and other stakeholders to present the approach, define needs and to co-construct the tool.

We developed an integrative tool designed for aquaculture impact assessment, MOCAApp', encompassing three modules. The first module is a farm-scale model to simulate fish growth rates and emission of solid and dissolved waste for 7 marine fish species produced in metropolitan France and overseas territories: Seabass (*D. labrax*), seabream (*S. aurata*), red drum (*S. ocellatus*), meagre (*A. regius*), trout (*O. mykiss and S. trutta*) and atlantic salmon (*S. salar*) (Callier et al. 2021). This farm-scale model, developed in R and Shiny, integrates a dynamic bioenergetic module (DEB) based on the NicheMapR package (Kearney et al., 2017) and a farm management module. The second module corresponds to a pre-existing Lagrangian dispersion model (Parcels v2.0), which was adapted to simulate dispersion and dilution of particulate and dissolved waste. This dispersion module uses the outputs of existing hydrodynamic models or measured water currents. Model validation, at cohort and farm scale, is in progress. The last phase of development will focus on the development of the third module, dedicated to the environmental impact of simulate aquaculture projects. This tool will be transferred to stakeholders to facilitate sustainable aquaculture development.

Keywords: environmental impact assessment, decision-tool, farm model, waste, dispersion, stakeholders

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CM 121: Observation of marine phycotoxins in phytoplankton and shellfish in three typical mariculture areas of the East China Sea during 2020–2021

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To learn the marine phycotoxins (MPTs) contamination status in mariculture areas in the East China Sea (ECS), from May 2020 to October 2021, 80 net-concentrated phytoplankton samples and 91 shellfish samples were collected from 12 stations in three typical areas of northern, central and southern of ECS, respectively, and MPTs of the samples were detected.

Six types of MPTs, including 2 PSTs, 3 LMTs, and DA, were detected. Lipophilic marine toxins (LMTs) were more common and diverse in these areas. Pectenotoxin-2 (PTX2) was the main LMT in the concentrated phytoplankton samples and the occurrence showed seasonal differences from north to south. Spirolide (SPX1) and gymnodimine (GYM) in the north and DA in the south of ECS were detected. Two PSTs, C2 and decarbamoylgonyautoxins 3 (dcGTX3), were only found in spring samples in the north of ECS.

Ten PSTs and three LMTs were detected in shellfish samples with a detection rate of 45.05%. The main types of PSTs were N-sulfonylcarbamoyl toxins, C1&2, gonyautoxin 5 (GTX5); and decarbamoyl toxins, decarbamoylgonyautoxins 2 & 3 (dcGTX2&3). The types of LMTs were SPX1, GYM, and AZA1. Spring showed a high incidence of MPTs. In samples collected from spring, the detection rate of MPTs is 69.23%, of which the detection rate of PSTs and LSPs was 48.72% and 53.85%, respectively. The detection rate of LMTs was relatively high in spring, but it could also be detected in summer and autumn, while PSTs could hardly be detected in these two seasons. The shellfish cultured in north ECS showed a high risk of MPTs contamination with 60.71% of the samples detected with MPTs. The diversity of MPTs in shellfish from the south ECS was more abundant, and the contamination of MPTs in the central ECS was not serious.

There were both similarities and differences between the MPTs in phytoplankton and shellfish samples, which were mainly related to the accumulation and transformation of toxins in shellfish. In ECS, MPTs, especially PSTs, were a serious potential threat in spring, then LMTs instead of PSTs became the main risk in summer-autumn seasons. North of ECS showed higher toxin diversity and the toxin detection rate was higher than the other two areas. It may attribute that this area was close to the Estuary of the fourth river in the world, the Yangtze River. To ensure the safety of seafood and marine environmental health, it is recommended to conduct long-term targeted tracking and monitoring of MPTs in mariculture areas in ECS.

Keywords: marine phycotoxins (MPTs), Paralytic shellfish toxins (PSTs), Lipophilic marine toxins (LMTs), mariculture areas, East China Sea (ECS), seafood safety

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CM 173: Sea trout: an effect indicator for Atlantic salmon aquaculture management

Rachel A. Paterson[1], Ola H. Diserud, Geir H. Bolstad, Richard D. Hedger, Tor F. Næsje

Norwegian sea trout, the anadromous fraction of brown trout (Salmo trutta) populations, have severely declined during the last decades. Of the 1251 recognized Norwegian sea trout populations, almost 40% are in a poor or very poor state or lost entirely. Among the anthropogenic factors affecting the state of sea trout populations, salmon lice from Atlantic salmon aquaculture have been found to have the largest negative impact. The Norwegian "traffic light system" regulates the production limits (maximum allowed biomass of farmed salmon) of the salmon aquaculture industry, and presently has one indicator, the mortality of wild Atlantic salmon post-smolt caused by salmon lice. However, the agreed system has not yet fully integrated other vulnerable species, such as sea trout, due to poor effect indicators for this species.

Sea trout spend their entire marine feeding period in the same coastal waters where salmon aquaculture operations are situated and are therefore more susceptible to lice infestations associated with aquaculture than wild Atlantic salmon post-smolts that migrate quickly through these waters. Sea trout may respond to high lice infestations by prematurely returning to freshwater, and thus the direct effects of lice infestations, besides the increased risk of marine mortality, will then be reduced time and growth at sea, and consequently reduced size and condition when returning to freshwater. This reduction in size and condition will negatively affect an individual's subsequent size-dependent life history traits (e.g., age of maturation, fecundity, survival). At the population level, this may reduce both the immediate sea trout spawning biomass as well as reduce future sea trout smolt recruitment. In this presentation, we will suggest an effect indicator for sea trout that captures the cumulative impacts from an increased lice load on sea trout populations, not only the immediate additional lice-induced marine mortality but also the effect on marine growth, reproduction, and later stage survival. The proposed sea trout effect indicator, based on well documented knowledge of sea trout life history and the concept of mean individual fitness, will be an important tool to guide the future sustainable management of Atlantic salmon aquaculture.

Keywords: *Salmo trutta*, Norway, sea lice, effect indicator

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CM 201: Factors explaining the occurrence of escaped farmed salmon and level of genetic introgression in wild salmon populations

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Throughout its 50-yr history, marine aquaculture of Atlantic salmon has been associated with escapes, and studies have shown that escapees may enter rivers and spawn successfully. This may lead to farmed-to-wild genetic introgression and maladaptation in wild populations. Yet, an open question is what factors can best explain the variability in the proportion of farmed escapees in wild populations, and when present, which additional factors may explain variation in the level of introgression.

Here, we have combined two large-scale data sets, one from monitoring escaped farmed salmon with origin determined for almost 500 000 individuals from 129 rivers and one with more than 50 000 individuals analyzed for genetic introgression from 239 Norwegian wild Atlantic salmon populations between 2006 and 2018, to model how anthropogenic, environmental and population factors may be associated with the occurrence of escapees and level of genetic introgression. We found that increasing regional farming intensity and river discharge increase the expected proportions of escaped farmed salmon in rivers, whereas a larger wild salmon population size reduces the expected proportion of escapees despite increasing the expected absolute numbers of escaped farmed salmon. On a large scale, introgression is primarily a function of proportions of escaped farmed salmon, and only to a minor extent a function of local environmental factors or salmon population characteristics. Large marine protected areas without salmon aquaculture may slow down the rate of intrusion and introgression by increasing the distance between intensive aquaculture and wild populations, but as long as salmon aquaculture is based on technologies where non-sterile fish can escape, all anadromous wild Atlantic salmon populations are at risk.

Keywords: Atlantic salmon, aquaculture, escaped farmed salmon, genetic introgression, Salmo salar

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CM 236: Ecological impacts of farming mussels offshore: The Lyme Bay case study

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With a growing human population, there is a requirement for society to source alternative means of sustainable protein. Mussel aquaculture has rapidly expanded serving as an important supply of protein, but its development has been limited due to competition for coastal space and the associated environmental impacts of farming in inshore waters. Offshore aquaculture developments have the potential to overcome such issues. Offshore mussel farm studies report an increase biomass or numbers of benthic and pelagic organisms around the farm relative to control sites using the structure for shelter, refuge and nursery. Coupled with the exclusion of fishing activities from farmed grounds, this may provide the potential to enhance both commercial and non-commercial species producing a spillover effect but also present the prospect for benthic habitats to be restored to previous state, serving as a de facto marine protected area (MPAs).

Reporting lower environmental impacts and higher growth potential compared to traditional inshore farms, offshore mussel farming has the potential to become one of the most sustainable, large-scale source of healthy protein. Over eight years, the study of the UK's first large-scale offshore longline mussel farm presents the first assessment of sediment characteristics, infauna assemblages and the associated changes of infauna functional traits following the development of this novel aquaculture in Lyme Bay, UK. Infauna were sampled taking a BACI (Before-After Control-Impact) approach along a gradient from the farm in order to evaluate the effects of the farm on the sediment ecosystem, study infaunal sediment environmental parameters and to evaluate the effects of the farm on the sediment macrofauna and its functional traits along a gradient from the farm. Overall, farm sites developed a wider range of traits supporting the hypothesis that offshore shellfish aquaculture increases ecosystem function.

These findings showed that advanced functional diversity and trait approaches are able to complement classical diversity indexes and tests, but also provide a clearer picture of ecological impact. As classical diversity indexes and statistical tests are mostly based on abundance data, they may not always be sensitive to ecological change in different environments while functional characteristics of taxa are what maintains ecosystem function. This highlights the importance of considering multifunctionality in environmental impact assessment as well as how crucial it is to perform long-term studies to show trends and well-established long-term effects. The outcomes of this study can help support decision-makers implement marine policy, especially regarding the licensing, monitoring requirements and assessment to adopt an integrated ecosystem-based management in order to support the offshore aquaculture industry grow sustainably.

Keywords: offshore aquaculture, Biological Trait Analysis, conservation, diversity, ecology, functional traits, impact assessment, infauna, mussel farm, OECM, sediment

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CM 292: Setting up a framework for mariculture risk assessment in China

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It is widely accepted that climate change and pollution have imposed significant impact on global ocean ecosystems and its food provision service (Liu et al, 2022). In China's case, large-scale intensive aquaculture operations can possibly carry with them undesirable biological and biochemical characteristics, which may have consequences on natural ecosystems beyond normally perceived spatial and temporal boundaries, and generate significant externalities and internalities, such as the spreading of pathogens and invasion of alien species. At the same time, rapid urbanization, economic development and population growth in coastal areas have exerted tremendous pressure on the coastal ecosystems, which is to some extent exacerbated by the fast expansion of largescale mariculture activities (Liu and Su, 2017), frequently resulting in harmful algal blooms or green tide and degraded water quality. The removal or reduced large and forage fish (and their fingerlings in particular), due to both habitat losses to reclamation/mariculture and overfishing for food or fishmeal, may have far-reaching effects on the coastal and shelf ecosystems in the long run, and may endanger the potential future growth for mariculture (Clavelle et al, 2019). Setting up a framework of ecosystem-based risk assessment for mariculture in face of multiple environmental stresses and taking into consideration of a wide range of indicators including environmental suitability (Liu and Su, 2014; Sun et al, 2020) and carrying capacity (Liu et al, 2021; Gangnery, et al, 2021; Liu et al, 2022; You et al, 2022) etc., is truly important for mitigating and alleviating the vulnerability, and promoting the practice of ecologically and economically sustainable mariculture.

Keywords: risk assessment, mariculture, climate change, multiple stress, vulnerability

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CM 312: Genetic introgression of escaped farmed salmon – what have we learned from the Norwegian large-scale experiment?

Sten Karlsson[1], Geir H. Bolstad, Ola H. Diserud, Peder Fiske, Ingerid J. Hagen, Kjetil Hindar, Grethe Robertsen, Sebastian Wacker

Millions of farmed salmon have escaped from net pens since the beginning of the Atlantic salmon aquaculture industry. We know that the escaped farmed salmon enter salmon rivers and spawn with wild Atlantic salmon, and that more than two-thirds of the Norwegian wild salmon populations are affected by genetic introgression; many with a very large proportion of the genome being of farmed origin. We also know that genetic introgression leads to changes in important life-history traits, lower fitness, and reduced viability of wild salmon populations. The phylogenetic origin of today's farmed salmon is wild salmon of the Norwegian west coast. These are being used in most of the world's salmon aquaculture and spread into wild populations of a different phylogenetic origins. Thereby, natural barriers between phylogenetic groups are being broken down by genetic introgression, which is a serious threat to the genetic diversity of wild Atlantic salmon.

Because of the large-scale aquaculture industry and its extensive consequences for wild conspecifics, Atlantic salmon has unfortunately become a model organism for consequences of aquaculture on wild populations. Here we present knowledge status and lessons learned from the Norwegian experiment.

Keywords: Atlantic salmon, *Salmo salar*, aquaculture, genetics, introgression

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CM 313: Introduction to the Paradigm of Seaweed Culture as an Eco-engineering Strategy for Ocean Negative Carbon Emissions (ONCE)

Nianzhi Jiao, Carol Robinson, Louis Legendre, Doug Wallace

Farmed seaweeds have an impressive capacity for carbon and nutrient uptake (Heery et al., 2020), but these benefits were outweighed by negative impacts arising out of processes that contribute to carbon fixation and biomass accumulation and are often considered to be a source of pollution in coastal waters. This presentation tends to describe the efficacy and potential environmental impacts of integrating large-scale seaweed cultivation for carbon sequestration and establishes a comprehensive roadmap for the implementation of ONCE in seaweed aquaculture areas. The potential problems and negative impacts of the adoption of this solution, together with the corresponding countermeasures, will be also introduced in this presentation. The presentation aims to provide a paradigm for eco-engineering solutions to achieve the global carbon neutrality goal.

Keywords: ONCE approaches, marine carbon sequestration, DOM

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CM 429: Carrying Capacity Assessment of a Fjord in Iceland, Arnarfjörður

Andreas Macrander[1], Sólveig Rósa Ólafsdóttir[1]

Fjords in Iceland are increasingly utilized for aquaculture, with increasing amounts of organic wastes being released into the environment. In Iceland, by law the carrying capacity needs to be assessed by the Marine and Freshwater Research Institute (MFRI) prior to any application for operational license for sea-pen aquaculture. The criteria for the carrying capacity estimation are that the respective water bodies will not be at risk of not having high or very high status according to the criteria set in the implementation of the Water Framework Directive in Iceland.

To assess the carrying capacity of the fjords, MFRI carried out comprehensive measurements of the environmental conditions in most Icelandic fjords to establish detailed knowledge on the physical environment to base the assessment on. The carrying capacity assessment is based on observations of hydrographic conditions, currents, and water renewal. Moreover, a numerical model, based on the ACExR/LESV box model, is employed to simulate the impact of fish farming on oxygen and nutrient budgets in the respective fjord.

Here, we report on observations and modeling results for a specific fjord, Arnarfjörður which is a threshold fjord in the Westfjords region in Iceland. Mooring timeseries and CTD data reveal that during summer and fall, Arnarfjörður has an isolated bottom layer, and oxygen saturation depletes to 35% in late October, while in winter, the entire water column is mixed and renewed. The model was adjusted to reproduce this seasonal cycle. Aquaculture was implemented in the model by increasing the supply of wastes, both in dissolved and in particulate form. Based on the model, it is expected that dissolved wastes from 14,500 tons of fish farming in Arnarfjörður will have minor effect on nutrient concentration because of steady renewal of the upper layers. However, decomposition of particulate wastes on the sea floor in areas deeper than 65 m is expected to reduce oxygen concentration in the bottom layer by up to 0.6 mL L-1 and is thus considered the limiting factor in the carrying capacity assessment of Arnarfjörður.

Keywords: fjords, aquaculture, Iceland, carrying capacity assessment

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CM 495: The Quality Standard for wild Atlantic salmon populations in Norway

Kjetil Hindar[1], Ola Diserud, Peder Fiske, Torbjørn Forseth, Sten Karlsson, Eva Thorstad

Atlantic salmon is an important species for Norway and other countries surrounding the North Atlantic. It is now on the Red List in major parts of its distribution area. Human threats to Atlantic salmon are manifold and include threats in fresh and sea water. A crucial question is: "How can wild Atlantic salmon be managed sustainably?" In Norway, this question is met by management in two ways: The first is by designating a set of rivers and fjords as being particularly important for the future viability of Atlantic salmon: 52 National Salmon Rivers, and 29 National Salmon Fjords. The second is a set of regulations that describe a Quality Standard for Atlantic salmon populations and what to do if these standards are not met. The Quality Standard emanates from Norway's Nature Diversity Act. The biggest threats to Norwegian wild Atlantic salmon today are escaped farmed salmon, sea lice and disease agents related to salmon farming. The Norwegian Scientific Advisory Committee for Atlantic Salmon stated in 2022 that sufficient mitigation measures are not in place to counter or stabilize these threats. Hydropower regulation and other habitat alterations are other population-reducing threats whereas climate change and pink salmon are among the most important emerging threats. The Quality Standard is evaluated for c. 450 salmon populations in Norway of which c. 200 is subject to detailed evaluation. The Quality Standard has two axes that both need good or very good status for the Quality Standard to be met for a population. One axis is genetic integrity which is classified according to SNP-based estimates of the proportional wild ancestry of the population's gene pool. The other axis is an evaluation of the proportional attainment of the spawning target of the population. This also includes an evaluation of whether or not the population produces a natural harvestable surplus. The pre-fishery abundance of Atlantic salmon in Norway was near its lowest in 2021 when only reaching 45% of the PFA of the 1980s. However, during the same period strong regulations have secured a higher current spawning population than was the case 40 years ago. Escaped farmed salmon are likely to be the most serious long-term threat because already, 1/3 of more than 200 studied populations show high genetic introgression. This also holds true for the National Salmon Rivers.

Keywords: *Salmo salar*, population management, legislation, threats, conservation limit, spawning target, stock-recruitment, genetic integrity, introgression

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CM 583: Risk of genetic impact from escaped farmed Atlantic salmon from a given farming location

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Norway is the largest producer of Atlantic salmon, and the government has established a strategy against escapes from aquaculture facilities with a vision that genetic influence on wild salmon populations shall not occur. The strategy has a two-pronged approach; 1) through escape-proof design and operation of aquaculture facilities and risk-based supervision by management, escapes of farmed fish shall be reduced as much as possible, and 2) in the event of escapes, genetic effects on wild populations (genetic introgression) shall be reduced to a minimum.

Since 2019, the Institute of Marine Research has assessed the risk of further genetic change in wild populations due to introgression of aquaculture Atlantic salmon escapees, using Bayesian networks. This method illustrates risk factors that can lead to possible consequences, and the uncertainty associated with these factors. Thus far the 13 production areas along the Norwegian coast have been assessed. While management has conveyed that this methodology provides the opportunity to operationalize risk-based supervision, the current per production area resolution is too low for assessing the consequences of escapes from a given location. Thus, in order to identify farming locations that in the event of escape have increased risk of causing further genetic introgression, the Norwegian Directorate of Fisheries put forward an order to the Institute of Marine Research, a neutral knowledge provider in advisory capacity to the Ministry of Trade, Industry and Fisheries.

The purpose of the order was to investigate the possibility of increasing the resolution of the current risk assessment in such a way that it could be used to assess the consequences of escape from a given location, on the individual wild populations. In the ongoing pilot project, the dispersal of escaped Atlantic salmon (pending on time-of-escape and age-at-escape), the geographical location of aquaculture facilities in connection to nearby water courses, the water courses attractiveness to escaped salmon and the resilience of the wild populations were assessed. The current talk therefore provides an example of “from science to advise” in a risk assessment framework.

Keywords: farmed escapees, Atlantic salmon, genetic introgression, risk science, governance management

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