AQUA NOR FORUM 2011

SUMMARY REPORT

“upscaling aquaculture systems”

land-based systems

(marine) cage systems

eco-system approach

The Aqua Nor FORUM 2011 was organised by the European Aquaculture Society, the Nor-Fishing Foundation, SINTEF Fisheries and Aquaculture and CREATE.

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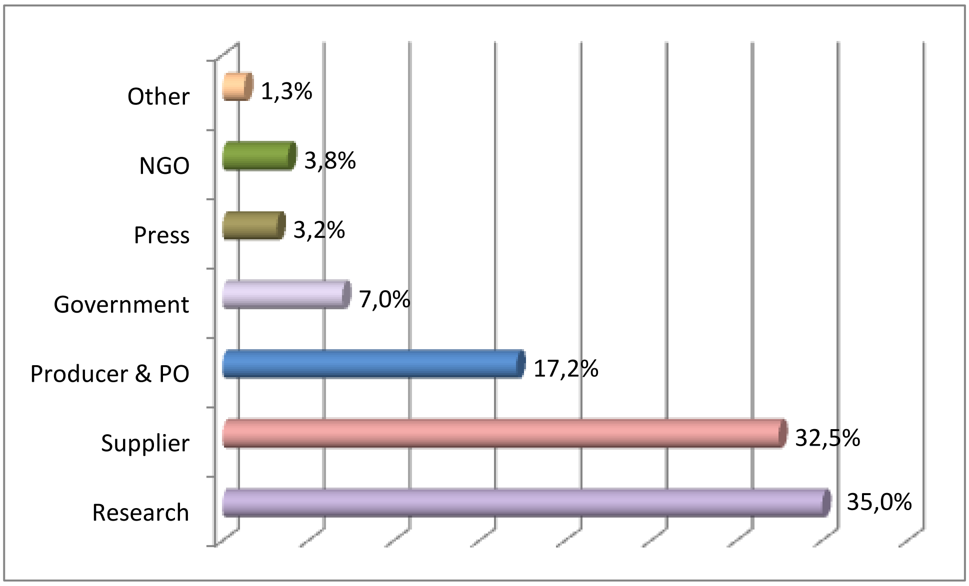
THE 2011 AQUA NOR FORUM!

The Aqua Nor FORUM is a new concept emerging from the long term collaboration between Aqua Nor and EAS, and organized for the first time at Aqua Nor 2007. The background behind the concept is that too many workshops are too presentation focused and workshop participants only have a very limited possibility to contribute.

In welcoming participants to the Forum, EAS President Yves Harache (left) cited the main objectives; to provide a forum for science, industry, consumers and policy makers to share knowledge and ideas on one of the critical constraints to the development of aquaculture in Europe –notably access to sites with high water quality to ensure high quality aquaculture products. By up-scaling production systems an increase in productivity can be obtained for any specific site; but this must be compliant with legislation, with regard to fish welfare, with regard to husbandry and especially to the environmental impacts of increased production systems. The 2011 FORUM provided good examples and good reasons why biologists, engineers and other stakeholders should work together today to develop the systems of tomorrow.

The Aqua Nor FORUM 2011 was attended by 159 participants from 25 countries.



While researchers and suppliers to the industry made up two thirds of those present, it was also encouraging to see good producer and government representation, and hence a range of stakeholders as per the objectives of the FORUM.

More than 17,500 visitors from 61 nations came to Aqua Nor. This was 3,500 more (+25%) than during Aqua Nor 2009. The exhibition area totalled 18,000 m2 and this represented an increase of 2,000 m2 compared to 2009. A total of 460 exhibitors from 26 countries were present.

AQUA NOR FORUM 2011 PROGRAMME OVERVIEW

UPSCALING LAND-BASED SYSTEMS

Session Moderator: Jean-Paul Blancheton, IFREMER, France
Panel Members and contributions (15 min each):

- Noam Mozes, Ministry of Agriculture and Rural Development, Israel; "Investment and functioning cost of low energy treatment systems, optimal size of the treatment devices for minimal consumption of energy"
- Catarina Martins, University of Algarve, Portugal/Netherlands. "Closing the tap in Recirculating Aquaculture Systems (RAS)"
- Luigi Michaud, University of Messina, Italy. "Bacterial population management, optimisation of biofilter, relation to possible pathology".
- Steven Summerfelt, The Conservation Fund, USA. "Technologies that eliminate escapees and minimize waste, while reclaiming resources in closed-containment systems".

UPSCALING (MARINE) CAGE SYSTEMS

Session Moderator: Arne Fredheim, SINTEF and CREATE, Norway
Panel Members and contributions (15 min each):

- Tore Kristiansen, Institute of Marine Research, Norway. "Farming fish in large, exposed and/or submergible cages – biological challenges and technological constraints".
- Ulrik Ulriksen, OCEA AS, Norway. "Technologies to deliver feed and medication - effective delivery of pellets over large distances and a large surface area to improve consumption levels and reduce losses".
- Gunnar Senneset, SINTEF Fisheries and Aquaculture, Norway. "Farming intelligence: The control of the total process of farming by understanding the integrated use of equipment and the process of operations and combining this with knowledge of biological issues and the physical environment".
- Cato Lyngøy, Marine Harvest, Norway. "What is the ideal cage size?".

UPSCALING THE ECO-SYSTEM APPROACH

eco

Session Moderator: Max Troell, Beijer International Institute of Ecological Economics, Sweden
Panel Members and contributions (15 min each):

- Thierry Chopin *et al.,* Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN), University of New Brunswick, Canada. "Progression of the Integrated Multi-Trophic Aquaculture (IMTA) concept and up-scaling of IMTA systems towards commercialization".
- Bela H. Buck, AWI, Germany. "Upscaling IMTA in offshore environments - challenges and possibilities".
- Margareth Øverland, UMB, Aquaculture Protein Centre, Norway. "Ecological feeds: Impact of conventional versus alternative diets in integrated aquaculture systems".
- Geir Lasse Taranger, IMB, Bergen, Norway. "Biological and technological methods to minimize risk of disease and parasite load from salmon farms to wild stocks".

Session Moderator: Dr. Jean-Paul Blancheton.

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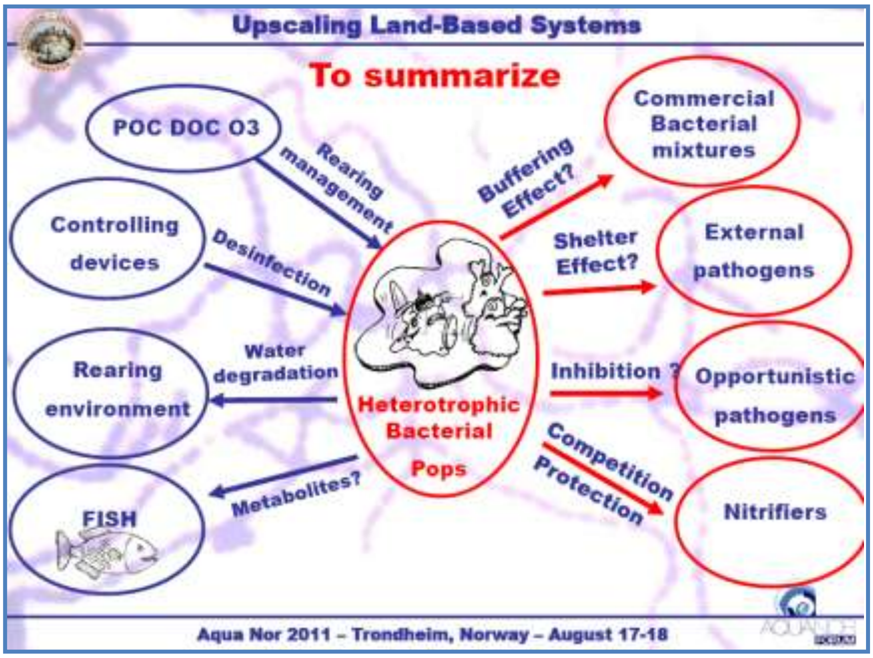
This session addressed land-based systems – with a focus on increasing production in Recirculating Aquaculture Systems (RAS) for production of juveniles and of market-sized fish. For some years, RAS has been seen as the solution to conflicts for space in the coastal zone.

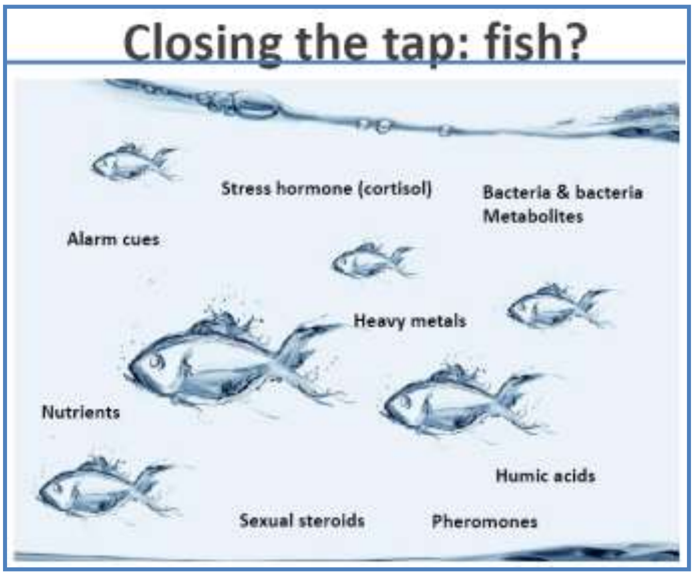
In hatchery production, it is a well established practice. However, for production of market sized fish at economically viable commercial scale, the story is more complicated.

Luigi Michaud from the University of Messina opened the session with an overview of bacterial populations and their relation to possibly pathology in RAS systems. In these systems, the importance of bacteria is of the same order of magnitude of fish. He identified a 'black box' of bacteria within treatment loops and showed that controlling water parameters (especially the suspended solids) can allow to control the whole RAS microbiota, including the biofilter associated bacteria.



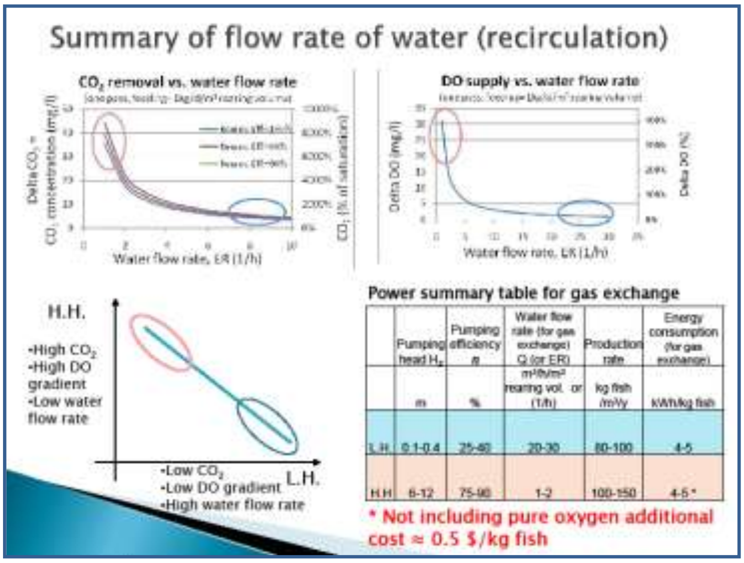
He also showed that heterotrophic bacteria could act as bio-control agents, providing a buffering effect or even a sheltering effect against pathogen and/or exogenous bacteria introduction.

Catarina Martins, of the Centro de Ciências do Mar, Universidade do Algarve followed with an interesting title of « Closing the tap in Recirculating Aquaculture Systems". In this presentation, she opened by suggesting that in conventional RAS the limiting factor for "closing the tap" is the accumulation of nitrate in the water. The use of denitrification reactors can reduce water use by 85% as compared to conventional RAS and waste discharge by 81% for nitrogen, 59% for chemical oxygen demand, 61% for total oxygen demand, 30% for CO2 and 58% for total dissolved solids. However, recent studies show that reducing water exchange rates by the use of denitrification reactors may be a limiting factor for fish growth and welfare. While growth retardation in nearly closed RAS seems to be species-specific, size-dependent and dependent of whether RAS are operated at fresh or saltwater, different growth inhibiting factors may play a role in explain growth retardation - namely: nitrate, orthophosphate, heavy metals and steroids.



By upscaling RAS, there will be a need to adjust the increase in potential growth inhibiting factors (i.e. feed, fish and bacterial load) to the levels of water exchange. This will bring new challenges to develop tailored made RAS feeds, to improve the use of treatment technologies such as ozone/UV and dephosphatation techniques as well as to develop management practices that minimise the effect of substances released by the fish and bacteria into the water.

The presentation by **Noam Mozes** from the Israel Ministry of Agriculture and Rural Development addressed the important subject of energy saving, through descriptions of investment and functioning cost of low energy treatment systems and optimal size of the treatment devices for minimal consumption of energy. Energy in RAS systems is mostly used for gas transfer (and combined nitrification in some cases) through the pumping of water and air. As the water head of systems is proportional to the water energy, the idea is to <u>obtain a low head (LH) RAS system</u>, where the water level difference; the head loss due to friction; the velocity head and the pressure head are all minimized.



His key messages were that:

- Separating water treatment to several cycles may offer reduction in treatment costs and improved treatment performances of different functions, such as ammonia removal and CO_2 stripping cycles.
- Energy and maintenance costs can be reduced by integrating low head treatment units of nitrification, solid filtration and protein skimmers.
- Increasing the production scale has a significant effect on energy efficiencies and on gross economic performances of RAS.

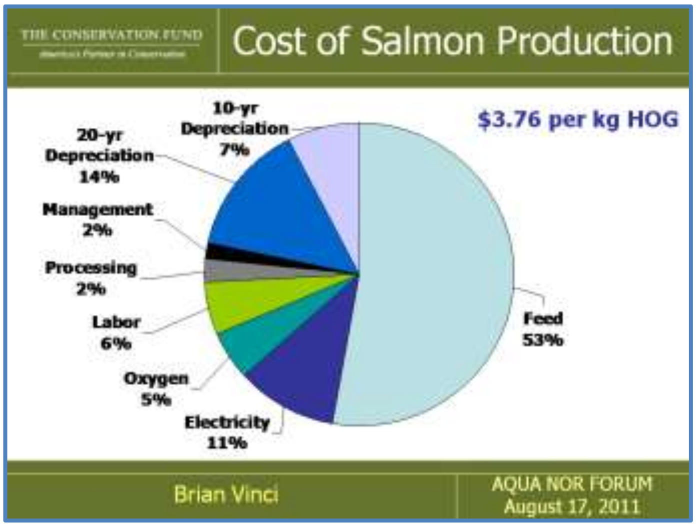
Technologies that eliminate escapees and minimize waste, while reclaiming resources in closed-containment systems was the subject of the final presentation in the session, and given by **Steven Summerfelt**, of the Conservation Fund Freshwater Institute.

Water recirculating systems have only minimal direct hydraulic connection with the environment, which means that environmental concerns, i.e., water pollution, disease transfer to or from wild stocks, and fish escapes, which are significant in other systems can be more readily controlled.

Two distinct waste streams may be produced in water recirculating systems: small, but concentrated, slurries of captured and backwashed biosolids and, in some cases, more dilute but relatively larger volume system overflows that can contain high (e.g., 30-100 mg/L) of nitrate nitrogen. However, the volume of overflow from water recirculating systems is on the order of 50-1000 times smaller than that discharged from flow-through fish culture system.

Dealing with these point sources of waste requires excluding escapees, plus capturing, transferring, storing, treating, or utilizing the concentrated waste biosolids and sometimes removing dissolved nutrients. Removing waste biosolids from all water flows as rapidly as possible is probably the best approach to minimizing release of phosphorus, ammonia, and organic matter to the environment. If advanced wastewater treatment is required, membrane biological reactor systems can be used to achieve very low concentrations of TSS and cBOD (both < 1 mg/L) and inorganic nitrogen (< 2 mg/L) to allow for subsequent reuse of this water and the alkalinity, salts, and heat that it contains.

In grow out tanks of $10 m^3$, Atlantic salmon grown in fresh water attained up to 4Kg in 24 months post-hatch at 13°c and at densities of up to 80 Kg m^{-3}. Their condition factor was 1.7 – better than average factors in net cages. Large scale projects (with investment of $50-100 million) in N. America are currently being planned or built for Atlantic salmon, coho, sea bream, yellow perch, sturgeon, Arctic char, walleye and sablefish and confidence in the technology is increasing.



SUMMARY OF THE DISCUSSION

Why do we need large scale recirculation systems?

Around 100 m^3 of water per kg fish produced is needed to circulate in a rearing tank. Increasing scarcity of good quality water sources and available space leads us to move towards recirculation systems that can allow an increase in intensiveness and a decrease in water use. Investment and operating cost per system size is also leading us to increase scale so that productivity in these systems is competitive.

Bacterial populations:

- It is useful to study functional groups rather than specific species of bacteria when looking for good management and design of RAS, as the specific species vary greatly among farms even if the effects of the microbial activities are similar.
- Demonstrating the positive shelter effect towards pathogens of a well controlled heterotrophic bacterial population has still to be researched.
- How does upscaling affect the microbiological effects of RAS (like shelter effect or buffering effect and stability)? Large scale may strengthen biological system stabilization, provided there is proper water mixing, but it may be difficult to obtain such mixing and avoid dead zones.

Substance accumulation

- Hormones accumulate but they are trapped by humic substances and degraded by denitrifying bacteria. Accumulation of steriods and other bioactive compounds may cause growth retardation in RAS, but no growth retardation was observed in large scale sea bass or salmon RAS. Growth inhibition in RAS may to a certain degree be a consequence of bad design and bad management. To design and operate a RAS well one need to combine engineers and biologists expertise together.
- Some possibly accumulating metals are trace elements useful for bacteria and fish.
- Nitrogen accumulation may be limited by the use of denitrifying filters using internal C source and /or Anamox processes. These may reduce the need for buffering the RAS.
- It is a challenge to keep perfectly mixed reactors (avoid unwanted bacteria) for large scale tanks and filters.

Waste treatment and valorization through algae / biofuel production

- Valorization of all the wastes through integrating RAS into IMTA should be considered. For example growing algae for biofuel using waste N, P and CO_2, reuse of the bacterial biomass… More research should be conducted on algae/biofuel/biomass/yield of growth. With proper systems, the waste containing nutrients (nitrate, phosphorus and calcium) may be concentrated quite well, however to use all the waste one need to produce large quantities of vegetables methane production, which may become economically feasible for large scale production.

- As well as the nutrient efficiency, the water efficiency will be increasingly important in the future. Efficient water utilisation (rearing and virtual in feed for instance) will be paramount in the water competition context.

Economy of the systems

- RAS may be ecologically and environmentally friendly, but the investment and maintenance costs are high. Can they be competitive in the market? High quality product, no sea lice and diseases reduced production time caused by temperature control are competitive advantages to net culture. The economic potential is currently validated in pilot scale systems, and the next two years are critical to show if large scale farms are working.

- There is a general understanding that in the future aquaculture will move in to directions: far offshore and onshore with closed systems. Maybe other RAS have to be investigated, like floating sea bags. There is not one ideal system but a large variety of systems to be adapted to fish demand (water quality), market demand, geographical and climate conditions, socio-economic characteristics of the location.

Conclusion

RAS will have to be included in a large variety of IMTA, in order to optimize the natural resources (feed, space, water…) mobilized in the production process.

Communicating the results of research to producers and convincing them to make the necessary technological investments remains a challenge, although more than 50% of the Atlantic salmon in the US is currently produced in RAS. This is species with a high end market and the production is being pulled by the consumers and NGOs, which helps convince the farmers to use RAS. The situation and premises may also change in the near future, and there may be no choice for certain farmers in Europe for example, that are forced by law to treat and pay for the effluents. Stricter legislation on this would push to more uptake of RAS technologies.

The economical models have not yet been evaluated. More validation of models is therefore needed to instil greater confidence to upscale the systems. This development will be triggered by "showcasing" existing efficient and profitable systems.

UPSCALING (MARINE) CAGE SYSTEMS

Session Moderator: Dr. Arne Fredheim.

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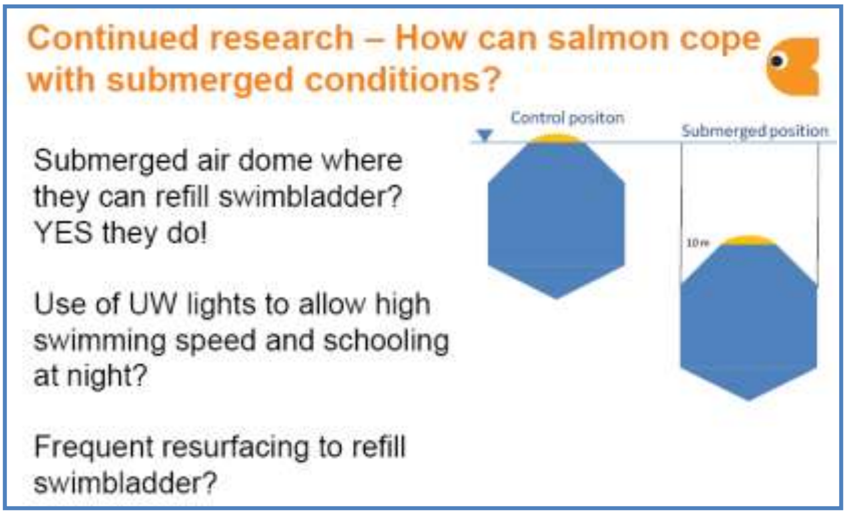
Whether coastal or offshore, the up-scaling of cage production systems relies on cage and equipment design, logistic and operational systems and control of the biomass. A standard net cage for farming of salmonids is at present 160m in circumference with a volume of more than 30 000m^3 and typically contains around 300 000 fish.

These advances have reduced the average biological feed conversion factor for salmonids from 3 to approximately 1.2 and the biomass production per employee has dramatically increased over the last decade. The increase in farm size and production capability is largely due to developments in technology, management practice and feed.

Tore Kristiansen, leader of the IMR Research Group Animal Welfare, opened the session with an overview of biological challenges and technological constraints when farming fish in large, exposed and/or submergible cages. A question now in Norway – and throughout Europe – is the future availability of good cage farm locations, given local/regional carrying capacity and especially coastal development. Moving further offshore has advantages and challenges and submersible cages are one possibility – as they avoid unsuitable surface conditions (waves, current, temperature), but also algae and jellyfish blooms, sea lice and parasites and (to a certain extent) biofouling.

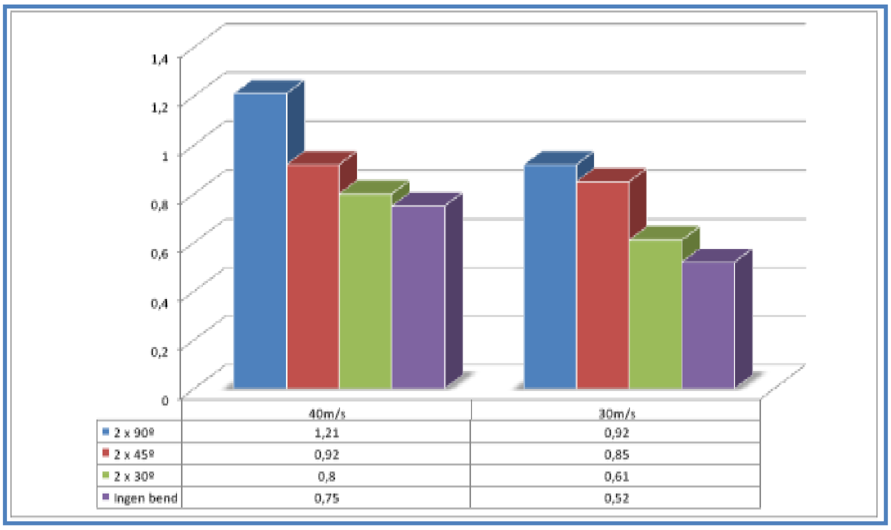


However, salmon (having an open swim bladder) need access to air!

Atlantic salmon can tolerate denial of surface access for more than two weeks without negative effects on performance, but long time submergence will have negative consequences for growth and welfare. A submerged air dome may help this.

Atlantic cod and other fish with closed swim bladder are vulnerable to sudden pressure changes, and submergible cages must be lifted to surface in a controllable manner. Lifting to 40% pressure reduction was safe and controllable for the fish. It is therefore of high importance that submergible cage technology must be tailored to the biological criteria set by the farmed species.

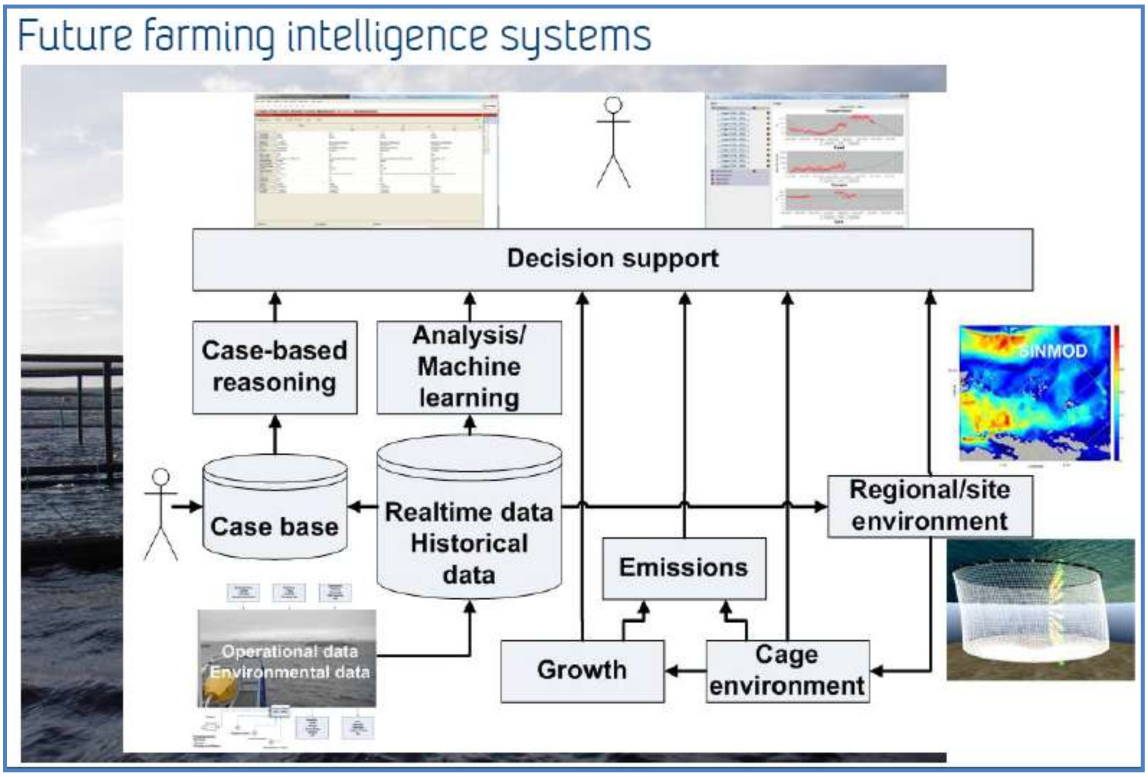
Ulrik Ulriksen is responsible for product development at Ocea AS and he addressed the available technologies to effectively deliver high volumes of feed pellets (up to 500 Kg fed per minute!) over large distances and a large surface area to improve consumption levels and reduce losses. Bulk deliveries of feed present new challenges with quality control and pellet breakage (up to 3% feed damage in delivery process). Understanding the fish behaviour is critical to determine the optimum feeding pattern and the choice of feeding method depends more on control routines and available technology than the fish biological precondition.



The use of braces to keep feed pipes straight and well organised is therefore of high importance, and increased volumes, variable feed quality and low transport speed can cause a build-up of 'fines' on the internal bends in pipes and eventually block them. Losses of feeds can vary from 0.3% to 13% when pipes have bends of 90°, 45° or 30° and feed delivery speeds of 40m/s or 30 m/s and this has very significant impact on feed (and hence production) cost.

It is important therefore to 'stay close' to the production and remote feeding is not the answer to best feed management.

The topic of "farming intelligence" - the control of the total process of farming by understanding the integrated use of equipment and the process of operations and combining this with knowledge of biological issues and the physical environment - was then presented by **Gunnar Senneset** of SINTEF Fisheries and Aquaculture.



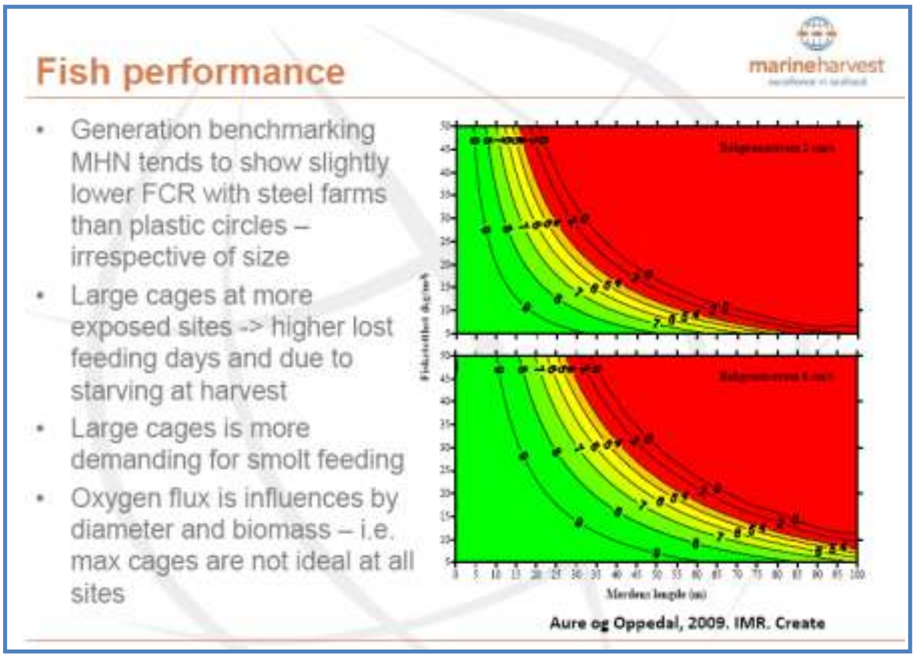
Better control and understanding will require developments in several areas, notably:

- Decision support systems for handling increased complexity, and
    - Integrating knowledge from a wide range of disciplines
    - Combining historical data with numerical models for prediction
    - Integrating data from multiple sources, including human experiences.
- Sensors for monitoring biology, environment, equipment and operations, that are low cost, reliable and with standardized interfaces for integration of multiple data sources.
- Failsafe/redundant systems for autonomous and remotely operated equipment.

The question is "What are the future functional requirements for farming intelligence?" and "Where are the knowledge gaps?"

Finally, **Cato Lyngøy**, group manager in Marine Harvest, attempted to answer the question “What is the ideal cage size?”or “Is bigger always better?” Not an easy one! The optimum size of a cage must be seen from the viewpoints of health and safety; environment, fish health and welfare, fish performance and industry change.

Bigger is not always s better as we have a very big population of fish in the cage that represents a major management challenge. For example, it may be more demanding to handle mass mortality, or sea lice treatment. Fish may not have equal access to feed and we may have less representation when taking samples. Cato also raised similar points to the other speakers, in terms of feeding (challenges in distribution to smolts, lost days) and oxygen flux in the cages.



Drivers towards change are production efficiency (including tonnes per concession and site, turnover, cost per kilo…), access to new sites that require new and stronger cages and restructuring into new production areas or zones.

So the ideal cage size is site-specific – and while producers and suppliers would prefer to use only one size, this sets limitations on the sites than can be used.

SUMMARY OF THE DISCUSSION

The discussion on session 2 did not so much address the question of upscaling *per se*, but more the advantages and limitations of farming fish in the big 160m cages currently used in Norway.

<u>The advantages:</u>

- We have the possibility to produce more fish in one cage and hence have to operate fewer cage units per site. The economy of scale.
- Fish may ‘suffer’ less, and losses from algal blooms may be reduced as the fish can move to deeper parts of the cage when necessary.

The limitations:

- Operating big cages may be seen as being similar to driving a car with only a small part of the windscreen being available to see clearly. We therefore need even better monitoring and management tools.
- We have no clear documentation to demonstrate a reduction in fish size variation at harvest, not of increase in quality in large cages.
- While legislation limits stocking densities to $25Kgm^{-3}$, we know that fish congregate at the best depth for them, so we also need to know more about the fishes' perception of their environment.
- Social perception of the farming activity is generally focused on sea lice and escapes, but these factors are not size-related.

As a final question, each of the panelists was asked to give his key constraint to increasing production of salmon in Norway.

Gunnar: Better integration of knowledge (and technology) from other sectors and notably from the offshore oil and gas sector.

Tore: Better monitoring data from production sites made available to researchers to allow them to progress on technological and environmental issues.

Ulrik: It took the sector 10 years to move from 70m to 160m cages and maybe the other equipment is struggling to keep up. Until the constraints of risk management, lice management and escapes are solved, cage size will not increase further and there may be a strong political argument not to increase. On risk management in large cages? Well, if a jumbo 747 jet goes down, there will be a single, large loss of life, but that does not mean that we should all be flying in small aircraft.

Cato: (In agreement with Ulrik). We know a lot more about the advantages and limitations of farming fish in these big 160m cages. Stocking of larger (1 Kg) smolts pre-grown in land-based containment systems and therefore decreasing the turnover time in the production cycle and mitigation of risk will allow us to overcome these limitations and reach the desired objective of a 5% increase in salmon production in Norway.

EAS GENERAL SPONSORS

Session Moderator: Dr. Max Troell.

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Aquaculture is at a crossroads and there are many critical aspects of its sustainability that needs to be addressed. Some challenges involve how to increase aquaculture's production capacity without exceeding ecosystems assimilative capacity and how resources should be utilized in more sustainable ways. This session addressed the use of and challenges for up-scaling of ecological approaches to aquaculture. The presentations covered various aspects of integrated farming systems and special focus was on integrated multi-trophic aquaculture systems (IMTA).

Thierry Chopin, Scientific Director of the Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN), and Professor of Marine Biology at the University of New Brunswick, kicked off the session with a rollercoaster ride through the progression of the Integrated Multi-Trophic Aquaculture (IMTA) concept and up-scaling of IMTA systems towards commercialisation.

To continue to grow, the aquaculture sector needs to develop more innovative, sustainable and profitable technologies and practices. IMTA has the potential to achieve these objectives and IMTA programs, in different states of development and configurations, are taking place in at least 40 countries.

To be able to scale up IMTA and increase its acceptance and adoption,

1) It will be important to understand that changes rarely happen overnight: it takes time, dedication, perseverance and an inter-disciplinary approach to progress along the R&D&C continuum;

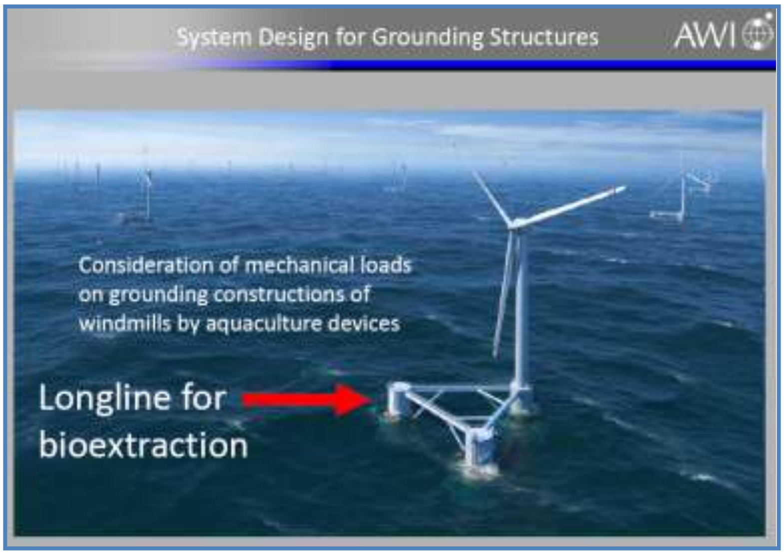
2) The current governance and regulatory structures pertaining to aquaculture will need to be revised to facilitate the development of IMTA practices and the commercialization of IMTA products;

3) The conversion of traditional monoculture sites into IMTA sites will also not occur overnight, but will be progressive, as the industry needs to develop markets to absorb the co-cultured biomass.

4) Evolving aquaculture practices will require a shift toward understanding the workings of resilient food production systems rather than focusing on monospecific technological solutions.

5) We should remember that there are more than fish in the oceans! Ocean cannot function with only fish, and aquaculture is not only fish aquaculture! Our seafood solutions cannot come from only this group of organisms;
6) The combinations of co-cultured species will have to be selected very carefully to be complementary and appropriate for the habitat, culture technologies and environmental conditions. They will have to provide efficient biomitigation and command an interesting added value. Their commercialization should not generate insurmountable regulatory hurdles;
7) A major rethinking will be needed regarding the definition of an “aquaculture farm” by reinterpreting the notion of site-lease areas and regarding how it works within an ecosystem and in the broader context of Integrated Coastal Zone Management (ICZM);
8) The value of the biomitigative services provided by the extractive components of IMTA systems will have to be recognized and accounted for (nutrient trading credits). They should represent financial incentive tools to encourage the practitioners of monospecific aquaculture to contemplate IMTA as a viable marine agronomy option to their current practices. Savings due to multi-trophic conversion of feed and energy otherwise lost, reduction of risks through crop diversification and increased aquaculture societal acceptability will also have to be considered.
9) The differentiation of IMTA products through traceability and eco-labelling will be key for their recognition and command of premium market prices;
10) Consumers’ perceptions and attitudes may have to change, particularly in the western world, regarding recycling and recapturing what is wastes for some and nutrients for others, which seems to be more readily accepted for agricultural than aquacultural practices. Biomitigative solutions, such as IMTA, should become an integral part of coastal regulatory and effluent management frameworks; and
11) Some visionary changes in political, societal and economic reasoning will have to take place to seek sustainability, long-term profitability and responsible management of coastal waters. Will humans soon be ready to face the concept of marine spatial planning (MPS) and the development of multipurpose integrated food and renewable energy parks (IFREP) and integrated sequential biorefineries (ISBR)?

Bela H. Buck, head of the Aquaculture Section of the Alfred Wegener Institute for Polar and Marine Research and the Institute for Marine Resources , then looked at the challenges and possibilities in upscaling IMTA in offshore environments, especially in offshore wind farms. Maximising the benefits that these offshore structures provide may be achieved by the expansion of current aquaculture production through novel offshore aquaculture approaches.



To address environmentalists and public concerns, offshore IMTA may be the key towards sustainable farming of aquatic products which would be acceptable in most European waters and in Germany, candidate species include blue mussels (*Mytilus edulis*) and the sugar kelp (*Saccharina latissima*).

However, there are challenges – notably in that the base structures of wind turbines have been engineered for that purpose and not to support aquaculture production systems. Furthermore, tides and currents may work in all directions, so that the IMTA productions are not lined up within the "nutrient cloud" as they would be in an inshore or fjord situation. A multi-use concept with other stakeholders in the offshore sector must employ a truly inter- and trans-disciplinary approach in order to make an enterprise possible and feasible. The concept of stakeholders involved in this area must, however, be critically reviewed.

On a different level, **Margareth Øverland** of the Aquaculture Protein Centre (APC), The Norwegian University of Life Sciences, presented ideas on the impact of conventional versus alternative diets in integrated aquaculture systems. Protein sources in fish feeds come under three main categories – plant, animal and microbial ingredients – and there are 'problems' with most of the alternatives. For example, feeding low-processed plant raw materials such as soybean meal leads to an increase in organic faecal waste. While bacterial meal produced from natural gas has a similar chemical content to fish meal, it results in reduced protein digestibility and increased nitrogen retention. However, highly processed plant ingredients have similar particulate and soluble nitrogen retention/loss and are therefore

more attractive. There is a similar tendency with regard to the fate of phosphorus.

There are several solutions to reduce the discharges from salmon production, and IMTA is certainly a very interesting and promising one.

While feeds based on alternatives will not differ in macronutrient composition, feed conversion ratio may increase, increasing solid and dissolved waste from plant based-diets. In contrast, single cell ingredients may increase solid waste and reduce dissolved waste improving feed conversion.

It is therefore highly important to match the multi-trophic species in IMTA systems to the output of the primary fed (fish) species.

To complete the panel presentations, **Geir Lasse Taranger** of the Institute of Marine Research (IMR), focussed on biological and technological methods to minimize risk of disease and parasite load from salmon farms to wild stocks.

Sea lice and viruses are major treats from salmon farms to wild fish stocks. Vaccination is the key to control disease transmission and outbreaks, and current work is exploring the genomes of sea lice and salmon for potential vaccines (and other therapeutics).

Sea lice can be combated by combining biological knowledge with new technological solutions, e.g. closed rearing systems with deep water inlet, submerged cages with “air lid”, or submerged lights and feeding that make the salmon swim at larger depths.

Cleaner fish (wrasses) are very effective, but they raise questions about fish welfare, overexploitation of wild stocks and potential disease transfer.

Finally, integrated multi-trophic aquaculture, e.g. use of blue mussels to counteract nitrogen outlets from salmon farms, may serve as vectors for disease transfer, but may potentially also filter out parasites such as sea lice. Details about the role of the mussels will have to come from large-scale IMTA systems.

SUMMARY OF THE DISCUSSION

The broad focus of the presentations was also reflected in the discussion. The first issue related to nutrient budgets for different feeds and it was argued that the large variability in such studies call for good replication. All sessions focused on open sea systems but research during the 1970s to 90s on land based integrated closed systems was also raised. These systems have benefits and also drawbacks, and the possibility to protect the culture environment against diseases was highlighted.

Studies on fish feeds containing seaweeds are still preliminary. It is not clear yet how much seaweed can be included and if fish growth would be affected at high substitution rates. When the total potential feed volume is considered, inclusion of just 5-10% of seaweeds would already imply a very significant production of biomass, as well as logistical and technical challenges to use that biomass to be addressed.

The utilisation of seaweeds for biogas and to some extend for biofuel was mentioned and there are large scale international research projects investigating the potential for this. The driving argument that seaweed cultivation does only need minimal land space for the initial seeding phase, but not for the grow-out phase and does not need irrigation and fertilizers (especially in an IMTA setting) is clear and advances are to be expected in the near future.

Major research needs identified for IMTA included the challenges for larger systems and how these will work in offshore environments. The economic performance - as well as the technical design of offshore IMTA systems - poses a special challenge. There are also open questions concerning liability, insurance and ownership. However, some research projects in the open ocean dealing with these subjects do have promising results.

More than 40 countries have ongoing IMTA research but small-scale systems dominate. Increased understanding about how hydrodynamics will affect growth and efficient distribution of nutrients will be key.

There are also regulatory challenges with these new systems of combined multi-species cultures.. For example, where bay area management is put in place, it is generally with a 2-year rotation for fish cultures in mind. However, how to manage species on a different rotation schedule, and what should the following periods be?

The incentives for farmers to adopt IMTA were discussed and without any direct benefits for the farmers it will be difficult to implement IMTA at a larger scale. Nutrient budgeting could allow for increased fish production in e.g. nutrient restricted areas if practicing IMTA. Also systems for nutrient trading credits could improve profits for farmers practicing IMTA.

The Norwegian situation was discussed and the possible limitation for mussel growth due to toxic algae. Also mussels in fish feed was mentioned which has proved successful.

To wrap up the session, the moderator asked each panel member for one key challenge to move IMTA forward....

> **Thierry:** The difficulty of conveying common sense solutions for the long term!
>
> **Margareth**: Feed (ingredient) resources will be limiting and there will be changes impacting the nutrients released from the fed species and available for the extractive species.
>
> **Bela**: Increasing demand of seafood means that more space for cultivations will be needed, and this will not be available near-shore. Offshore production based on IMTA and linked to offshore structures may be the only option for expansion.
>
> **Geir Lasse**: The key challenge will be the acceptance among relevant stakeholders to use the coast in this way for food production.

AQUA NOR FORUM 2011 ORGANISERS

EUROPEAN AQUACULTURE SOCIETY — WWW.EASONLINE.ORG

The EAS is an international non-profit association dedicated to the promotion of contacts and the exchange of information amongst all involved or interested in aquaculture at the European level, as well as beyond. Established in 1976, the society's primary activities include publication of a quarterly magazine, publication of a series of special publications, publication of an international scientific journal and participation in the development of sustainable aquaculture in Europe through various EU projects and initiatives. EAS has organised its annual Aquaculture Europe meetings since 1987.

THE NOR-FISHING FOUNDATION — WWW.NOR-FISHING.NO

The Nor-Fishing Foundation was established in 1992 by the Norwegian Ministry of Fisheries and was conferred the exclusive right to organise the international fisheries trade show Nor-Fishing and Aqua Nor. The exhibition centre is called Trondheim Spektrum and Trondheim Spektrum AS has been technical organiser for both Aqua Nor and Nor-Fishing since 1993.

SINTEF — WWW.SINTEF.NO

The SINTEF Group is the largest independent research organisation in Scandinavia. The abbreviation SINTEF means The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (NTH). SINTEF's goal is to contribute to wealth creation and to the sound and sustainable development of society. SINTEF generates new knowledge and solutions, based on research and development in technology, the natural sciences, medicine and the social sciences.

SINTEF Fisheries and Aquaculture Ltd perform basic and applied research for commercial customers as well as governmental institutions and bodies, the Norwegian Research Council, the European Union, the United Nations (FAO), and others.

CREATE — WWW.SINTEF.NO /PROJECTWEB/CREATE/

CREATE combines world-leading companies that supply equipment and technology with prominent scientific research institutions into a centre with a common focus to innovate technology, products and solutions specifically to improve the grow-out phase of marine fish culture. CREATE focuses research and development within the following three main research pillars and integrate knowledge between them:

- Equipment and constructions - the physical equipment used to farm fish.
- Operation and handling - the process of executing and carrying out operations necessary to farm fish.
- Farming intelligence - control of the total process of farming by understanding the integrated use of equipment and the process of operations and combining this with knowledge of biological issues and the physical environment.

SINTEF Fisheries and Aquaculture are the host institution for the centre. The centre was established spring 2007 and is sponsored by The Research Council of Norway with NOK 80 million over eight years.

WE LOOK FORWARD TO WELCOMING YOU AT FUTURE EAS EVENTS!

October 18-21, 2011

"Mediterranean Aquaculture 2020"

Rhodes, Greece

September 1-5, 2012

"Global Aquaculture: Securing our Future"

Prague, Czech Republic

(organized by EAS and WAS)

August 9-12, 2013 (just before Aqua Nor 2013)

Trondheim, Norway

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