



Towards a green transition in Danish aquaculture: Opportunities, challenges and new directions

Summary report from the
The first AquaNet conference on Danish aquaculture
(Copenhagen, April 13, 2023)

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Background

AquaNet, the new Danish aquaculture organization, held its first symposium on Thursday, April 13, addressing a green transition in Danish aquaculture, including both opportunities, challenges and new directions. The increased focus on the need for producing high quality protein sustainably to feed the growing world population has drawn attention to the potential role of aquaculture in providing healthy food, and more than 100 participants from research, the industry and other sectors were gathered at the event to discuss potentials, solutions and challenges in an expansion of Danish aquaculture and a transformation of the sector towards more sustainable production. Overall, there was a strong agreement towards an expansion of sustainable aquaculture to be vital for the future blue/ green food production. In the following, key topics and challenges together with solutions, which were identified at the symposium, have been summarized, in an attempt to cover the topics of the presentations as well as the diversity of opinions and arguments presented to the best of our ability.

The symposium covered 7 thematic sessions introducing key topics, challenges and potentials in the future development of Danish aquaculture by experts in each field and included panel debates and interaction and discussion between speakers, the panel and the audience.

Panel members (Roundtable discussions): Johan Wedel Nielsen, Aquamind A/S, Søren Laurentius Nielsen, Tænketanken HAV, Niels Dalsgaard, Dansk Akvakultur/Musholm, Hilary Karlson, Bioøkonomisk Vækstcenter, Guldborgsund Kommune, Mikkel Detz Jensen, Biomar A/S

Program

8:30-9:00 Coffee and bread

9:00-9:15 Background and aims of AquaNet: Mathias Middelboe (KU-BIO)

9:15-10:10 Session 1: Challenges and limitations in Danish aquaculture production

9:15-9:30 Potentials for sustainable growth in Danish mussel farming. Jens Kjerulf Petersen (DTU Aqua)

9:30-9:45 Seaweed production in Denmark – status and challenges. Annette Bruhn (Aarhus University)

9.45-10:00 Green transition in Aquaculture in Denmark, and aquaculture as an important driver in the green transition of the food production; challenge and possibilities. Lisbeth Jess Plesner (Dansk

Akvakultur)

10:00-10:10 Getting the camel through the eye of the needle, is permissions the biggest obstacle to growth in Danish aquaculture sector? Johan Wedel Nielsen (Aquamind A/S)

10:10-10:25 Session 2: Aquaculture technology – Increasing production and reducing environmental impact

10:10-10:25 Recent examples of how to reduce environmental impact. Per Bovbjerg Pedersen (DTU AQUA)

10:25-11:00 Round table discussion on key aquaculture challenges, potential and solutions (Moderator: Kurt Buchmann, KU-SUND)

11:00-11:15 Break

11:15-11:30 Session 3: Economic aspects and perspectives: What is required to develop a more climate friendly and economically viable aquaculture industry with a better reputation?

11:15-11:30 Economic aspects and perspectives: Towards a more climate friendly and economically viable industry. Rasmus Nielsen (KU-IFRO)

11:30-11:45 Session 4: Food biotechnology – optimization of aquaculture products

11:30-11:45 Full exploitation of the biomass from aquaculture for food ingredients – is that possible? Charlotte Jacobsen (DTU FOOD)

11:45-12:15 Round table discussion on improving aquaculture economy, reputation, climate impacts and food products (Session 3 and 4) (Moderator: Max Nielsen, KU-IFRO)

12:15-13:15 Lunch

13:15-13:30 Session 5: Animal welfare: Is an increased aquaculture production compatible with high animal welfare?

13:15-13:30 Animal welfare in green transition of Danish aquaculture. Nicolaj Lindeborgh (Animal Protection Denmark)

13:30-14:00 Session 6: Disease prevention – sustainable alternatives to antibiotics

13:30-13:45 Prophylactic measures against diseases – exemplified by RTFS, bacteriophages, changes in water parameters, management and hygiene. Lone Madsen (DTU Aqua)

13:45-14:00 Selective, marker-assisted breeding of disease resistant fish in aquaculture. Kurt Buchman (KU-SUND)

14:00-14:30 Round table discussion on how to maintain and improve animal welfare and reduce disease issues during and expansion of the aquaculture sector (Session 5 and 6)

(Moderator: Louise von Gersdorff Jørgensen, KU-SUND)

14:30-14:50 Break

14:50-15:05 Session 7: Funding landscape – opportunities for aquaculture funding in DK and EU

14:50-15:05 Overview of the Danish and international aquaculture-related funding calls and deadlines. Marie Terpger (KU-SCIENCE)

15:05-15:35 Round table discussions – brain storm on potential funding opportunities/projects for supporting a future sustainable and expanded aquaculture sector (Session 7)

Moderator: Violetta Aru (KU-FOOD)

15:35-15:50 Wrap up and next steps. Kurt Buchmann (KU-SUND)

Summary of discussions and output:

Session 1: Challenges and limitations in Danish aquaculture production

Potentials for sustainable growth in Danish mussel farming

Challenges

The major challenges in today`s food production include climate change, biodiversity losses, nutrient run-off and the world food crisis. These challenges create the need to develop sustainable solutions in the food industry. Mussel farming is a prime example of a blue food for a green transition in aquaculture. This is due to the mussel`s high nutrition, their removal of nitrogen and the resulting increase in biodiversity. Its production in Denmark has increased fivefold in the last ten years and holds a huge potential for sustainable growth. However, future challenges are posed in the very low shellfish consumption in Denmark, the high degree of seasonality and a very competitive market which only results in few producers starting a new business. Furthermore, the visual pollution (seascape), physical pollution and environmental pollution (e.g., sedimentation under farms) constitute obstacles.

Solutions

1. Social acceptance and public awareness

A general social acceptance and public awareness on the potential of using farmed aquaculture species. Non-governmental organizations need to be involved in order to inform consumers about aquaculture benefits towards helping both biodiversity and the climate. A shift from more species farmed in agriculture to aquaculture farmed species would result in a reduction of produced CO₂.

2. Socio-economic analysis

In order to reduce pollution, solutions to visual pollution have to be developed and mussel farming for human consumption has to be separated from mussel mitigation farming. Moreover, carrying capacity assessments are necessary to be ensured in a wider context regarding production, the environment and social aspects.

Seaweed production in Denmark – status and challenges

Challenges

Coastal and land-based seaweed farming is a promising area of low trophic aquaculture. However, there are certain barriers in the production of seaweed concerning cultivation technology, species domestication and the value chain.

Solutions

Regarding the economy, funding and investors for upscaling are needed. Future research has to focus on the cultivation technology of seaweed in regards to mechanisation and resource efficiency. Moreover, emission capture systems (CO₂) and the utilisation of nutrients have to be investigated. Concerning the safety of food and feed, no harmful minerals, PFAS, medicine and pesticides should be used. Future studies have to elucidate the possible risk and impact of non-indigenous species and focus on species domestication (e.g., new species, strain optimisation, breeding). Furthermore, a consensus on monitoring climate and biodiversity effects is in demand.

Green transition in Aquaculture in Denmark, and aquaculture as an important driver in the green transition of the food production; challenges and possibilities.

Challenges

Farmed fish and seafood production have a lower land use, lower carbon footprint and lower environmental footprint than terrestrial animal production and contain important nutrients. Notwithstanding, the majority of food products in Denmark are farmed through agriculture and not via aquaculture. The reason is partly the lack of social acceptance and lack of political and administrative will. Other barriers are the access to space, nutrients and waters and the administrative framework.

Solutions

1. Feasibility studies (economy and environment)

Comparative analyses, climate effectivity analyses and tools have to prove the advantages of aquaculture over other food productions. Feasibility studies are in demand for “transforming” agriculture to aquaculture. Moreover, both land and marine based environmental tools can be used to increase fish production (sea and land based). Last, a political priority for aquaculture the same as for “farming” is missing.

2. Communication

A constructive dialogue with the governance and the public, that addresses solutions to reduce the carbon footprint while increasing productivity in aquaculture, is needed.

Getting the camel through the eye of the needle, is permissions the biggest obstacle to growth in the Danish aquaculture sector?

Challenges

The administrative and regulatory framework creates challenges due to permissions and planning laws. For the main part, the permits and not the grant money pose an obstacle in Danish aquaculture. This is due to environmental legislations on nutrients (e.g., nitrogen) that make it difficult to obtain permits for new aquaculture farms.

Solutions

1. Pilot farm – new nutrient management

A new nutrient management and licensing in aquaculture is required and permissions for new space should be approved faster. Testing effects of farm management on nutrient loss and climate footprint. Moreover, better monitoring efforts for farms should be made.

Session 2: Aquaculture technology – Increasing production and reducing environmental impact

Challenges

The discharge of nutrients and greenhouse gases per kg produced fish need to be reduced to support a green transition in aquaculture. To achieve this, new environmentally friendly technology and solutions which support a resource-efficient production ought to be developed.

Solutions

1. Locations

It is possible to reduce the environmental impact and increase the fish production at the same time. Promising recirculating systems and land-based farming (e.g., closed or semi-closed production systems) provide many environmental advantages.

2. Removal and valorisation of waste

An end-of-pipe treatment (e.g., constructed wetlands and woodchip beds) is important to reduce nutrient discharge (e.g., nitrogen). Moreover, waste such as side-streams have to be valorised.

3. Environmental feed

In order to decrease the carbon footprint and nitrogen load from aquaculture, environmental fish feed must be produced (e.g., alternative, sustainable protein sources). Through research and development, biomass, productivity and technical innovation can improve.

Session 3: Economic aspects and perspectives: What is required to develop a more climate friendly and economically viable aquaculture industry with a better reputation?

Challenges

Aquaculture is competitive and the production of fish in Denmark has only slightly increased over the past 30 years due to regulatory constraints. Regulation is essential to address environmental challenges such as emissions, climate, spreading of diseases and chemicals and antibiotics. However, “bad” regulations harm both productivity and the environment.

Solutions

1. Productivity

In order to stay competitive, farmers need to continuously improve productivity. As 2/3 of the productivity growth is provided by supporting industries, the sector size is important. Therefore, future research should focus on how to secure an adequate size to promote innovations and attract investments. Focus on benefits for the society should be emphasized (export, sustainability).

2. Regulation and technical innovation

Environmental and climate externalities (e.g., nutrients, CO₂) should be regulated by providing farmers (specifically organic farming) with economic incentives (e.g., tax or an emission quota). This will lead to innovations in climate friendly technology, feed, breeding and logistics which are needed to increase the farmer's productivity and competitiveness. Moreover, research has to be carried out on tradability and new licenses for production (emissions). Last, a fine balance between the investment costs and the economic gains and environmental improvements are necessary.

Session 4: Food biotechnology – optimization of aquaculture products

Full exploitation of the biomass from aquaculture for food ingredients- is that possible?

Challenges

The need to feed the growing world population and the need for reducing food waste remain the overall challenges. In aquaculture, the current exploitation of resources is hampered by inefficiency. Up to 70% end up as low-value products or waste. Consequently, a biorefinery approach and a proper logistic and infrastructure is demanded to ensure high quality of side-streams (e.g., Mussel shells, head and bones of cod etc.). Technologies need to be adapted to industrial scale.

Solutions

1. Biorefinery approach of using side-streams

It is possible to increase the degree of utilization of aquaculture raw materials (e.g., production of fish oil, peptides, proteins and savoury ingredients with umami flavour). The majority of seafood consumers is interested in products containing side-streams, as long as they are produced in an environment and sustainable matter. For instance, side-streams of small pelagic fish can be sorted similarly to larger fish such as cod/salmon and most side-streams can be handled in a food grade manner. Nevertheless, the knowledge transfer and upscaling of lab solutions is missing. Particularly for small industries, logistical and marketing challenges present a problem.

Session 5: Animal welfare: Is an increased aquaculture production compatible with high animal welfare?

Challenges

High intensity production has shown to be problematic in other animal groups as it is an environment with only a few elements of the natural habitats for the farmed animals. Accordingly, animal welfare might also be in danger, especially in highly intensive fish production.

Solutions

1. Low Trophic Aquaculture

The Danish aquaculture sector must continue sustainable growth in production, including environmental sustainability, animal welfare sustainability and economic sustainability. The most sustainable aquaculture concept is the cultivation of low-trophic species (e.g., seaweed, mussels). Research on new products to enhance human consumption and on the welfare of mussels is required inside of low trophic-level aquaculture. Furthermore, the production of fish, preferably local species, is required to be extensive and with a focus on their natural habitat. Regarding inspections and regulations, welfare-indicators and their threshold values have to be studied for each species individually.

Session 6: Disease prevention – sustainable alternatives to antibiotics

Prophylactic measures against diseases – exemplified by RTFS, bacteriophages, changes in water parameters, management and hygiene

Challenges

Rainbow trout fry syndrome (RTFS) is a bacterial disease that causes high mortalities among farmed rainbow trout in Denmark. RTFS outbreaks might be more fatal in RAS systems due to higher infection pressure, cleaning difficulty, higher stocking density and a higher stress level of the farmed fish. At low oxygen levels and suboptimal breeding conditions, disease outbreaks occur. The pathogen *Flavobacterium psychrophilum* often develops antibiotic resistance to Florfenicol.

Solutions

1. Microbiome management and learning from the wild

Better biosecurity and management are necessary to prevent disease outbreaks. New and better technology in aquaculture can prevent disease outbreaks in RAS systems (e.g., protein skimmers). Future research has to focus on the pathogen and the disease for alternative treatments and (multifactorial) prophylactic measures (e.g., salt treatments, phage therapy). Moreover, reproducible infection models ought to be developed. Future studies can entail the optimisation of vaccine procedures, microbiome management, feed additives, phage treatments via feed, water and biofilters and phage-cocktails against multi-bacterial infections. Furthermore, fish densities and management strategies should be compared to the economic output.

Selective, marker-assisted breeding of disease resistant fish in aquaculture

Challenges

The green transition in aquaculture is dependent on a high health standard of aquaculture fish. Although some vaccines are already used to secure the health of rainbow trout in Denmark, more green solutions are needed in aquaculture management, feed and breeding.

Solutions

1. Genetic prophylaxis

Integrated control strategies and prophylaxis have to be applied in aquaculture. A promising tool to elevate the health of aqua cultured fish and secure sustainable farming is the marker assisted genetic breeding of disease resistant fish. An increase in aquaculture production and a reduction of the climate foot print can be achieved when marker assisted selective breeding is combined with other methods.

Session 7: Funding landscape in DK and EU

1. Funding of basic research

- Marie S Curie Innovative Training Network
- ERC grants, Marie S Curie Fellowship
- Danish National Research Foundation (DNRF)
- Independent Research Fund Denmark (IRF)

2. Funding of innovation and collaboration with non-academic end-users

- Global challenges
- Innovative Europe and Horizon Europe

- Innovation Fund Denmark
- GUDP/MUDP/EUDP (Udviklings- og Demonstrationsprogrammer)

3. Funding from other private foundations

- Carlsbergfondet, Velux/Villum, Lundbeckfonden, Novo Nordisk Fonden

4. Information about SUBMARINER Network for Blue Growth EEIG

SUBMARINER Network is coordinating the BlueMissionBANOS (BMB) at www.bluemissionbanos.eu with 17 partners from all Baltic and North Sea countries. BMB supports the deployment of the EU Mission to Restore our Ocean and Waters within the Baltic and North Sea Lighthouse Area. BMB's aim is to connect the actors from politics, industry, science and civil society to foster the following three Mission Ocean objectives: 1) Protect and restore marine and freshwater ecosystems and biodiversity, 2) Prevent and eliminate pollution of the oceans, seas and waters, 3) Make the sustainable blue economy carbon-neutral and circular.

SUBMARINER Network is mapping the above-mentioned initiatives in the Baltic and North Sea area. Together with the European Commission, they collect and show the relevant actions, projects and initiatives contributing to the Mission Ocean's objectives on an interactive Mission Charter dashboard. New actors can be featured in the Mission Charter and get recognition by the European Commission resulting in invitations to future networking events when submitting their project through the Submission Form. The next big annual Mission Ocean LIGHTHOUSE stakeholder event will happen in Gothenburg on November 14-16, 2023. For more information or questions, please reach out to SUBMARINER Network (ea@submariner-network.eu).

- Map with pledged actions: <https://maritime-forum.ec.europa.eu/en/frontpage/1650>
- Mission Charter: <https://ec.europa.eu/eusurvey/runner/MissionOceanWatersCharter>
- Submission Form: <https://ec.europa.eu/eusurvey/runner/MissionOceanWatersCharter#page2>

Outlook

Thanks to all participants, AquaNet will continue to act as an “aquaculture lighthouse” for creating a sustainable network of researchers, companies, interest organizations and public agencies discussing the future of Danish aquaculture. The second annual AquaNet Symposium will be held in spring

2024. The AquaNet symposium was also mentioned in “Eurofish Magazine” (<https://eurofish.dk/magazine-issues/em-3-2023/>) (p. 34).