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# AQUACULTURE EUROPE 2019

## *Summary Report*

BERLIN, GERMANY OCTOBER 7-10

# OUR FUTURE GROWING from WATER



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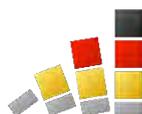


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**This document provides information on the AE2019 Plenary and Parallel Sessions, with a compilation of reports received by the session chairs. Sessions follow the order of the AE2019 Programme. Only simple editing has been made by the EAS secretariat.**

The winners of the AE2019 Poster Awards, as designated by the Session Chairs and Programme co-chairs, as well as the winners of the AquaTT and Aqualex Multimedia Consortium Lindsay Laird Award and the EAS Student Group Ibrahim Okumus Award are also presented.

*Compiled by the European Aquaculture Society secretariat. November 2019*

***Photos by Ana Viskovic and the EAS Student Group.***

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## CONTENTS

<b>Acknowledgments and AE2019 Organising Committees .....</b>	<b>3</b>
<b>Overview, Opening and Plenary Sessions.....</b>	<b>4</b>
The Inaugural Aquaculture Europe Student Spotlight Award .....	6
<b>Parallel session summaries.....</b>	<b>13</b>
Aquaponics & IMTA .....	13
Macroalgae .....	19
Climate Change.....	20
Nutrition: Physiology and Requirements .....	22
Reproduction and Broodstock management.....	25
Fish welfare.....	28
Fish Welfare – General contributed .....	30
Recirculating Aquaculture Systems (RAS).....	32
Microalgae .....	32
PERFORMFISH / MEDAID Forum - Sustainable Sea Bass and Sea Bream farming in the Mediterranean .....	35
EAS Student Group workshop.....	36
Nutrition: Animal Ingredients in Aquafeed.....	38
Food Quality and Safety.....	39
Sustainable Aquaculture Technologies.....	40
Precision Farming: AI and Big Data .....	41
Environment/Aquaculture Interactions.....	44
AE2019 Innovation Forum .....	46
Genomic Research, Tools and Applications .....	50
Value Addition and Marketing.....	51
Functional Aquafeeds .....	53
General Biology of Farmed Species .....	55
Sustainable Aquaculture 4.0: Nutrition and Breeding Innovations .....	57
Women in Aquaculture.....	59
Environmental and Ecosystem Management.....	62
Sustainable Systems for Large Scale Production .....	65
Baltic Aquaculture .....	66
Governance, Policy, Regulations and Strategic Planning.....	67
Escapes/Interaction of Farmed and Wild Fish .....	70
Selective Breeding .....	71
Mollusc Production and Restoration .....	73
Percid Fish.....	75
Aquaculture in Central and Eastern Europe .....	77
Pathogens, Diseases and Treatment .....	78
Cage Systems and Offshore Structures.....	81
Hatchery Technologies and Practices .....	82
Laboratory Aquatic Models and Ornamentals.....	83

EUROSHRIMP FORUM and Shrimp .....	84
Education, Knowledge Management, Transfer and Extension Networks .....	86
Compounds in Lipid Transport.....	87
<b>AE2019 Poster awards.....</b>	<b>88</b>
AE2019 Best Poster Award .....	89
AE2019 Best Student Poster Award.....	90
EAS Student Group Ibrahim Okumus Award .....	91
AE2019 Lindsay Laird Award.....	92
<b>Join us at AQUAculture Europe 2020 in Cork, Ireland .....</b>	<b>93</b>

## ACKNOWLEDGMENTS AND AE2019 ORGANISING COMMITTEES

The organisation of our Aquaculture Europe events would not be possible without the hard work and commitment of our organising committees, programme co-chairs and session chairs. We are especially grateful for all the time and energy that these volunteers provided to the meeting.

### **AE2019 Steering Committee**

Chair: Stefan Meyer (KNAQ, Germany)

Members: Gavin Burnell (EAS President Elect, Ireland), Henrice Jansen (WUR, Netherlands), Birgit Schmidt-Puckhaber (German Agriculture Society, Germany) and Bernhard Feneis (VDBA and FEAP Vice-President, Germany).

### **Programme Co-Chairs**

Carsten Schulz (Kiel University, Germany) and Tomáš Polícar (University of South Bohemia, Czech Republic).

### **Local Organising Committee**

Chair: Birgit Schmidt-Puckhaber (German Agriculture Society)

Members: Werner Kloas (IGB), Alexander Brinker (LAZBW), Helmut Wedekind (LfL), Peter Breckling (DFV), Christopher Naas (IFB Potsdam) and Fabian Schaffer (IGB).

**We are also extremely grateful to our fantastic team of student helpers!**



## OVERVIEW, OPENING AND PLENARY SESSIONS

*Organised by EAS and generously supported by AE2019 Gold Sponsor Biomar, Session Sponsor Sorgal, Industry Forum sponsor Rentenbank, as well as associate and media partners, AE2019 was held at the Estrel Hotel and Congress Center in Berlin, Germany.*

*AE2019 attracted a total participation of just over 2700 from an impressive 85 countries. Of the full conference delegates (more than 1400), 328 were students. The trade show presented products and services from 150 exhibitors. The abstract submission for AE2019 broke all EAS records, with 1039 abstracts received, resulting in 798 oral presentations (all sessions, including workshops and fora) and 443 poster presentations.*

*A new part of AE2019 was the use of Eposters – and 96 were presented in the sessions that were selected to pilot this presentation format. Also new in AE2019 was the Student Spotlight Award at the opening plenary session, as well as the AE2019 Innovation Forum and special sessions including “Women in Aquaculture.”*

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The event was opened with welcome addresses from AE2019 Steering Committee chair Stefan Meyer, EAS President Gavin Burnell and LOC chair Birgit Puckhaber.

The theme of the event was “**Our Future: Growing from Water**” and this was addressed by three plenary sessions that paved the way for the parallel sessions of oral and poster presentations. The AE2019 programme co-chairs Carsten Schulz (Kiel University, Germany) and Tomáš Polícar (University of South Bohemia, Czech Republic) orchestrated the session chairs that had very difficult choices in the selection of abstracts for their sessions, given their huge number.

### **The first day kicked off with a fascinating opening plenary presentation entitled “Aquaculture (finfish) and the Environment” given by Professor Charles R. Tyler of Exeter Biosciences at the University of Exeter, UK**

Fish are incredibly diverse and have adapted to live in almost every type of water on earth (in some cases even heavily polluted waters). The physiological diversity that has enabled them to do so is quite staggering. Equally aquatic environments, most notably freshwaters, are some of the most threatened globally due to high demands for freshwater, excessive pollution, overfishing and alterations due to changes in climate. While aquaculture is already a key economic contributor to many countries, fish pathogens are the number one factor in limiting yield and preventing further investment to grow the sector.

Fish are excellent barometers of aquatic ecosystem health and declines in both their diversity and abundance globally is a major cause for concern, not least because of their fundamental roles in ecosystem function and as a source for food for hundreds of millions of millions of people. Understanding the adaptive physiological mechanisms of fish is important as we seek ways to better protect our fisheries to ensure their sustainability and also for aquaculture as we look to develop efficiencies in production, preservation of genetic integrity and ensuring good animal welfare.

To illustrate his talk, Charles gave examples of initiatives to seek innovative ways for disease prevention in aquaculture [www.adaproject.org.uk](http://www.adaproject.org.uk) innovation in genetics and breeding, water quality management, sustainable aquaculture futures [www.exeter.ac.uk/saf](http://www.exeter.ac.uk/saf) and many others.

## So what will (environmental) success look like for future aquaculture?

Charles suggested that:

- Freshwater resources are used efficiently - reducing detrimental effects to the functioning and productivity of natural aquatic systems and balancing the benefits of freshwater supply for other human needs.
- We have reduced/avoided discharges of pathogens, toxic chemicals, antibiotics, excessive levels of nutrients etc., that may impact adversely on biodiversity and other natural capital resources.
- We are energy efficient with a low carbon cost relative to other food production systems (feed inputs and operational engineering).
- The spatial footprint of aquaculture has been minimised relative to its net benefits when assessed against other food production systems and considering its wider impacts including biodiversity, natural resource productivity (e.g. mangroves), areas of cultural and (inter)national heritage importance, or areas of outstanding natural beauty.



Seen through the lens of the **One Health** Approach, realising the growth need in aquaculture sustainability requires systems thinking and a highly integrated approach that cross diverse research sectors (science, social sciences, economics, policy). Sustainable aquaculture futures requires effective partnerships with governance and regulatory bodies and crosses diverse policy areas nationally and internationally.



# eas student SPOTLIGHT award 2019

All student abstracts submitted before the deadline were eligible for the award. Selection of the finalists was overseen by the EAS Board Member Kathrin Steinberg, EAS President Gavin Burnell and the AE2019 SC Chair Stefan Meyer. EAS Board members were given abstracts to assess and judge.

The winners of this selection procedure and taking part in the Spotlight Award 2019 finals were:

<p><b>Hanlin Xu</b> Universidad de Las Palmas de Gran Canaria</p>	<p><b>Renata Goncalves</b> DTU Denmark</p>	<p><b>Frank Thomas Mlingi</b> NTNU Norway</p>
		
<p>IMPROVED USE OF LOW FM AND LOW FO DIETS IN GILT HEAD SEABREAM (<i>Sparus aurata</i>) JUVENILES OBTAINED BY COMBINED BROODSTOCK SELECTION AND NUTRITIONAL PROGRAMING</p>	<p>NUTRITIONAL REQUIREMENTS OF EUROPEAN LOBSTER (<i>Homarus gammarus</i>, L.): EFFECT OF PROTEIN, LIPID, AND CARBOHYDRATE DIET CONTENT ON METABOLIC POSTPRANDIAL RESPONSE</p>	<p>GONAD DEVELOPMENT AND PLASMA LEVELS OF SEX STEROIDS IN FARMED LUMPFISH <i>Cyclopterus lumpus</i> UNDER DIFFERENT PHOTOPERIOD AND TEMPERATURE REGIMES</p>

The three finalists received a €300 cash contribution towards travel and subsistence costs to attend the event and a free registration. They were provided with guidelines to prepare their pitch. **Each presentation was just 3 minutes and in front of the biggest audience they had ever seen!**

**Deciding the winner was the task of AE2019 delegates in the plenary session.** 362 out of an estimated 750 in the room used menti.com to vote online and named Frank Thomas Mlingi as the winner of the first AE Student Spotlight Award. For his prize, Frank was awarded an additional €300 by EAS President Gavin Burnell.



The AE2019 Student Spotlight Award was deemed to be a great success. Finalists shown here with EAS Board Member Kathrin Steinberg (at right).

We will repeat it each year starting from Cork at AE2020.

The plenary session on day two addressed the most relevant topics from the tri-lateral constellation of aquaculture production, trade and consumption in Europe. Introduced by AE2019 SC Chair Stefan Meyer and facilitated by Alexander Wever, AWF Consulting, it included an overview of , presentation of short video clips representing typical consumer statements about aquaculture, and followed by a panel discussion with representatives from production and certification.

Alexander Wever set the stage with a presentation on concerns and standpoints of key players in the aquaculture value chain – and covering the global seafood market, the rising importance of aquaculture product and consumption patterns that should put aquaculture in a great place. But he went on to outline the challenges for aquaculture growth – not least regarding the positioning of our products for the consumer.



**Future will bring a lot of challenges for Aquaculture!**

- Competition for space: Wind Energy, Agriculture
- Competition for use of water: Drynesses, Agriculture
- Competition for use of feed raw materials: Human Nutrition
- Overcoming old & new prejudices: Antibiotics, animal welfare
- Changing nutrition behaviours: Vegetarians, Vegans, ...
- A lot of Bad Practice around the world
- .... And there is the „Market“ and the „Customer“

AWF Consulting © 8

The understanding of the value chain, product positioning and understanding buyer motivations were underlined here. He ended his introduction with the need to be able to influence our customers buying decisions, through appreciating and understanding their widely differing attitudes towards (farmed) fish. **This is the elephant in the room - the un-spoken challenges that inflict on the relationship between consumer, traders and producers.**

The next part of the session featured video clips of students from the University of Kiel expressing examples of these widely differing attitudes, through example of frequently occurring statements about farmed fish. These are shown in the table overleaf.

The final part of the session gave a voice to a Danish producer of trout and pikeperch, Aquapri, represented by Morten Holm and the Aquaculture Stewardship Council, represented by Barbara Janker. They each addressed the sentiments behind these attitudes, focusing on how they are addressing different consumer profiles, the need to document our production practices, the role of certification to bring up the level of best practice and to ensure that products ‘fit’ consumer expectations.

## AE2019 Plenary 2 CONSUMER STATEMENTS

"No, I am not buying products from aquaculture. This is not good food for me and my family. They are feeding the fish only antibiotics and it takes lots of wild fish to feed this aquaculture fish. NoNoNo!"

"Yes, we eat a lot of fish, and we enjoy only the highest quality! But this is why we would never buy fish from aquaculture. Seafood is expensive and a special meal. Therefore, we look only for the highest quality from wild fisheries."

"Luckily, both my husband and my children love to eat seafood. This makes it a lot easier for us as a family, to have a balanced diet containing fish and seafood. But we are also very concerned about what we buy! I understand that there are big differences in quality of the products and the way the fish are produced, how animal friendly and sustainable they are, and so on... I am not really sure what to look for, when I am buying. Sometimes when I am too uncertain, I buy a vegetarian alternative instead."

"I love fish! It's as simple as that. But it has to be a really sexy, wholesome experience for me! Super fresh, perfect colour and texture, exclusive flair. This is what I am looking for. And then together with a very expensive bottle of wine and some lovely atmosphere...anything can happen :-)"

"I don't really care where my seafood comes from, as long as it is cheap, tasty and readily available for me. If I can't find it, I would take chicken or pork for the same purpose"

"Of course we eat fish! But only from our fish farmer in the neighbourhood. It is a little bit of a tradition to make a short trip on the weekend to visit the farm, buy some fish and put it on the BBQ in the evening. Whenever we visit the farm, we can have a look at the fresh fish, get a couple of hints for cooking the fish and can always be sure to have a great meal!"



The take home message of this second plenary was that consumer expectations do indeed have a strong influence on the way we produce our fish and how we trade them. But it is a two-way-system, where the feedback from consumers to producers has an influence, but where "loudly voiced opinions" published in the media and sometimes without "scientific due-diligence" are indicators, but not necessarily drivers for our actions.

In trying to cover the multiple facets of “Life in Water”, and the challenges that we face, the final plenary was provided by Dr. Dina Dziuba, Aquaculture Reinsurance specialist at Hannover RE.

Dina gave an overview of aquaculture reinsurance and her take on a SWOT analysis of the sector. She especially focussed on climate events and their positive effects on the fish industry, but also negative effects on health, habitats and natural hazards.

### Aquaculture Reinsurance One of the Specialty Lines at Hannover Re

<ul style="list-style-type: none"> <li>• Profitability on producer level is generally very good</li> <li>• Long term necessity of fish as food resource</li> <li>• Growth of the aquaculture industry due to limited fishing potential</li> <li>• High technological level in some areas</li> <li>• Sustainable solutions</li> </ul>		<ul style="list-style-type: none"> <li>• (Non-)profitability on insurer/reinsurer level</li> <li>• Volatility of production and insurance results             <ul style="list-style-type: none"> <li>• No subsidies</li> <li>• Low technological level in some areas</li> <li>• Unsustainable production systems affecting the environment in some areas</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>• Need for increased production</li> <li>• Growth will bring further opportunities for insurers</li> <li>• Investments will bring opportunities for the industry</li> <li>• New technologies can be implemented</li> <li>• Subsidies would help the development</li> <li>• Cooperation of stakeholders could increase opportunities</li> </ul>		<ul style="list-style-type: none"> <li>• Climate Change</li> <li>• Increased loss activity, missing models</li> <li>• Restrictions due to environmental concerns</li> <li>• Large units increase accumulations</li> <li>• Selfinsurance/Competition/Innocent capacity</li> </ul>

5 Managing risks in a changing environment hannover re

### Climate Change and Aquaculture Effects of Climate Change on Fish Industry

<p><b>Positive Effects</b></p> <ul style="list-style-type: none"> <li>• Quicker growth</li> <li>• More efficient feed utilisation</li> <li>• longer breeding periods</li> <li>• Larger production areas due to reduction of sea ice</li> </ul>		<p><b>Negative Effects on Fish Health</b></p> <ul style="list-style-type: none"> <li>• Emerging diseases, disease spread ↑</li> <li>• Molluscs die due to acidification</li> <li>• Effect on fish physiology and potentially fish behaviour</li> <li>• Smaller fish size (Temp ↑ - solubility effect – O<sub>2</sub> ↓)</li> </ul>	
<p><b>Negative Effects on Natural Hazards</b></p> <ul style="list-style-type: none"> <li>• More heavy rains</li> <li>• More rain at one place during cyclones</li> <li>• More heavy storm surges</li> <li>• More/heavier inundations (influx of salt water)</li> <li>• More frequent HAB</li> </ul>		<p><b>Negative Effects on Habitats</b></p> <ul style="list-style-type: none"> <li>• Regional shift of wild fish</li> <li>• Loss of feed fish or higher fishing costs</li> <li>• Political conflicts over fishing grounds</li> <li>• Replacement of open farmed species</li> <li>• More death zones</li> </ul>	

11 Managing risks in a changing environment hannover re

One example she gave was the recent press headline that Denmark was to halt the development of aquaculture in the open sea, politically positioned so as to enhance aquacultures’ green credentials by reducing environmental impacts. This was followed by her views on the requirements for sustainable systems, types of technology and the need to nurture fish welfare in these systems.

Aquaculture therefore has a responsibility to adapt to changes in climate and to (continue to) develop technologies and systems to achieve this. But the big question is subsidies. A World Bank

2008 survey showed that 66% of surveyed countries provide crop insurance subsidies (across all development levels), 35% of surveyed countries provide livestock subsidies, but only very few countries provide significant aquaculture subsidies. Those that do include China, Mexico, Spain, Turkey and South Korea.

Without subsidies, she suggested that this could (only) be achieved by fostering alliances to increase resilience – through public/private partnerships, transfer health plans, early warning systems, lobbying and sustainable insurance programmes.

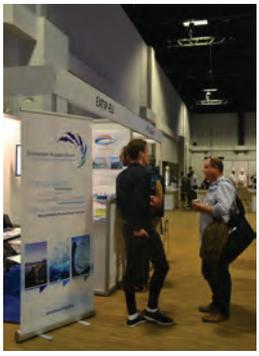


The AE2019 trade event was also extremely well attended, with a record 150 booths for exhibitors showing their latest products and services.

### **Many other special sessions complemented the AE2019 conference sessions.**

- Following our agreement made last year, **the 5th NordicRAS workshop** was held just prior to AE2019, with more than 350 attendees. Participants were therefore able to attend both events within the same week and the RAS sessions of AE2019 started from the 8th to avoid crossover and allow NordicRAS attendees to participate in AE2019.
- **The AE2019 Special Sessions** are targeted towards aquaculture producers and suppliers. They include sessions on marine litter, parasite management, nutrition and breeding innovations, shrimp production and aquaculture in Central and Eastern Europe. They also included the EU EATIP Day, addressing low trophic aquaculture.
- Another of these special sessions was entitled “**Women in Aquaculture.**” Organised by EAS and The Fish Site (on the back of its very successful series of the same name), this panel session will look at ways to ensure greater gender diversity at all levels of the aquaculture sector, with first-hand insights from an invited panel into how women can overcome perceived gender-related obstacles and build thriving careers right across the aquaculture sector.

**The huge number of abstracts submitted, the overwhelming attendance from so many countries and the number of requests for special sessions and project dissemination events once again confirmed the status of Aquaculture Europe as being THE European aquaculture event.**



## PARALLEL SESSION SUMMARIES

The following session reports were provided by the session chairs, with only minor editing made by the EAS secretariat. **They appear here in the order of the AE2019 Programme Book.** Unfortunately, one or two sessions are missing, with no report having been provided.

### AQUAPONICS & IMTA

**Chairs: Benz Kotzen (University of Greenwich, UK) and Hendrik Monsees (IGB Berlin, Germany).**

The 'Aquaponics and IMTA' sessions were combined and held across two days (morning of Tuesday October the 8th and the full day Wednesday 9th). The sessions were chaired by Benz Kotzen and Hendrik Monsees and there was significant interest in all the sessions indicated by good turnouts. The sessions were lively with a good feedback and interaction with the audience.

Both aquaponics and IMTA papers were delivered which seemed appropriate, but it was felt by the chairs that an additional session would have allowed for more papers to be accommodated.

#### Tuesday Session

The first talk was presented by Luca Grosso, on behalf of himself Alessandra Fianchini, Stefano Cataudella, Michele Scardi and Arnold Rakaj on INTEGRATED MULTITROPHIC AQUACULTURE WITH THE SEA URCHIN *Paracentrotus lividus* AND THE SEA CUCUMBER *Holothuria tubulosa*: AN INNOVATIVE MODEL OF SUSTAINABLE AQUACULTURE. The focus of the talk and discussion was on the sea urchin and sea cucumber and how these organisms could contribute to the future of aquaculture. The talk noted the negative aspects of marine aquaculture and the potentials for IMTA as a more balanced system. The advantages of the species was discussed and then the experimental research into the species was reviewed with a final elucidation on the benefits and costs.

The 2nd talk was delivered by Filipe Soares, on behalf of himself and Ana Nobre, Tomé Silva, Rui Pereira, Helena Abreu, Luísa Valente, Luís Conceição on NUTRIENT-BASED MODELS AS COMPLEMENTARY TOOLS TO ASSESS FINFISH AMMONIA EXCRETION AS THE PRIMARY NUTRIENT SOURCE IN A SEAWEED COMMERCIAL IMTA FARM. This talk focused on nutrient fluxes and the need for good estimates of these in order to provide better efficiencies and higher profit. The discussion focused on modelling approaches and results of simulation tests. The take home message was that 'nutrient-based models may be an alternative solution and/or complement to often-used approaches (i.e. pilot scale trials and simple calculations).

The 3rd talk was delivered by Frank Kane on behalf of himself and Joanne Casserly on IMTA AND SMARTER MONITORING FOR GREENER AQUACULTURE. This talk started with an expose of the motivation behind IMPAQT (which is a Horizon 2020 project with numerous partners) where the vision was where IMTA could be enhanced by new/emerging management technologies, enabling economically, environmentally and socially sustainable aquaculture development, generating enhanced public and investor confidence. Five objectives were discussed where the overall objective IMPAQT is to 'develop and validate in-situ a multi-purpose, multi-sensing and multi-functional management platform for sustainable IMTA production.'

The 4th talk was delivered by Marco Antonio Lorenzo, on behalf of himself and M.A. Poli, E.C. Legarda, I. Pinheiro, M.A. Martins, W.Q. Seiffer and F.N. Vieira on INTEGRATED MULTITROPHIC AQUACULTURE APPLIED TO SHRIMP REARING IN A BIOFLOC SYSTEM WITH TILAPIA AND SARCOCORNIA. The discussion started with biofloc and the benefits of biofloc in growing shrimp where 6400l of water are required to grow 1kg of shrimp and with biofloc this is 100l. The question was asked whether it is possible to use some of the concepts of IMTA to provide more sustainability to the biofloc system in light of some issues relating to solids in the water which are greater than 500mg/l. The tests undertaken with shrimp, tilapia and sarcocornia and the conclusions were 'yields in the IMTA system increased with the integration of *L. vannamei*, *S. ambigua* and *O. niloticus* species in a biofloc system up 21.5%' but 'the presence of Sarcocornia did not affect nitrogen and phosphorus recovery, despite reducing (23%) the amount of nitrate.'

The 5th talk was delivered by Philipp Sandmann on behalf of himself and Adrian A. Bischoff on the UTILIZATION OF AFRICAN CATFISH *Clarias gariepinus* SEDIMENTS FOR CULTIVATING THE POLYCHAETE *Hediste diversicolor* (O.F. MÜLLER, 1776) UNDER DIFFERENT TEMPERATURE REGIMES. This discussion focused on the investigation of the 'possibility and feasibility of intensive polychaete culture based on salmon aquaculture waste' where the research focus was on control life cycle of *Hediste diversicolor*, (ragworm) intensification culture beyond current practices and the assessment of the potential as a fish feed ingredient. The worm was discussed as was the experimental setup to test demonstrate the ability of the worm to incorporate freshwater aquaculture waste from *Clarias gariepinus*, to cultivate *Hediste diversicolor* under different temperature regimes and its survival rate and to investigate effects of temperature on the fatty acid profile. The conclusions were '*H. diversicolor* can grow between 12°C - 20°C feeding on *C. gariepinus* freshwater aquaculture waste. There is evidence that it grows better between 12°C-16°C and the proportion of 18:2ω6 fatty acid increases with decreasing temperature and the proportion of 14:0, 15:0 and 16:0 fatty acid decrease with rising temperature and older animals may contain a "better" suited fatty acid profile for fish feed.'

The 6th talk was delivered by Gösta Baganz on behalf of himself and Daniela Baganz, Georg Staaks, Hendrik Monsees and Werner Kloas on COMMERCIAL AQUAPONICS: TWO ECONOMIC SCENARIOS FOR A DOUBLE CIRCUIT SYSTEM. The talk commenced with a discussion on aquaponics and why it is not yet commercially successful and discussing an alternative to the conventional recirculation system which is a 'double recirculation system'. This discussion continued with an expose of the Waren operation north of Berlin growing African catfish (*Clarias gariepinus*) and tomatoes. The economics and two scenarios were considered. The conclusions were that aquaponics can be profitable if it exploits its potential, regardless of the high investment costs, that it needs to be considered as long term investment and that urban applications are feasible and some already exist.

The 7th and last talk of the morning was delivered by Vincent Gennotte on behalf of himself and A.A. Forchino, S.M. Takedo Tchuindjo, J. Leroy, P. Maesen, C. Mélard, C. Rougeot, R. Pastres and D. Brigolin on ENVIRONMENTAL AND ECONOMIC ASSESSMENT OF A PILOT AQUAPONIC PRODUCTION: A LIFE CYCLE APPROACH. This talk focused on a life cycle analysis (LCA) and life cycle cost (LCC) using an aquaponics experiment with 20m<sup>3</sup> of water, with lettuce and herbs and tilapia. The discussion focused on inputs and outputs, the conclusions being that energy was a significant component where energy consumption was responsible for 57-91% of environmental impacts and in life cycle costing the major inputs were energy, labour and infrastructure.

## Wednesday Session

Benz Kotzen presented 'WHEREFORE ART THOU AQUAPONICS – THE HERD OF ELEPHANTS IN THE ROOM': FUTURE AQUAPONICS IN EUROPE TOWARDS SURVIVAL GROWTH AND SUCCESS. This first paper of the Wednesday sessions, but the 8th talk overall discussed the issues of where aquaponics sits within the market, comparing aquaponics to hydroponics and also the issue of organic and other potential certification scenarios. The urgent need for a collaborative aquaponics organisation was discussed in order to promote collaborative aquaponics and aquaponics research

The 9th talk was delivered by Harry Palm on behalf of himself and U. Knaus, S. Appelbaum, G. Burnell and B. Kotzen on THE NEW DEFINITION OF AQUAPONICS: FUTURE PERSPECTIVES AND CONSTRAINTS. The discussion focused on the definition of aquaponics and why this definition is necessary aquaponics and the various types of aquaponics that fall within this definition. The Fish Glass House in Rostock was discussed including green algae polyculture with catfish. The focus turned to the challenges in aquaponics, including the 'lack of knowledge on nutrient and energy fluxes in traditional (trout, carp) commercial aquaculture systems, the role of microbes and micro-sediments, function of soil, peat and peat replacements such as "Biohumins" to increase plant quality. (and) how to cope with fluctuating nutrient loads'. The conclusions noted that many research questions still needed to be solved, e.g. role of microbes and micro-sediments, the issue of Brexit, too few aquaponics products on the markets with little customer exposure and tight competition with regular produce, a lack of societal understanding to value sustainable products and the issue of educating the next generation.

The 10th talk was delivered by Hendrik Monsees on behalf of himself and Johanna Suhl, Maurice Paul, Werner Kloas, Dennis Dannehl and Sven Wuertz on LETTUCE (*Lactuca sativa*, VARIETY SALANOVA) PRODUCTION IN DECOUPLED AQUAPONIC SYSTEMS. The discussion commenced with an introduction to the IGB (Leibniz Institute for Freshwater Ecology and Inland Fisheries) facilities and the design of their decoupled systems. Issues with aquaponics were noted and a number of hypothesis were raised including that 1) decoupled aquaponics can achieve comparable or higher yields as conventional hydroponic systems, 2) organic substances and/or RAS-derived microorganisms have beneficial effects on plants growth, and 3) aquaponics has a high potential to save CO<sub>2</sub> emissions. An experiment was designed and the results illustrated and explained with the conclusions that decoupled aquaponic can compete with conventional hydroponics, emissions are reduced (N of RAS), fertilizer is saved (i.e. CO<sub>2</sub> in hydroponics), water is saved (in hydroponics) and there were no effects on quality.

The 11th talk was delivered by Mathilde Eck, Iris Szekely, Sébastien Massart, and M. Haïssam Jijakli on the STUDY OF THE EVOLUTION OF MICROORGANISMS COMMUNITIES IN AN AQUAPONIC SYSTEM OVER THE COURSE OF A FULL LETTUCE GROWTH CYCLE. The actual title on the day was KINETIC ANALYSIS OF THE EVOLUTION OF THE MICROBIOTA OF AN AQUAPONIC SYSTEM. The discussion commenced with the question of 'what is the current state of the art concerning microorganisms in aquaponics?', with a discussion on the bacterial communities and microbiota, noting that each part of the aquaponic system had its own community and that microorganisms can have beneficial functions for aquaponic systems and plant care. 3 questions were raised: 1) How about the kinetics of the microorganism communities? 2) were they resilient to changes in the system? and 3) after the winter fallow period, how did the communities settle in the system? The discussion then explained the 6 week period experiment and the evolution of the communities in parallel with the water parameters and the microorganisms in each section of the aquaponics system. The conclusions were

that 'aquaponic microorganism communities are resilient to system changes, a drastic change in the communities was observed after a few weeks with the questions was there adaptation then stabilisation? Was the *Lactobacillus* and **Streptococcus** brought by plants and was this beneficial for fish.

The 12th talk was by Thomas Tomson on behalf of himself and M. Haïssam Jijakli on SAPRISTI, AN INNOVATIVE MODULAR TOOL IN THE IMPLEMENTATION OF A METHODOLOGY FOR THE RECOVERY OF FISH FARMING EFFLUENT BY AQUAPONICS. The talk commenced with a discussion on the consumption of water per kg of fish comparing flow through to various types of RAS and also the recovery of RAS effluents. The discussion moved to coupled and decoupled units and that it is not easy to choose between coupled and decoupled systems and the tool SAPRISTI was devised to do this. SAPRISTI is the French acronym of «Sustainable Aquaponics Pilot for Research and Innovation in Science and Transfer to Industry and this consists of 3 identical RAS systems to a greenhouse with hydroponic units. Tests were carried out with lettuce as coupled, decoupled or hydroponic over 4 weeks, sludge and mineralization were analysed. The conclusions were that the best combination for lettuce was decoupled aquaponics with deep water culture or NFT and the best combination for sludge mineralization was aerobic with a pH6 at 35°C for 15 days.

The 13th talk was delivered by Elena Mente on behalf of Nikos Vlahos, Ioannis Mitsopoulos, Kostas Babouklis, Emmanouil Kapetanios, Stavros Frangou, Anastasios Manolios, Kalliopi Giannoulatou, Eand irini Mardoglou on the DESIGN, AQUASCAPE AND CONDITIONING OF A BRACKISH AQUAPONICS SYSTEM. The talk commenced with an outline and objectives of the FoodOASIS project which were to 1) design and establish a new laboratory-scale and a pilot small-scale aquaponics system, 2) to develop the aquaponics software which will ensure the best system management and to 3) evaluate the aquaponics software and develop new protocols which are critical for a sustainable aquaponics production. The design of the system (6 sets) to be tested was explained with 2 salinity treatments 6 and 8ppt using sea bream and rock samphire. The conclusions were that the study advanced the knowledge that brackish water could be used as an alternative source of water and that it thus allowing for the reuse of water, reduction of waste disposal to the environment and minimization of marine pollution. Additionally, the study highlighted 'that the simultaneous production of seawater fish and plants (halophytes) with high nutritional and increased commercial value in brackish water aquaponic systems is feasible.'

The 14th talk was by Anton Rossbach on FRESH-WATER-PRODUCING SEAWATER-AQUAPONICS AS A SOLUTION FOR THE DROUGHT IN THE NORTHEAST OF BRAZIL. The discussion commenced with introducing the water demand in Fortaleza, Brazil which is unsustainable. The solution is to have an integrated system using the energy of the sun to produce fresh distilled water in greenhouses where water evaporated from fish tanks condenses and is used for the plants within a system of 'aeration, refrigeration, CO<sub>2</sub>-fertilization and desalinisation. Three different scenarios were costed and the business case revealed.

The 15th presentation was by Benoît Stalport on behalf of himself and, Pierre Raulier, Nicolas De Cock, Frédéric Lebeau and M. Haïssam Jijakli on the DEVELOPMENT OF AN INDIVIDUAL-BASED GENERIC AQUAPONIC MODEL USING OBJECT ORIENTED PROGRAMMING. The discussion commenced with the introduction of this Interreg project "Smart Aquaponics" and the development of smart tools for aquaponics with sensors in the aquaponics unit connected to the cloud and accessed by phone. Object Oriented Programming (OOP) by python was introduced and where all aspects of the system and environment can be inputs and can be monitored.

The 16th presentation was delivered by Pierre Raulier on behalf of himself and Benoît Stalport, Frederic Lebeau, Doriane Stagnol, Caroline Bini, Bart Leenknecht, Thomas Abeel, Sara Crappé, Nick Pannecouque, Germain Desmet, Christophe Hermans, Noémie Lardinois, Charlotte Boeckeaert, Herinaina Andriandroso, Jad Nassard, Bertrand Vandoorne, Vincent Lefevere, and Haissam Jijakli on SMART AQUAPONICS: DEVELOPMENT OF A TOOL FOR EDUCATION, DECISION SUPPORT AND MONITORING FOR AQUAPONICS. This talk also based on the Interreg project started by looking at various scenarios of aquaponics in education and industry noting that as aquaponics was new that there are few or no advanced teaching programmes and no specific tools. One of the ways of fostering aquaponics then was to use Smart Aquaponics an application that is being developed as a training programme, simulator and monitoring tool. Where with a game it is possible to develop a small system into a commercial system, design systems and have simulations of different scenarios that may occur and allows connection at all times with one's aquaponic system thereby anticipating accidents and failure.

The 17th presentation was delivered by Alexander Boedijn, on behalf of himself and Esteban Baeza, Rob Van den Ven, Carlos Espinal, Ragnheidur Thorarinsdottir and Maja Turnšek on MODELLING AND DIMENSIONING AQUAPONICS AS THERMAL TREATMENT NETWORKS THAT OPTIMIZE GEOTHERMAL ENERGY USE. This talk focused on geothermal heating of greenhouses and aquaponics. The question 'why geothermal' was asked and a map shown of where geothermal energy was available, but the issues of cost and all year round availability was raised. A diagram showing a geothermal aquaponic system was discussed. 'The geothermal well can supply heat to the aquaponic system in three ways: 1) to the greenhouse, 2) to the RAS facility or 3) to the RAS facility as a mixed flow with the residual heat from the greenhouse'. Geothermal performance and scenarios were discussed. The conclusions were that development of a 'model structure of a thermal treatment network enables assessment of geothermal energy use potential, geothermal aquaponic facilities face a trade-off between extracting additional heat and alternative heat use, simulated scenarios suggests aquaponics contributes positively to exploitation of a geothermal well and the RAS model must be validated'.

The 18th presentation was delivered by Simon Goddek on behalf of himself and Alyssa Joyce, Oliver Koerner, Karel Keesman on A FULLY INTEGRATED SIMULATION MODEL OF MULTI-LOOP AQUAPONICS: PUTTING THEORY INTO PRACTICE. This talk focused on decoupled multi-loops aquaponics systems that can take advantage of nutrient, water and energy cycling. Sizing of systems is important so that wastes from the RAS component can be utilized effectively within the hydroponic (HP) system, based on parameters such as plant growth rates, evapotranspiration and species-specific plant nutritional needs. However, in order to create the optimal fit, water and nutrient flows need always to be synchronised. The focus then turned to an aquaponics-sizing simulator based on deterministic mathematical models that are transferrable to various environmental conditions with simple parameterisation. Two independent model systems, for (1) the greenhouse, incorporating HP and climate control biofeedback and (2) the aquaculture facility was developed in the modelling and simulation environment MATLAB. The simulation allows for the sizing of the system and also allows for the determination of the required flows in between the respective sub-systems. The model provides a means to a better understanding with respect to water and nutrient dynamics in an aquaponics system. The simulation outputs also include yield predictions for both plants and fish, energy (thermal and electricity) and water requirements for the system, thus allowing for economic feasibility calculations.

The 19th presentation was delivered by Edson Panana on behalf of himself and B. Delaide, P. Bleyaert and S. Teerlinck on ORGANIC REDUCTION AND NUTRIENT RECOVERY PERFORMANCES OF PIKEPERCH *Sander lucioperca* SLUDGE AEROBIC DIGESTION AND LETTUCE GROWTH PERFORMANCE IN ITS EFFLUENTS. This discussion focused on recent findings about sludge treatment in aquaponics for organic reduction and nutrient mineralisation in anaerobic and aerobic reactors. There was an initial discussion on coupled and decoupled aquaponics, highlighting the benefits of decoupled systems with the potential for nutrient recovery by sludge digestion in a bioreactor. The mineralised elements can then be reintroduced into the hydroponic part to increase nutrient concentration with reductions in the discharge of nutrient to the environment. The potentials for nutrient recovery were shown and the experiment discussed. 'The results indicated that sludge digestion should be done in at least two steps. A first step in anaerobic reactor with pH of 6.5 to 7.5 for organic reduction, nitrogen mineralisation (and biogas production), and then a second step in aerobic and acidic conditions to treat the AN effluents while mineralising P and the rest of the nutrients.'

The 20th presentation was delivered by Ulrich Knaus on behalf of himself and H.-D. D. Hübner and H.W. Palm on AQUAPONICS (S.L.) PRODUCTION OF SPEARMINT *Mentha spicata* AND BASIL *Ocimum basilicum* WITH BIOHUMIN AND AFRICAN CATFISH *Clarias gariepinus*. The main question raised was whether in order to reach marketable quality of the herbs it was better to use fertilizer or alternative humus substrates. The discussion discussed the herbs and then introduced "Biohumín". The experiments were described and illustrated and data discussed. The conclusions noted that the best plant growth and SPAD values were found in control group with fertilizer solution (Universol Orange 16-5-25+3.4MgO+TE at 2000  $\mu\text{S cm}^{-1}$ ). However, the addition of '15% Biohumín increased performance of mint and basil, but mint and basil grew better with intensive effluents from the catfish production. Mint grown with intensive effluents from catfish production + 15% Biohumín can be used for commercial production in coupled aquaponics. 15% Biohumín in garden pots can achieve market plant quality of *Mentha spicata*. For basil 15% Biohumín seems too low and higher contents of alternative humus substrates should be tested in the future'.

The 21st presentation was delivered by Gilles Stouvenakers, on behalf of himself and Sébastien Massart, M. Haïssam Jijakli on AQUAPONIC WATER SUPPRESSIVENESS ON *Pythium aphanidermatum* ROOT ROT IN LETTUCE AND ITS ORIGIN. The presentation commenced with a discussion on the context of plant diseases in aquaponics and that no pesticides or biopesticides had been developed for aquaponics and biopesticides was an area that has yet to be exploited. It was noted that some research showed that some bacteria in aquaponic water could be acting as biocontrols. The discussion then focused on the experiment and forthcoming paper on whether aquaponic water is able to suppress plant diseases in in vivo conditions and what is the cause. *Pythium aphanidermatum* was used in the experiment using 6 six scenarios including hydroponic, aquaponic and comp with and without *Pythium aphanidermatum*. The conclusions were aquaponic water suppresses *Pythium aphanidermatum* in lettuce unlike hydroponic and COMP waters. The mineral content and pH modification of aquaponic water to obtain COMP water lead to a microbiota shift and a loss of suppressiveness. *P. aphanidermatum* inoculation leads to a microbiota diversity modification but not in the case of aquaponics water (and) the source of aquaponics water suppression could be link to biocontrol microorganisms.'

The penultimate and 22nd presentation was delivered by Sarah Milliken on behalf of herself and Benz Kotzen, Ranka Junge, Morris Villarroel and Tjasa Griessler Bulc on AQU@TEACH: INNOVATIVE EDUCATIONAL TOOLS TO PROMOTE LEARNING AMONG EUROPEAN STUDENTS USING AQUAPONICS.

This presentation focused on the Erasmus + project which is delivering an innovative e-learning course on aquaponics, which can then be used by universities to teach students undertaking aquaculture or similar programmes, aquaponics. The various methods of teaching and modules were discussed as were experiments that were undertaken by groups of students at 4 EU institution. Public release of the programme will be in March 2020.

The final and 23rd presentation was delivered by Luigi Petrocchi Jasinski on behalf of himself, G. Galliano and L. Rossi on TOWARDS SUSTAINABLE AWARENESS: IMPLEMENTATION OF AN AQUAPONIC CODE OF PRACTICE. The presentation focused on the need for a code of practice for aquaponics, discussing what aquaponics was and its position in the market and reaction by consumers. There were 3 main actions that are required; 1) Developing a code of practice, 2) Certification of some kind, and 3) promoting consumer awareness. The beneficial credentials of aquaponics are important here in terms of sustainability – these were discussed. Other issues discussed were animal welfare, traceability and food welfare. Finally, creating a relevant logo and consumer awareness based on benefits was discussed

## MACROALGAE

**Chair: Jorunn Skjermo (SINTEF Ocean, Norway).**

Macroalgae cultivation is photosynthesis driven aquaculture in the sea, as for kelp, or in land-based systems, as for green, red and smaller brown species. This is a non-fed and usually non-fertilized biomass production. Macroalgae production is basically centred in East-Asia, with > 99% of the global macroalgae production. Of this biomass 97% is cultivated. Europe has a small but important macroalgae industry based on wild harvesting of kelp and a few other species mainly in Norway and France, but the number of macroalgae farmers are rapidly increasing, especially in Norway, Portugal, Denmark and the British Islands. Most of the sea-based farmers cultivate brown algae (sugar kelp, winged kelp and finger kelp) whereas land-based farmers also cultivate green and red algae.

The applications of macroalgae biomass are in human food, feed, pharmaceuticals, materials and energy. An increasing number of research projects are focused on the development of products from cultivated macroalgae, especially focusing on biorefinery and profitable product combinations using the whole biomass, to increase the interest of the market for macroalgae (-based) products.

There are also a number of more cultivation technology-oriented projects going on now for the development of knowledge and tools for automated, upscaled cultivation necessary to make the industrial scale macroalgae farming in Europe less labour intensive and profitable. The opportunity for using services given for free by the environment/ecosystem, are much less when the production is done in more or less closed systems on land but the choice between land-based and sea-based cultivation depends mainly on the species, as some species depend on a substrate to attach to and to grow a large biomass, whereas other species can be cultivated free-floating in tanks or incubators.

Macroalgae needs nitrogen rich water for optimized growth and one cultivation strategy is to use ammonium rich effluents from fish farming as a fertilizer, either in salmon driven integrated

multitrophic aquaculture (IMTA) systems in the sea or in closed cultivation systems on land. These cultivation forms are shown to increase the biomass yield.

Land-based cultivation is possible and even necessary for a range of macroalgae species. One speaker presented the use of closed photobioreactors, originally built for microalgae cultures, for cultivation of both green and red macroalgal species of high commercial value. The investment and maintenance costs are high using these cultivation systems, but a main benefit is a very high degree of control of all the phases during the production and the possibilities for a tailored biomass production with high content of target components. Another speaker demonstrated how a land-based production system integrated with the water flow from a RAS could be used to increase the content of antioxidants in the algae biomass. In this case the antioxidants are important as the algal biomass is used for further processing into food packaging materials, where the antioxidants contribute in the shelf life of the food product.

As China is the biggest macroalgae producer, Europe has a lot to learn, both regarding what to do and how to do it, but also what we shouldn't do. The European macroalgae industry is very young and small compared to China but there are still many similarities. For instance, the Chinese are very innovative and want new, healthy products. For this they look for new applications for their biomass and the macroalgae-derived components. One such example is a more diverse use of alginate. As labour costs increase in China they also need automation and mechanisation and the seaweed industry has a close collaboration with researchers for developments along the value chain. Different from Europe is that there is a low focus on regulations, for instance regarding breeding and impact on the environment. Both Europe and China have challenges regarding access to sea area and may need to move the production more off-shore.

As long as there is no large-scale production, and at the same time also a requirement for significant initial investments, there is a need of relatively high sales prices of early production years. The food market, especially in the premium sections, has been identified as an enabler for this phase. But there is a strong need for products that may induce a larger macroalgae production in Europe and unlock the production potentials for these low-trophic biomass. Feed proteins and biofuels are demanded volume products, but so far the price on these products are far too low and the production costs too high for using macroalgae biomass as feedstock for such products. So in short, the macroalgae industry needs a bigger market.

## CLIMATE CHANGE

**Chairs: Myron Peck (University of Hamburg, Germany) and Orestis Starvrakidis-Zachou (HCMR, Greece).**

This session covered a variety of topics related to climate change ranging from laboratory experiments to bioeconomics and policy recommendations. In total, 14 oral and 8 poster presentations were made with several contributions from the EU CERES and ClimeFish projects. Another two scheduled presentations were cancelled and these open slots were used to re-open discussions of previous talks. Oral presentations were organized into four major thematic areas: i)

single-species and/or laboratory experiments, ii) risk assessment, iii) projections for shellfish, and iv) projections for finfish including bioeconomics).

The session was well attended with roughly 120 people participating in both the morning and afternoon sessions. The audience actively engaged by filling the time remaining after talks with questions. The high quality of the presentations and the strong participation by the audience in this session indicates that projecting climate change impacts is a highly active field of research within the aquaculture community.

### **Single species**

Two of the three presentations in this group focused on the effects of ocean acidification while another simulated the impacts of scenarios of climate change on production. In particular, Michelle Barbosa (Stony Brook University, USA) presented the results of laboratory experiments examining the effects of acidification and multiple stressors such as food availability and pathogen exposure on early life stages of the Eastern oyster *Crassostrea virginica*. Patricia Anacleto (IPMA, Portugal) reported on a laboratory experiment designed to test the combined effects of ocean warming and acidification on the energy budget of zebra seabream *Diplodus cervinus*. Finally, Irene Martins (University of Porto, Portugal) discussed how a simulation model was used to explore how future changes in temperature and salinity would impact the productivity of the commercial algae *Gracilaria* sp. These and other presentations underscore that climate change is projected to have adverse effects on specific species and that significant knowledge gaps remain on biological responses to climate drivers. Moreover, scientific interest has shifted from the traditional study of temperature as the sole driver of climate change to a more comprehensive examination of the combined effects of multiple drivers such as ocean acidification, changes in salinity, food deprivation and exposure to pathogens.

### **Risk assessment**

Assessing the risks and opportunities stemming from climate change is of paramount importance for informing policy on strategies to mitigate potential negative effects to the aquaculture sector. Three talks underscored this issue. Remigiusz Panicz (Faculty of Food Sciences and Fisheries, Poland) presented a pathogen and biomass risk assessment model for inland aquaculture under climate change. Myron Peck summarized the advances made to integrate physical, ecological, economic and social science within 13 aquaculture storylines in the EU CERES project. Next, Lena Schenke (AquaBioTech, Malta) discussed the specific challenges faced by the aquaculture sector on various European islands. Common elements of these presentations were i) a recognition of the importance of the participation of stakeholders in the identification of risks and opportunities, ii) that indirect (e.g. pathogen) and direct effects of climate change need to be studied simultaneously, and iii) the challenge posed by the inherent uncertainty in projections of biological and socioeconomic impacts of climate change.

### **Shellfish**

Shellfish aquaculture received a lot of interest with three additional shellfish topics being presented. Isabel Fuentes-Santos (CSIC, Spain) started by presenting projected impacts of climate change on mussel growth in the Galician Rias. Alhambra Cubillo (Longline Environment Ltd, UK) reported on how different, interlinked models were used to project climate change impacts across several shellfish species in different areas of Europe. Pierre Gernez (University of Nantes, France) focused on

the challenges of assessing climate impacts on offshore *Crassostrea gigas* aquaculture at a pan-European level. Key elements in the discussion included identifying sensible and useful indicators for adapting to climate change as well as finding ways of addressing the large uncertainty associated with physical climate model projections. Modelling tools were recognized as one of the best ways to assess both the direct and indirect effects of climate change on shellfish production and to explore potential adaptation measures under various socioeconomic scenarios. Presentations stressed the utility of these tools to developing robust science-based recommendations for policy.

### **Finfish projections**

The session was concluded with four presentations on projecting climate change impacts on finfish aquaculture. These includes talks by Gergo Gyalog (NAIK, Hungary) on Hungarian carp aquaculture and Orestis Stavrakidis-Zachou (HCMR, Greece) on Greek aquaculture production. Oivind Berg (Institute of Marine Research, Norway) presented the complexity of potential climate change impacts and mitigation measures for northern European aquaculture and Cornelia Kreiss (Thuenen Institute of Marine Fisheries, Germany) discussed the future profitability of typical finfish farms across northern and southern Europe. The effects of extreme weather events, particularly those of exceptionally high temperatures, on disease and parasite dynamics, escapee events and the overall profitability of the sector are an increasing concern. Several approaches to incorporate these effects into assessments were discussed. For some species and farm types, climate change was projected to increase profits while others species / farms appear particularly vulnerable. The need to adapt to climate change was highlighted and several mitigation strategies were presented including the importance (and challenges) of specific technological advancements.

## **NURITION: PHYSIOLOGY AND REQUIREMENTS**

### **Chair: Alessio Bonaldo (University of Bologna, Italy)**

The session was chaired by Alessio Bonaldo, with the assistance of Antony Philip and Anne-Catrin Adam. It comprised 16 oral presentations with presenters from 10 different countries and covering 7 finfish species, i.e. gilthead seabream, European sea bass, Atlantic salmon, rainbow trout, Nile tilapia, yellowtail kingfish and Bluefin tuna. The session was followed by a very large audience with more than 150 attendants throughout the day.

### **Feeding management and strategies (with a special focus on gilthead seabream and salmonids).**

In gilthead seabream a study aimed to evaluate the rhythmicity of some of the gastrointestinal tract factors that are related to digestive efficiency in gilthead seabream juveniles as well as to determine how these factors are affected by different feeding protocols. At the end of the study, a higher incidence of daily rhythmic patterns in the studied parameters and a higher expression of *slc15a1*, as a marker of protein absorption function, may suggest a better digestive efficiency in animals fed three or four times per day.

A second study on the same species was undertaken in order to assess the effects of different feeding frequencies on growth, feed digestibility, somatometric indexes, fish plasma biochemistry,

and digestive condition of fish fed different fishmeal and fish oil dietary levels with the final aim to provide guidelines designed for the daily management of feeding practices under farming conditions. Based on the results, frequent feeding does not support an increase in feed utilization during the on-growing of sea bream and this could be a useful indication to plan feeding activity at farm level which maximize growth and costs of feeding procedures.

Another study aimed to mitigate the impact of adverse water temperature during gilthead seabream juveniles' production through diet formulation. At the end of the experimental period key performance indicators, like growth and FCR were similar between the fish fed Control and the Low fishmeal diet. In addition, energy digestibility was higher for fish fed low fishmeal diet when compared to the other diets. This absence of significant differences in growth performance indicators implies a significant reduction of protein and fishmeal in juveniles' seabream diets.

The last study on gilthead sea bream explored the effect of high and low rearing density on growth, plasma biochemistry, gut microbiome structure, humoral immunity of skin mucus and digestive enzymes activity in gilthead sea bream fed low and high fishmeal and fish oil dietary level. At the light of this study, at both considered FM and FO dietary levels, fish can be reared at both 10 and 30kg/m<sup>3</sup> without compromising performance and health status.

In salmonids, a study on Atlantic salmon juveniles determined the effect of dietary lipid, LC-PUFA and dissolved oxygen on the growth performance, feed digestibility, nutrient retention, haematology, plasma biochemistry and steroid synthesis. In conclusion, these results indicate that LC-PUFA requirements for Atlantic salmon should be considered as proportional to total lipid in the diet and this demand can be influenced by hypoxia.

A study on rainbow trout aimed to determine the impact of early life history (exposure to hypoxia or normoxia) on FI, growth and oxygen consumption in later life, either at a high (i.e. high in starch) or low (i.e. high in fat) oxygen demanding diet. Results of this study show that fish exposed to hypoxia at early life, had an increased oxygen consumption and feed intake at later life. The impact of early life on oxygen consumption was dependent upon DOD, indicated by the interaction effect between oxygen history and diet for oxygen consumption.

### **Mineral nutrition and requirements.**

A study evaluated the effects of parental and direct feeding of dietary selenium in rainbow trout. The study showed a long-term parental effect in fry on the antioxidant metabolism, independent of the Se status, with a reduced activity of antioxidant enzymes, when originating from parental groups fed Se supplemented diets, in contrast to direct Se feeding.

In Atlantic salmon, a study investigated the impact of dietary zinc levels in low fish meal diets to Atlantic salmon parr in freshwater, smolt and post-smolt in seawater. Animals fed the basal diet, with lowest dietary Zn supply were able to cope without compromising on growth despite their whole body and vertebrae Zn status declining by 100%, compared to the fish fed highest dietary Zn level.

In European seabass, a study evaluated effects of metal-amino acid complexes (Availa®Zn, Availa®Fe, Availa®Mn, Availa®Cu, Availa®Se), supplemented at half the level of inorganic or in combination with inorganic minerals (sulphates of Zn, Fe, Mn and Cu, and Se in the form of selenite), on growth performance, gut and skin morphology, hepatic enzyme activity and zinc content in skin. Metal-

amino acid complexes supplemented at one-half the level of inorganic sources maintained growth performance of the animals. Performance results indicate metal-amino acid complexes are a more effective or bioavailable source of trace minerals than inorganic sources in European sea bass, as demonstrated previously in Atlantic salmon.

### **Lipid and fatty acid nutrition.**

A study evaluates different dietary ARA/EPA/DHA ratios on several oxidative stress indicators and microbial community of gilthead seabream juveniles. Overall results indicate that diets with high EPA and DHA levels slightly increased lipid peroxidation but seemed to promote a healthier gut microbiota.

In another presentation, two trials were performed on Pacific Bluefin tuna using inert formulated diets as juvenile feeds for weaned fish in order to establish adequate dietary levels of both lipid and omega-3 long-chain polyunsaturated fatty acids. The present study suggests that tuna juveniles can be grown on inert extruded dry feeds that result in good fish growth and accumulation of the health-promoting fatty acid DHA. Furthermore, a blend of vegetable oil and krill oil could be used as the dietary lipid source up to a dietary lipid level of 15% without affecting fish performance.

### **Vitamin and sulphur amino acid requirements**

A first presentation evaluated the effects of dietary vitamin B1, 9 and 12 supplementation in gilthead sea bream growth, productive parameters and health status when fed diets low in FM-FO. These preliminary results show that vitamin B1, B9 and B12 supplementation on gilthead sea bream fingerlings is not required to maintain growth during a 9 week period, if fed a practical diet based on plant ingredients. Another trial had the objective to quantify the dietary methionine requirement and sparing effect of cysteine in juvenile Yellowtail Kingfish. The decline of SGR past the optimum methionine intake, indicates a maximum methionine threshold, possibly induced through the build up of excess methionine derivatives via transamination or transsulphuration pathways. The results suggested the dietary specification of methionine, currently relied on in commercial aquafeeds for yellow king fish, may be inadequate.

### **Other topics.**

A first presentation in this last section aimed to characterize the functional properties and patterns of expression of some genes related to taste receptor in both larval and adult gilthead seabream tissues. The findings indicate an adaptive evolution of saT1R gene repertoire towards amino acid perception and provide a molecular/cell basis for both oral and gut chemoreception in seabream. Surprisingly, however, results in young larvae suggest only gut sensing capabilities.

In a second study, the authors quantified and qualified the effects of diets differing in the main type of non-protein energy source (starch vs. fat) on performance and total bile acid pool in rainbow trout. Diet did not affect growth, survival and feed intake, although, the fat diet resulted in a significant better FCR compared to the starch diet. Diet did have significant effects on body composition. Compared to the starch diet, feeding the fat diet significantly decreased protein content, and increase fat and energy content of the fish.

The last presentation evaluated the effect of faeces collection methods (decantation vs. mechanical filtration) and the dietary inclusion level of test ingredients (10 and 30%) on the energy, fat, protein

and amino acid digestibility of ingredients in Nile tilapia. Faeces collection method had little effect on the nutrient and energy ADC of the various ingredients tested. Changes on the dietary incorporation level of the ingredient had little effects on the protein and amino acid ADC of fishmeal, and meat and bone meal. However, incorporation level of the test ingredient (10 or 30%) showed significant effect on the ADC of protein and amino acids for soybean meal, rapeseed meal and cottonseed meal. The ADC values for protein and most amino acids tended to be lower for the 10% ingredient inclusion relative those obtained for 30% inclusion level.

## REPRODUCTION AND BROODSTOCK MANAGEMENT

**Chair: Constantinos C Mylonas (Hellenic Center for Marine Research, Greece).**

The session was well attended in the morning, with around 70 people. Unfortunately, we had two cancellations, one of which was the plenary-invited presentation by Professor Yonathan Zohar titled “From fertility to sterility of farmed fish-hormones and genes”. The cancellations created a “hole” in the program of 40 min, which was put in the beginning of the session. To keep the people in the room and reduce the disruption of the program, but also to reward the people that came to listen to the expectedly very interesting presentation of Professor Zohar, the chair prepared a presentation focusing on two subjects.

First, a brief description was made of the major results of the project DIVERSIFY (FP7, GA 603121), which was completed at the end of 2018. The project aimed to contribute to the expansion of the European aquaculture industry by diversifying its production with new/emerging species. The species selected in DIVERSIFY have important advantages over the ones cultured currently, such as fast growth and large size, or low requirement in fishmeal and oil. In addition, DIVERSIFY determined the drivers for market acceptance of the new food prototypes in order to position the EU aquaculture sector as a leader in aquatic food production. In the area of reproduction and broodstock management, the project had significant breakthroughs. Firstly, the reproductive biology of greater amberjack (*Seriola dumerili*) was studied in the wild and in captivity, and broodstock management methods have been developed for the Mediterranean region and Canary Islands. Hormonal spawning induction methods have been shown to be very effective in producing large numbers of eggs, and substantial numbers of juveniles have been produced and sent to commercial operations for cage rearing. Similarly, reproduction control methods have been developed for the flat head grey mullet (*Mugil cephalus*) and wreckfish (*Polyprion americanus*). The latter species is a congener of the New Zealand “hāpuku” (*Polyprion oxygeneios*), for which reproductive control has been achieved recently and F1 broodstocks have been developed, as presented later in the session. Finally, DIVERSIFY has developed methods for the paired spawning and artificial fertilization of meagre (*Argyrosomus regius*).

Secondly, Prof. Zohar’s presentation was made available to the conference, and the session chair presented the most important information regarding the use of novel molecular methods for the induction of sterility in a number of cultured fishes. The rationale for inducing sterility in cultured fishes includes (a) achievement of better somatic growth, through absence of reproductive maturation, (b) prevention of flesh quality deterioration and mortality (salmon), (c) prevention of

genetic pollution of wild populations from aquaculture escapees (sea cages) and (d) protection of IP rights of new strains produced by selective breeding. According to the work presented, the method developed prevents the migration of the primordial germ cells (PGCs) during early embryogenesis to the gonad anlage, thus preventing the proliferation of gamete cells and the development of a functional gonad. The method is based on the silencing of the “deadend” gene (*dnd*) and was shown to be 100% effective in producing sterility in zebrafish. Then, it was shown to be also effective in Atlantic salmon, trout and tilapia, and is currently being optimised for commercial application. **This method holds great promise for the development of non-GMO sterile fish and is certainly going to attract the interest of the marine, sea cage aquaculture industry (among others).**

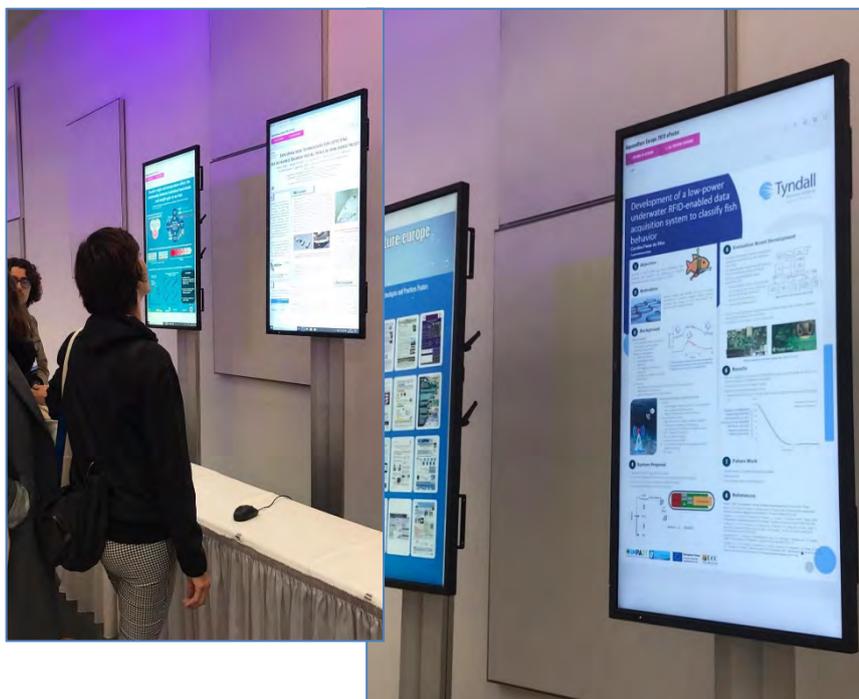
The Fish Reproduction and Broodstock Management session included presentations on the use of reproductive hormones for the induction of maturation, ovulation and spawning in greater amberjack, Senegalese sole (*Solea senegalensis*), burbot (*Lota lota*) and grey mullet (*Mugil cephalus*). In these species, gametogenesis proceeds normally in captivity (except in male sole that exhibit problems in spermatogenesis), but fish usually fail to undergo oocyte maturation, ovulation and spawning. Treatment with reproductive hormones, such as gonadotropin releasing hormone agonists (GnRH<sub>a</sub>), induces the endogenous release of pituitary luteinizing hormone (LH), which in turn stimulates the necessary production of sex steroids, that are the final effectors of gamete maturation, resulting in ovulation and spermiation. Also, in this session, work was presented on the development or optimization of artificial insemination methods, cryopreservation of sperm, and evaluation of sperm quality.

Another group of presentations dealt with the artificial induction of gametogenesis in the European eel (*Anguilla anguilla*). In this species, a severe dysfunction occurs in captivity, with both males and females failing to undergo gametogenesis, due to inhibition of pituitary gonadotropin production. As a result, all efforts at the domestication of this species involve first the use of gonadotropin preparations (follicle stimulating hormone, FSH and LH) given in the form of weekly injections for a period of 3-5 months. The treatments used include carp pituitary extract (CPE), salmon pituitary extract (SPE) or recombinant FSH (recFSH, and sometimes also recLH) of piscine origin (including from European eel). More recently, androgens have been also used in the gametogenesis induction period, usually treating the fish before the use of gonadotropins. Once gametogenesis is completed, males undergo spermiation with the same treatment, whereas females may be treated with an additional treatment of gonadotropins or with the maturation inducing steroid 17 $\alpha$ ,20 $\beta$ -dihydroxy-4-pregnen-3-one (DHP) in order to undergo oocyte maturation and ovulation. Once ovulated, fertilization is done artificially by stripping the gametes from both sexes. Based on the work presented, the effectiveness of the gametogenesis induction protocol depends both on the doses, but also on the sources of the FSH/LH. One study showed that SPE is more effective than CPE, while another one showed that recFSH from European eel was equally effective as CPE for the induction of oogenesis.

Apparently, the development of hormonal protocols for the induction of spermatogenesis/oogenesis and then ovulation in European eel is still the subject of significant research investment. Although great progress has been achieved during the last decade, with the number of spawns and resulting larvae increasing greatly, a final working protocol that will result in relatively rapid gametogenesis and ovulation of high-quality eggs, is very much still the target for the efforts at the domestication of this unique fish. It is clear also for a number of other cultured species, especially emerging or new ones, that hormonal manipulations for the control of reproductive function –mainly induction of

oocyte maturation, ovulation and spawning, and the enhancement of sperm production- are in great need by the aquaculture industry.

Other aspects presented in this special session included the use of non-invasive methods for the identification of sex and sexual maturation using ultrasound technology, specifically for Atlantic salmon and lumpfish (*Cyclopterus lumpus*). Currently, invasive and semi-invasive methods are available for salmonids (direct gonad inspection through incision, endoscopy, blood sampling) and other fishes (direct gonadal biopsy in the females), but these methods come with increased risk of handling stress, infection and mortality.



*Attendees viewing Ep posters – presented in several sessions for the first time at AE2019.*

The main objective of the continuing efforts in many species to use ultrasound technology for monitoring sex and sexual maturation, is the establishment of relatively rapid, non-invasive methods in order to reduce stress and improve animal welfare in broodstock management of aquaculture populations. Ultrasound may be used effectively and reliably in females, but in males there are still problems related to the structure of the gonad. This is a common theme in many species, and points to the need for still further work before this technology can substitute the common use of gonadal biopsies and sacrifice of the fish to measure gonadosomatic index (GSI) and run histological analyses of the gonads.

In the area of new technologies for monitoring reproductive maturation, there was also a study on the development of high throughput techniques to evaluate barramundi sperm quality using Computer Assisted Sperm Analysis (CASA). This method offers significant advantages in the evaluation of sperm quality compared to the manual evaluation methods. These go beyond the speed and ease of the CASA methods, and include higher reliability, reproducibility and objectivity, and remove technician bias. In addition, CASA methods provide a suite of more information regarding sperm movement and morphology, that are not possible for the traditional method. It is clear that more and more researchers are adopting CASA, having decided that the initial investment cost for the purchase of the equipment and software (25-35,000 euro) is definitely worth it. However, the method is currently rather rare in the industry, with the exception perhaps of larger companies involved in breeding selection programs.

The session also included a presentation on the reproductive development of some interesting invertebrates. The *Holothuria tubulosa* is one of the sea cucumber species that are consumed by many Asian cultures, and in recent years they have gained increasing interest as a cultured species in the Mediterranean, in particular as a species in Integrated Multi-Trophic Aquaculture (IMTA) efforts, and as a species that can take advantage of the organic wastes of sea cage aquaculture. On the other hand, polychaetes are currently being investigated as potential raw material for fish feeds, especially for maturation diets for shrimp and fish, due to their high content of essential fatty acids.

## FISH WELFARE

**Chair: Michail Pavlidis (University of Crete, Greece).**

In this session, sixteen presentations were given covering a broad range of topics, including the development and evaluation of stress and operational welfare indicators and the development/application of new technologies to monitor fish behaviour, activity and performance.

### **Development of reliable stress and welfare indicators**

Xavier Gutiérrez, from the Norwegian Institute for Water Research in Chile, presented a modelling approach to evaluate the relationship between smolt salmon physiological status and production systems, towards the development of innovative predictive tools that can enhance Atlantic salmon farming. Sonia Rey on behalf of Maureen Ellis, from the University of Stirling (UK), presented first data for the validity of a Qualitative Behavioural Assessment (QBA) method, for assessing the subjective experience of fish and their welfare status. Results demonstrated that even non-experienced observers show good agreement when scoring fish using QBA, being able to consistently observe differences between tense and calm fish.

Mark Schumann, from the Institute of Inland Fisheries (Potsdam-Sacrow, Germany), presented the development of a “Welfare Index Model” for rainbow trout reared in RAS or flow-through systems, and Lina Weirup, from the Gesellschaft für Marine Aquakultur mbH (Germany), the development of a welfare evaluation system for rainbow trout reared in flow through systems, based on several Operational (OWIs) and Laboratory Welfare Indicators (LABWIs). Carolina Gutierrez, from Swansea University (UK), communicated the development and validation of a “Welfare Scoring Index”, for lumpfish (*Cyclopterus lumpus* L.), based on visual scores of fin damage, eye darkening and suction disc deformities.

Linda Tschirren, from the Zurich University of Applied Sciences (Switzerland), investigated the expression levels of several genes in different brain parts of juvenile carps experiencing either a positive, a negative or no stressor, towards a better understanding of the primary stress response in fish. Lluís Tort, from the Universitat Autònoma de Barcelona (Spain), presented recent data on the development of novel and reliable indicators of prolonged, chronic stress in fish. Results, demonstrated that cortisol content in scales was strongly correlated with plasma cortisol concentrations, indicating that scales cortisol may provide a retrospective measure of the past stress experience in fish.

## **Feed ingredients and the stress response**

Alexander Jaramillo-Torres, from the University of Life Science (Oslo, Norway), communicated the identification and usage of quantifiable microbiota-related markers as indicators of gut health and intestinal function in Atlantic salmon, towards the development of functional feeds. Jessica Petereit, from the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research (Germany), investigated the effect of stress and alternative feed formulation on growth characteristics, feed utilization and stress response in juvenile turbot, showing that stressed fish, feeds less and show a depressed length increment compared to the non-stressed individuals. Francisco Guardiola, from the University of Murcia (Spain), presented the role of  $\beta$ -glucans on Pacific red snapper's (*Lutjanus peru*) skin mucosal immunity, following exposure to *Aeromonas hydrophila*. Data showed that the activity of several humoral-related enzymes (e.g. proteases, nitric oxide, SOD) and lysozyme were affected by  $\beta$ -glucans diets, boosting the innate immune response and enhancing resistance against *A. hydrophila*.

## **New technologies to monitor fish behaviour, activity and performance.**

Jian Zhao, from the Zhejiang University (China), proposed a new methodology to detect, localize and recognize unusual behaviours of farmed tilapias (*Oreochromis niloticus*). The methodology is based on Graph Networks and Recurrent Neural Networks (RNN) and may provide a successful alternative of computer vision based-tracking, for on-site monitoring of fish behaviour and assessment of fish welfare without tracking and foreground segmentation.

Jaume Pérez-Sánchez, from the Consejo Superior de Investigaciones Científicas (Spain), presented the development and validation of a miniaturized device for recording and processing acceleration data and operculum movements (i.e. respiratory frequency), in individual gilthead seabream and European sea bass. The device provides a reliable methodology for remote and individual sensing of fish behaviour and metabolic status with applications from fish phenotyping to selection breeding. Jeroen Brijs, from the Swedish University of Agricultural Sciences (Sweden), investigated whether in vivo monitoring of heart rate and gut blood flow in freely swimming farmed rainbow trout could be used as a reliable stress and welfare indicator in common aquaculture practices, including harvest.

Raminta Kazlauskaitė, from the University of Glasgow (UK), presented a novel experimental set-up to evaluate the efficiency of plant-based diets on farmed fish growth. For this, a synthetic, continuous salmon gut microbial fermentation system, called "SalmoSim", was developed. The system simulates salmon gut compartments representing generalized marine lifecycle stages and, when fully developed, may provide a platform with a broad range of applications from the study of microbial population dynamics to the characterization of links between the gut microbiota and digestion.

## **Methods to assess consciousness in fish**

Albin Gräns, from the Swedish University of Agricultural Sciences (Sweden), presented a newly developed non-invasive technique allowing measurements of brain activity by electroencephalography (EEG) in rainbow trout. It was shown that electrodes attached to the head of the fish, by the use of a silicone cup, can sufficiently determine brain activity. This method can be used to evaluate different stunning methods used in fish farming. Luis André Barbas, from the Instituto Federal de Educação Ciência e Tecnologia do Pará (Brazil), evaluated the effect of eugenol, a commonly used and commercially available plant extract for anaesthesia of fish, on the central nervous system of tambaqui, *Collossoma macropomum*. The application of electroencephalographic

(EEG) recordings revealed that, during exposure to eugenol, although complete body immobilisation was achieved, fish presented an intense neuronal excitability, which was consistent with a seizure-like event.

Overall, the session was a real success and the broad content of contributions allowed a diverse range of topics to be presented and species to be covered. The presence of more than 80 people attending highlighted the interest on fish welfare and provided a valuable interaction.

## FISH WELFARE – GENERAL CONTRIBUTED

### **Chair: Lina Weirup (Gesellschaft für Marine Aquakultur mbH, Germany)**

Science, industry and the general public have developed an increased interest in animal welfare topics. This year's Aquaculture Europe has acknowledged this development and provided a full day session on "Fish Welfare" and a morning session on "General Contributed Fish Welfare", making it the most complex contribution to welfare issues at any EAS Conference so far.

The "General Contributed Fish Welfare" session included seven presentations from seven different countries; Germany, Switzerland, Faroe Islands, Portugal, UK, Spain and Sweden. The topics, as well as the species of study were diverse. From the seven different study-species represented, four belonged to the family of Salmonidae, two to the family of *Cyprinidae* and one to the *Sparidae* family. Topics covered the effects of stress on the immune system and appetite, the effects of environmental conditions on behavioural coping mechanisms, the state of nutrition and health, as well as research into stunning methods.

Preventing fish from especially chronic stress is one of the main tasks in aquaculture concerning fish welfare, as well as fish production in terms of health, feed intake and successful growth. The pathways behind the properties and effects of stress are still under investigation and are of great importance, not only for long established aquaculture species, but also for newcomer species to verify their suitability for intensive aquaculture. Joan Martorell-Ribera therefore evaluates the effects of stress on the immune system of the newcomer species *Coregonus maraena*, by defining reliable markers for stress-induced immune modulation. That stress also affects feed intake is well known, but it is not identified in detail how different stressors affect this essential process. Constanze Pietsch was able to demonstrate the effect of different stressors, by looking at the appetite gene regulation in the brain of *Cyprinus carpio*.

Behavioural observations are an important tool in assessing stressors and welfare, e.g. detecting poor environmental conditions for fish. Asa Johannesen studied the effects of sea-waves on the vertical distribution and behavioural coping mechanisms of *Salmo salar* held in net cages at exposed locations. While *S. salar* are well equipped to cope with both currents and waves, the nature of salmon cages can compromise their ability to cope in poor conditions. These findings need to be considered and further looked at, when it comes to choosing exposed locations for aquaculture.

In order to maintain fish welfare, a sufficient amount and a balanced composition of nutrients are essential. Welfare deficiencies caused by insufficient accessibility of nutrients were discussed by

Susana Ferreira for the case of *Garra rufa* used in ichthyotherapy. To stimulate fish to feed on dead skin, fish keepers are at times suspected of starving them, leading to delayed growth and possible death. Ferreira found that with a good quality commercial feed and a certain daily dose a compromise can be achieved between *G. rufa* purposefully interacting with humans and receiving its nutritional requirements. Investigating the impacts and potential causes of failed fish or runt syndrome in *Oncorhynchus mykiss* pre and post seawater transfer, Josip Barisic found a poor nutritional status, as well as osmoregulatory dysfunctions to play a role. Investigating genetic aspects of this syndrome and a better bloodstock selection are suggested to improve sea trout aquaculture. To advance welfare and nutrition in aquaculture, there is also a growing interest in the manipulation of fish gut microbiota, as it is a key to digestion, nutrient metabolism and absorption, disease resistance and immune function. Aware of how the intestinal microbiota varies with many factors, and the long road ahead to establish baseline parameters to guide these manipulations, Carla Piazzon took a look at the intestinal microbiota of adult *Sparus aurata*, a protandrous hermaphrodite fish.

A main topic in welfare discussions are the methods for stunning and slaughtering fish. Stunning with CO<sub>2</sub> is criticized because of undesired adverse behavioural effects, long stunning times to reach unconsciousness, and possible immobilization of fish while still being conscious. Therefore, alternatively electrical stunning is widely being used. Erik Sandblom however points out the potential risk of electro-immobilizing fish without reaching loss of consciousness. Thus, the relationship and timing of ventilatory failure and loss of consciousness following electrical stunning needs further studies, combining measurements of cardiac and brain electrical activities.

During all talks the “General Contributed Fish Welfare” session was well attended with great interest from the audience leading to numerous questions and a lively discussion. The topics presented reflect the complexity of fish welfare. The session’s findings help to understand and positively influence those facets of aquaculture that will aid to provide higher welfare standards for fish, as well as a more sustainable and efficient production for farmers.



*The EAS stand at AE2019*

## RECIRCULATING AQUACULTURE SYSTEMS (RAS)

**Chairs: Astrid Buran Holan (ScaleAQ, Norway) and Carlos O. Letelier-Gordo (DTU Aqua, Denmark).**

This session covered research topics that concern how different water sources and treatment strategies affect the microbial community dynamics and final performance of RAS, including H<sub>2</sub>S formation, disinfection and advances in waste management processes. Many of the studies presented new results and were very interesting, judged by the response and questions from the audience.

The session emphasised that a key challenge in RAS is the accumulation of particulate organic matter. Accumulation of particulate organic matter has several effects in RAS, such as reduced nitrification efficiency in the bioreactor, clogging of the CO<sub>2</sub> degasser leading to reduced stripping efficiency, biofilm growth and increased risk of H<sub>2</sub>S formation, unstable microbial dynamics and bacterial blooms. **Identifying solutions to reduce the particulate organic matter in RAS is therefore of up-most importance and crucial for the farmer to reach the aimed production and have a long-lasting facility performing at its optimum for years.**

The session also touched into the topic of disinfection in RAS. There is however a need for more research on how to disinfect such a production system, and if this should be done on a regular basis, e.g. between batches as to reduce the risk of producing potential pathogens.

The session indicated a knowledge gap in technological commercial applicability, as several studies were evaluated in small experimental systems at low rearing densities. To be relevant for the industry, more research could benefit from having a more applied focus, where the experiments should be performed in semi-commercial farms or have up-scaling strategies as part of the study.

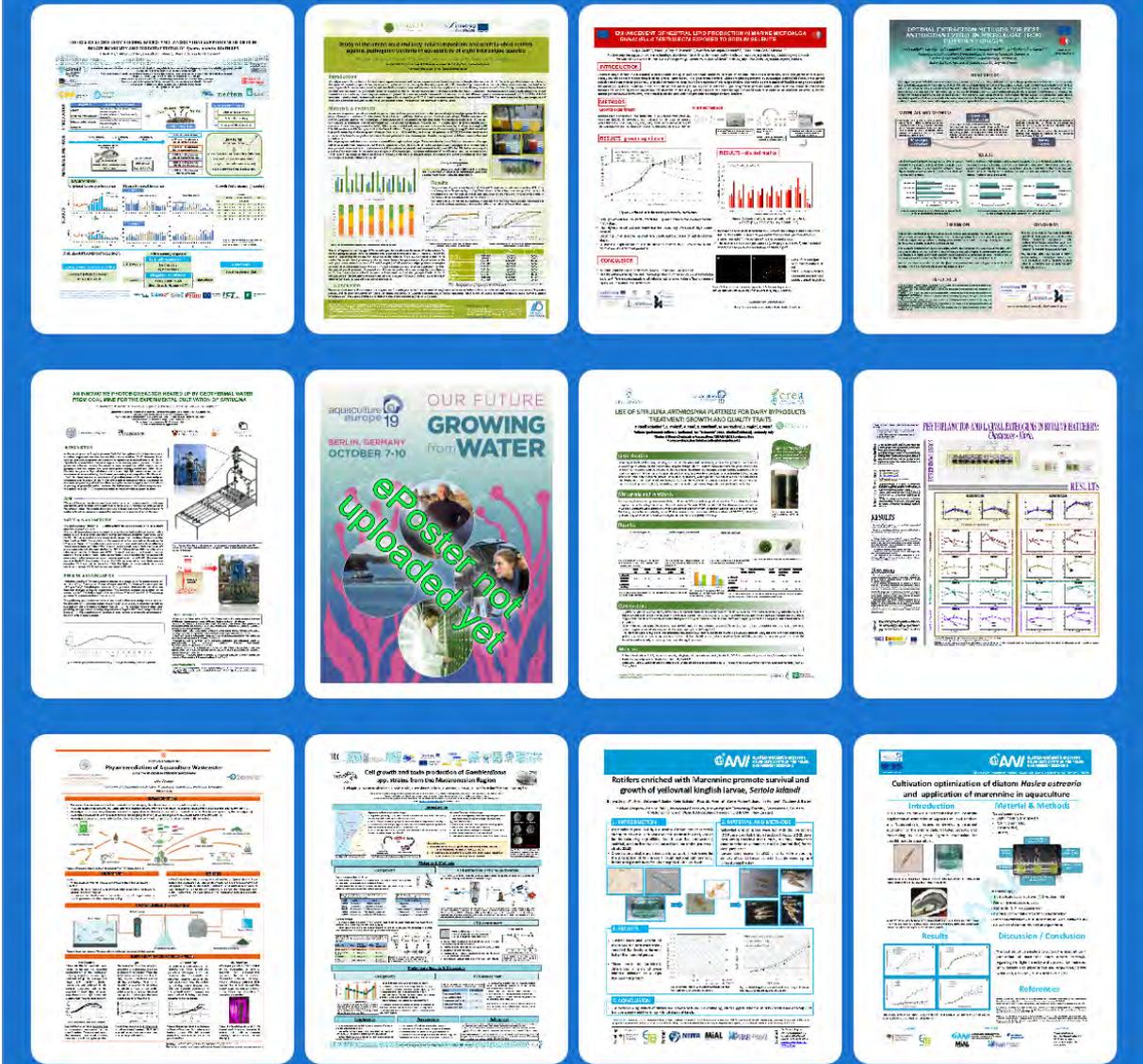
## MICROALGAE

**Chair: Kjell Inge Reitan (NTNU, Norway).**

This session had 9 oral presentations and in addition 17 e-posters, indicating that the production of microalgae for use in aquaculture is a topic with high interest. It was also a high number of attendees in the room during the whole session. The presentations covered different aspects related to production and use of microalgae. Different production technologies for cultivation of microalgae were treated by half of the presentations. The scale of the production is important, depending on the need for algae. For use in hatcheries as enrichment diets for live feed and larval feed the need is high quality microalgae at low or medium volume scale. When algae are regarded as a feed resource the need is for higher biomass and higher volume cultivation.

Upscaling of microalgae cultivation from laboratory scale to semi commercial scale is an important task and will involve changes in both temperature and light conditions of the cultures. These change in cultivation conditions is important to evaluate when increasing cultivation volumes., especially for more challenging microalgae species as *Rhodomonas salina*. The cultivation of microalgae at high volumes was shown at the national algae pilot at Mongstad, Norway, where several microalgae

# Microalgae Posters



A selection of Eposters presented in the microalgae session

species were cultured at a pilot facility. The different microalgae species were cultured for industrial application as for aquaculture feed, food products and chemicals. The production price is still high, and it is necessary with further strain improvements and process optimization.

Microalgae can be an interesting part of both Recycling Aquaculture Systems and Aquaponics. Microalgae will then utilise the inorganic nitrogen and phosphorous from the cultured fish in the system. The microalgae will then reuse the wastes into high value biomass that can be used as feed resource or raw material for industrial purposes.

Microalgae as *Nannochloropsis* sp. and *Chlorella* sp. were used as partial replacement of fish meal in feeding of European sea bass *Dicentrarchus labrax* juveniles. The use of *Nannochloropsis* sp. showed better immune response on the fish that the use of *Chlorella* sp., and is therefore regarded as a better feed resource for use in fish feed. *Nannochloropsis* sp. was also showed to have antimicrobial activity against some fish pathogens. It is therefore suggested that this species can be used as fish

disease prevention for alternative environmental friendly chemotropic reagent for use in green and sustainable aquaculture.

The use of microalgae in hatcheries, both for production and enrichment of live feed, demands for high quality microalgae with high content of essential fatty acids that are located in phospholipids. To obtain this, it is important to know the effect of the cultivation conditions, especially the degree of nutrient limitation of the cultures. A study with use of *Isochrysis* T-Iso as diet for rotifers showed that cultivating under phosphorous deficiency at nitrogen sufficient conditions increased the content of DHA in the phospholipids. This gave an increased viability of the rotifers and is expected to be important for successful performance in marine finfish larvae culture

One presentation in the session studied the possibility to establish blue mussel hatchery with use of living microalgae as larvae feed. One challenge is the high cost for microalgae cultivation. A possible way to reduce production cost is to cultivate the microalgae by using mixotrophy with use of organic nutrients. This could increase the biomass production and stability of microalgae and in that way reduce production costs.

It can be concluded for the session that microalgae have a huge potential for use in several aspects of aquaculture. The microalgae is an interesting contribution both in fish, shrimp and mussel hatcheries, as well as a future aquafeed and food resource. But production costs and availability are still major challenge that need to be addressed.

## PERFORMFISH / MEDAID FORUM - SUSTAINABLE SEA BASS AND SEA BREAM FARMING IN THE MEDITERRANEAN

**Chairs: Katerina Moutou (University of Thessaly, Greece) and Bernardo Basurco (Mediterranean Agronomic Institute of Zaragoza, IAMZ, Spain).**

Report and pictures from [www.performfish.eu](http://www.performfish.eu)

More than 80 aquaculture industry and research representatives participated in the Industry Forum "Sustainable Solutions to Address Sea Bass and Sea Bream farming in the Mediterranean", jointly organised by the PerformFISH and MedAID projects. The aim of the forum was to communicate the main results obtained within both projects to aquaculture experts. The event was held at the Aquaculture Europe 2019 conference in Berlin, one of the key events in the calendar for the industry.

PerformFISH partners presented tangible solutions to solve the specific challenges in selective breeding for disease resistance, health and welfare, feeding management, and key indicators to measure performance in Mediterranean farms. MedAID then provided an overview on their latest findings regarding social acceptability and the economics related to production and markets of Mediterranean aquaculture products.



The event ended with an open discussion with the participants to determine how these solutions can be implemented at farm level and the next steps to be carried by the projects in the coming years.

The agenda and the presentations given at the Forum are available [here](#).

See the new PerformFISH [VIDEO](#) on Mediterranean aquaculture challenges



**Chair: Kathrin Steinberg, EAS Board Member and ASC, Germany**

The topic of this year's EAS-SG workshop was '**EAS Avengers – AqualIndustry Challenges**' and was focused on the identification of issues within the aquaculture industry and the question how students can help to overcome these issues. The workshop was attended by over 50 people, mainly students but also industry representatives and university supervisors.

Kathrin Steinberg (Student Representative on the EAS Board) gave a short introduction on the EAS and the Student Group as well as all the student activities within the conference. This year the EAS SG not only organised the Student Workshop and Student Reception, but also a sightseeing tour through Berlin and, for the first time, the Student Spotlight Award.

Ana Nobre (SPAROS) gave a brief introduction on the main EAS SG sponsor, SPAROS, and a more detailed insight on FEEDNETICS, a tool and modelling approach that can be used at farm level, but also for research purposes. This was followed by short presentations of the travel grant winners, who presented their most recent research projects or industry experiences. Laura Klatt gave some insights on our second sponsor Kunststoff Spranger and provided detailed information on what it means to work in the industry and what students can learn from the industry and vice versa. Laura's presentation was followed by some insights into the status of aquaculture in Spain, Portugal, France, Italy and Greece by the EAS\_SG National Coordinators.

The academic side of challenges within aquaculture was covered by Lourdes Reig and Rosa Flos who discussed with the students how they perceived aquaculture, how that differed from the perception of non-aquaculture students and what academia can do to overcome issues. The presentation was very interactive and gave everyone the chance to reflect upon their own perception and potential prejudices.

In preparation of the workshop, the National Coordinators (NC) collected information about issues within the industry from different producers. These were presented by Andrew Richardson (covering feed related issues), Philipp Segler (covering alternative feed ingredients) and Kathrin Steinberg (covering issues related to engineering and technical problems). The attendees then split into groups to discuss the topic they were most interested in and network amongst their peers.

At the end of the workshop, the NCs for Ireland, Aideen Kearney and Silvia Blanco, provided an outlook to Ireland for AE2020 with a specific focus on aquaculture related institutes. They were spontaneously joined on stage by Gavin Burnell, EAS President and chair of the steering committee for AE2020.

The student reception at Crack Bellmer was attended by over 150 students and former students from all over Europe and allowed a relaxed and interesting networking with delicious finger food and drinks. The event was financed by the European Aquaculture Society.



# student RECEPTION



**Chairs: Luisa M.P. Valente (CIIMAR and ICBAS-UP, Portugal) and Elisabete Matos (Aquasoja, Portugal).**

**Session sponsor**



This half day session was very well attended and focused on the use of animal-based ingredients, specifically as replacements of fish meal and fish oil from reduction fisheries, towards circular economy. Presentations focused on European seabass, rainbow trout and Atlantic salmon. As for the ingredients discussed, mostly were land animal proteins and fats, namely insect meals and poultry-based ingredients. Some marine ingredients were also debated: hydrolysates from anchovy and giant squid, and also phospholipids from krill or fish. Finally, the life cycle assessment of some of these ingredients was presented, as well as a mathematical model that allows for the prediction of the performance of aquafeeds formulated with sustainable ingredients. Below is a summary of the main results presented.

Insect meals seem promising novel ingredients for aquafeeds. According to Motte from ÿnsect, yellow mealworm (*Tenebrio molitor*) has shown an excellent zootechnical performance in European seabass and rainbow trout. Basto et al. from CIIMAR showed that it was possible to replace 100% of the fish meal in the diet without impairing seabass growth – however, lipid metabolism was altered at these high levels. Authors suggested a maximum replacement level of 80% to maintain adequate EPA and DHA levels in the muscle for human consumption. Preliminary studies show some immunomodulatory effects, and these should be further investigated.

An overview of land-based protein and fat sources in European seabass (namely poultry by-product meal, hydrolysed feather meal, poultry fat and mammal fat) was presented by Valente et al. from CIIMAR. These ingredients have shown good results when included in seabass aquafeeds, being highly digestible and resulting in adequate growth and feed conversion ratios. Again, replacement levels were capped by the need to maintain adequate levels of EPA and DHA in the muscle, as well as effects in lipid metabolism (liver alterations and fat deposition at the highest levels of replacement). It was concluded that around 75% of fish meal or fish oil can be replaced without negative effects. Further studies should evaluate simultaneous replacement of fish meal and fish oil.

Marine-based hydrolysates are undeniably suitable for fish feeds, promoting not only good zootechnical performance, but also having positive effects on the immune response. Results presented by Costa et al. from CIIMAR showed that anchovy and giant squid hydrolysates as supplements (3% inclusion) in plant-based fish feeds presented both bactericidal and bacteriostatic activities against fish pathogens and can be a potentially effective strategy for health enhancement in fish. It was also shown by Jaxion-Harm from the TripleNine Group that marine-based phospholipids (from either fish or krill) promoted growth and reduced mortality in Atlantic salmon fry, a species that appears to have a requirement for this class of lipids.

While most fish meal and oil replacements in feeds are performed in the name of sustainability, the fact is there are still few studies measuring the environmental impact of these substitutions. An LCA evaluation of poultry-based ingredients presented by Matos et al. from Sorgal showed that they are, in fact, more sustainable than traditional fish meal and fish oil. The work also highlighted some

potential improvements that can be made in the ingredient production systems in order to further reduce the impacts.

The final presentation of the session by Pereira et al. from Sparos focused on the comparison between in vivo growth trials and the use of mathematical models when accessing fish feeds performance and, especially, ingredient replacement in feeds. Zootechnical trials are costly and time consuming. If we consider the number of ingredients to be tested times the number of target species, we can see clearly the advantage of the use of models that can predict performance based on the nutrient composition of the diets. The model presented seems to be a valuable tool for feed formulators, albeit needing further development.

Overall, this session's presentations have focused on sustainable replacements for traditional ingredients, favouring locally produced ingredients, able to promote growth and modulate immunity, with low environmental impact, supporting circular economy strategies.

## FOOD QUALITY AND SAFETY

**Chair: Johannes Pucher (German Federal Institute for Risk Assessment, Germany).**

The session consisted of seven oral presentations and 24 poster presentation.

The session of oral presentations started with a presentation by Remko Oosterveld (GlobalGAP) describing how food safety and food quality along the value chain are included into the GlobalGAP aquaculture Standard.

In the following, research activities on food safety of aquaculture based food products were presented. Miguel Angel Pardo (AZTI) presented some findings of a European survey on zoonotic helminths as parasites in fish from European freshwater and marine aquaculture farms. The samples were taken on farms and in supermarkets. Based on the study, the authors conclude the overall risk of parasite infection in the selected farmed fish species to be low.

Andrew D. Younger (Cefas) presented a study on the likelihood of misclassification of shellfish production areas in Brazil according to the European Food Hygiene Regulations depending on the size of the monitoring data set used. The authors named factors that might lead to misclassification being (1) varying numbers of monitoring data sets included into the compliance assessment and (2) the consideration of maximum E. coli counts as a legislative standard.

Christian Schlechtriem (IME) presented current investigations on the nature and levels of residues in farmed fish from plant-based feed resources as part of the European pesticide regulation. To quantify the transfer of feed based pesticide residues to edible fish tissues, a series of test schemes were presented ranging from worst case scenario calculations, metabolism and feeding studies in two fish species, and an in vitro hepatocyte assay.

Johannes Pucher (BfR) presented a literature review on the microbial milieu and the occurrence of potential pathogenic bacteria in biofloc systems for the production of shrimps. The bacterial communities varied between and within the different biofloc systems. Often, the occurrence of

vibrio as potential pathogenic bacteria was reported. The authors recommend monitoring of microbial communities (including pathogens) in future biofloc research to increase the data base on biofloc microbiomes.

In the last section of the session, research activities on the quality of aquaculture food products were presented. Y.D. Ahongo (INRA) reported how long it takes to culture post-spawning female trout until the quality of raw fillets and smoked fillets has recovered including parameters like coloration, fat content, and mechanical resistance. The authors conclude that technological and sensory properties of the flesh are recovered in female trout 24 weeks after spawning.

Olajumoke Omosowone (FUTA) presented a study on the effect of dried garlic as an agent against the infestation of smoke-dried African catfish by the beetle *Dermestes maculatus*. Rising garlic concentration in smoke-dried fish resulted in an increased mortality of *Dermestes maculatus*. Based on their data, the authors conclude that dried garlic might be used as an agent to combat *Dermestes maculatus* infestation in smoke-dried fish.

## SUSTAINABLE AQUACULTURE TECHNOLOGIES

**Chair: Alexander Brinker (FFS, Langenargen, Germany).**

This session comprised seven diverse presentations in which speakers addressed their topics from fundamental, applied, governmental and industry perspectives. This variety notwithstanding, all seven nevertheless fitted well to the broad topic. The session was well attended, in fact there were more attendees than seats, though the diversity of topics resulted in a steady in and outflux between speakers. Vivid and critical discussions after most talks reflected interest of the audience and the pertinence of the addressed topics. Overall the quality of presentations was high, from both senior researchers and industry representatives.

Given this inherent variety, it is not possible to condense proceedings into a meaningful overview, so a quick recap is provided instead:

- Pauline Donohoe efficiently tackled the importance of administrative burdens in hindering aquaculture growth within Europe and described a toolbox of solutions to ease matters which will be available soon. These are of greatest value for larger scale enterprises but a significant proportion of small- to medium-scale enterprises may not be able to benefit in and anything like the same way.
- Kristina Bergman presented a thorough study of the ecological footprint of RAS farming of certain warmwater species in northern climate. Key findings included an overwhelming importance of feed in the LCA balance and a surprisingly strong harmful impact of animal by-products in fish feeds on greenhouse emissions.
- Hallstein Baarset introduced GAIN (Green Aquaculture Intensification in Europe), a Horizon 2020 project, focusing on the evaluation of different valorization pathways and leading to promising value chain perspectives.

- Rui Rocha addressed the potential of certain low-cost cooling options to improve product quality in artisanal cockle fisheries. It was shown that simple, easily achieved, cooling lead to improved oxygen exchange and a significantly improved food product.
- Anneliese Ernst presented a case study exploring a times series of microbial diversity in a saltwater RAS.
- Thomas Adams outlined the possibilities offered by biophysical modeling to identify new sites for aquaculture operations, focusing on the risk to salmon farming from sea lice. The models aim to balance costs of location further offshore against the benefits of reduced disease risk and improved dispersal of excretions.
- Finally, Langley Grace gave a supplier presentation exploring the potential for open ocean farming. Such operations seem to be even able to withstand catastrophic events like hurricanes and are driving the development of fascinating technology, for example for underwater feeding. However, investment will be crucial for success in developing operations because failures are almost inevitable on the way to achieving successful fish production.

## PRECISION FARMING: AI AND BIG DATA

**Chair: Martin Føre (NTNU, Norway).**

The session was entitled “Precision farming, AI and big data”, and was the first of its kind in the history of EAS. There were thirteen oral presentations and four ePosters (see below) aimed at this topic in the conference. The room varied between 50 and 100% full through the session, peaking about 1 h after lunch. Since this was in a relatively large room (Festival), this shows that the session was quite popular. This impression is strengthened by that the audience were keen on discussion presentations, when there was time for this. In the beginning of the session, the presenters were informed that each of them had 15 min + 5 min that they could distribute as they wished between presenting and discussions/questions (with a recommended division of 15 min presentation and 5 min for questions). Most of the presenters were able to keep to these limits (although some did not get time for questions), and we were able to keep the schedule quite well throughout the session.

Due to the title of the session, some of the presenters had quite technical presentations. Although a very technical focus can have adverse effects on the questions and discussions following the presentation, this was not the case here. All questions/discussions were focused, to the point and relevant for the preceding presentation, unlike what has been the case when such presentations have been held in previous iterations of the AE-conference. This is probably because the session topic attracted an audience with an above average interest and competence in technology, thereby ensuring a better match between the presentation format and the audience. This is an argument for also arranging similarly themed sessions in future AE-conferences, as this increases the value and impact of technological presentations.

## State of the art and session contents:

Oral presentations covered a wide range of topics that could all be categorized within precision farming, AI, big data or several of these. The morning half of the session (10:30-12:50) started with four presentations aimed at machine vision techniques, both using hyperspectral imaging and conventional cameras. While the study using hyperspectral imaging focused on detecting dietary changes due to skin spectral characteristics, the other three focused on identifying individual fish in groups of larger fish using skin patterns, eyes and other external features. These studies covered experiments conducted in scales ranging from controlled lab settings, through land-based tanks to full-scale sea-cages, and featured Rainbow trout, Sumatra barb and Atlantic salmon.

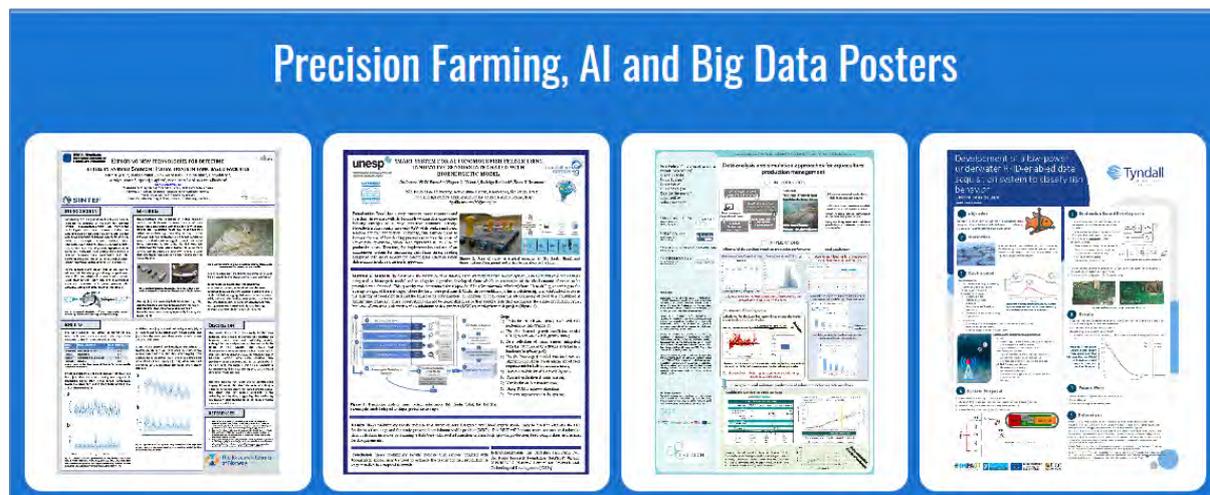
The last three presentations before lunch were on modelling, starting with a holistic approach to modelling the carrying capacity of aquaculture taking animal growth, diseases and physical/oceanographic dynamics into account. This was followed by a presentation on how Computational Fluid Dynamics (CFD) can be used as a tool when designing aquaculture fish tanks, also showing some results from initial studies on modelling flow patterns in such tanks when containing fish. The final presentation before lunch focused on how machine learning may be used to obtain models able to forecast algal blooms based on a set of input parameters. Such algal blooms may potentially be damaging for aquaculture operations, making this study relevant as a potential component in early warning systems. Although neither of these studies were aimed at specific aquaculture species, the carrying capacity model was said to have been used for oysters, breams and salmon.

The first presentation after lunch focused on how it is possible to glean insights into aquaculture production by characterizing historical production data, and how this can be used to derive patterns for predicting future production cycles. In the following presentation, the audience were given an outline of the blockchain concept and a thorough discussion of how blockchains can be of use in aquaculture. These two presentations thereby delved into the utility of historical production data and traceability which are both important components in improving the data management and utilization aspects of fish farming. The following presentation was on the development of a system for monitoring fish in aquaculture, applying internet of things (IoT) principles and networking technologies to obtain a better overview of the conditions at the farm, ranging from environmental conditions to states in the fish. This was the only presentation focused on sensor technology applied directly to the fish.

The next two presentations were on underwater robotics applied to sea-cages, starting with a study of using an autonomous vehicle for cage inspection in Seabass/Sea bream cages in the Mediterranean, presenting some initial results from a field study. The following presentation outlined a similar autonomous inspection concept applied to salmon aquaculture, using bio- and net-interactive control functions (i.e. vehicle control that relates to the fish and the net). Both these presentations gave an overview of the current status on how robotics may be useful in aquaculture operations. The final presentation in the session was on a monitoring system designed for measuring water quality parameters in fish farms, incorporating different aspects such as alarms on undesirable situations, and abilities to forecast negative events such as the “dead water phenomenon”.

The ePosters also covered featured studies closely linked to the main topic of the session in focusing on the development of a low-power embedded device for wireless monitoring of fish activity,

experiments to link monitoring technologies with fish stress, using AI and statistics to derive predictive models and preliminary results on developing a smart system for autonomous feeding using modelling and big data.



### Summary, gaps, future trends and industrial challenges:

In sum, the presentations covered a broad part of what may be considered the state of the art in the session topics. However, it is apparent that the research within this sphere is focused relatively strongly on the “Observe” part of precision farming (i.e. quantifying what is happening in the cage/tank). These studies also show that the potential for obtaining good numerical data describing the states of the fish by using e.g. computer vision or biosensors is increasing rapidly. This is also something the industry is starting to pick up on, and current industrial trends point towards an increased diversity and number of instruments being deployed at modern fish farms. However, there is little to gain by collecting more data if they are not used or processed properly, thus there will be a future need for more focus on using modelling, AI-methods and other techniques to utilize and refine the data obtained by monitoring methods into information (i.e. the “Interpret” phase in precision fish farming). The modelling-oriented presentations in the session targeted parts of this challenge, showing that there are relevant activities in this area already. However, there will clearly be an increasing future need for modelling and estimation solutions to cope with the increasing data flow from fish farms.

The presentations on underwater robotics illustrate that the research activity on achieving underwater inspection and intervention through robotic tools (thereby addressing the “Act” phase in precision farming) is well underway. This is partly because such studies can build upon results and tools emerging from research in other marine industries, such as oil and gas, but also because the industry already use underwater vehicles in their daily operations. However, both studies focus on implementing control algorithms for underwater vehicles originally designed for other purposes than aquaculture. This is reasonable since there exist few robotic solutions customized for use in fish farms, but this also highlights the design of robotics specifically for aquaculture operations as an important future research area which requires close collaboration between industry and research.

One potentially important field that was not directly addressed by either of the presenters is decision support (i.e. the “Decide” phase in precision fish farming). This is an area that should receive more attention in the future, as the increasing amount of information and data obtained with current technologies help build a comprehensive and multifaceted description of the situation

in the tank or cage. Such a foundation, together with predictive models, is ideal inputs for AI-based decision support methods. Hopefully, both research and industry will realize this and seek to address this in the future.

## ENVIRONMENT/AQUACULTURE INTERACTIONS

**Chairs: Shawn Robinson and Peter Cranford (Fisheries and Oceans Canada, St. Andrews Biological Station, New Brunswick Canada)**

The goal of this session was to highlight and discuss the wide-ranging series of biological and physical interactions that occur between the natural environment and aquaculture operations. This topic is particularly relevant as many of today's current discussions/controversies in the development of aquaculture centre around the social perceptions on the impacts of aquaculture on the environment and associated ecosystems. For those people that are charged with managing the aquaculture industry or developing it, the impacts of the natural environment (biological or physical) on farming activities, is of great concern, particularly in the light of predicted climate change scenarios. The importance and cost of maintaining the social license for the aquaculture industry hinges on a strong understanding of the environmental interactions that occur in its development and the relative risk associated with it.

This session, which ran the full day on Wednesday, October 9, received 35 applications to present a paper. A total of 14 papers were chosen for oral presentation and 21 were chosen for posters. There was a wide range of topics available for the session and therefore our objective for the oral session was to highlight the broad spectrum of research that is occurring on environmental interactions internationally. The choices were very difficult to make.

The strategy for selecting talks was to break the session into representative themes:

- Physical/chemical factors that affect aquaculture species
- Interactions of aquaculture species with microbial populations
- Release of organic material from aquaculture farms including escapes
- Tracking a plastic pollution originating from aquaculture farms
- Understanding the economic implications of aquaculture environmental interactions

The session was well attended with an average number of about 40 people per talk. This obviously varied due to the content of the other concurrent sessions that were of specific interest to the attendees. All of the talks were given on time and there was only one no-show for the session. The audience was well engaged in the talks and questions were asked after each presentation. The question period generally had to be curtailed in order to keep the presentations on schedule. Both chairs also reminded the audience several times that they should visit the poster presentations from the session as well, since they were very relevant to the discussions that were being held.

Overall, the session did a good job highlighting all the varied aspects that are associated with the environmental interactions in the aquaculture sector. There was a number of cross-cutting themes within the session that linked to other concurrent sessions such as climate change, aquatic animal

health, genomic research, escape interactions, cage systems etc. This was readily apparent in both the oral talks as well as the poster presentations. The commonality of themes between sessions highlight the importance of understanding the dynamics of the natural environment and the development of the aquaculture sector in both the industrialized and the semi-industrialized countries.

There were several important themes that were highlighted in the session. The chemical and physical stressors that cause impacts in farmed and wild organisms are important to be understood, particularly in the light of impending climate change. Understanding the optimal ranges of the organisms will enable practitioners to look for solutions when environmental conditions move outside of those zones. The second theme on microbial interactions highlights the rapidly growing field in microbial ecology and its interaction with food production systems, human health systems and general ecosystem stability. The talks in this section highlighted some of those dynamics that are currently being studied. Some aspects of this field were also presented in other sessions at the conference. The third theme on the release of organic matter has a long history at aquaculture conferences and techniques to both monitor and remediate this input to the environment continue to evolve. This is likely to be an ongoing theme well into the future since the subject is of great concern to environmental managers and the general public. The fourth theme is currently very topical and centred around the release of plastics and micro-plastics into the environment. The 2 talks in the session did a good job of highlighting some of the issues in this field and putting the problem into perspective with regard to the aquaculture industry from an international perspective. The final theme in the session, represented by one talk, discussed the importance of economics and highlighting the supply chain in order to identify problems and potential solutions. These macroscale economic approaches will be important to develop solutions to minimize negative environmental interactions at the industry scale.

Overall, we were happy with the session and the response by the presenters (both oral and poster) and the audience. There were a lot of good discussions held during the breaks and some new research connections were made between different labs. The overall response to the session was quite positive and should probably be continued, in some fashion, at future meetings.

**Chairs: Stefan Meyer (AE2019 SC Chair) and Bjorn Myrseth (EAS Past President).**

The Innovation Forum took place for the first time at Aquaculture Europe 2019. It was organized by the European Aquaculture Society in cooperation with HATCH - world first sustainable aquaculture accelerator program, and the German Startups Association. Given that the aquaculture sector is the fastest-growing sector in the food industry, new ideas are necessary to develop innovative products and services that will maintain growth in a sustainable way. EAS recognises the importance of innovation and the need to support start-ups – and that is the background to the development of the Aquaculture Europe Innovation Forum.



In this one-day event, 15 start-up companies (6 of them from the HATCH accelerator program) with great new ideas and products were selected to pitch their products and present business models to invited panels of innovation experts, investors, AE2019 exhibitors and an audience of aquaculture experts representing the global sector.

The program was managed by Stefan Meyer and Bjorn Myrseth, who chaired the morning and afternoon sessions respectively. To open the day, Dominik Ewald, CTO of Monitorfish (Startup in Berlin), and a member of the German Startups Association, and Carsten Krome, CEO and Managing Partner at HATCH gave introductions and welcomes.

The first guest speaker - Olaf Birkner, founder, and CEO of Coloom - presented advice on how to get yourself noticed and raise awareness for your startup. In the afternoon session, the second invited speaker - Viggo Halseth, Chief Innovation Officer at Nutreco - explained what an investor looks for in a start-up. Finally, towards the end of the day, Razvan Anistoroaei - Policy Officer at the European Innovation Council at DG RTD- European Commission – presented the European Innovation Council, as a one-stop-shop for innovators and for connecting innovation ecosystems. To mix up the pitches, Rob Van De Ven, aquaculture engineer, ex EAS Student Group Chair and now CEO of Landing aquaculture shared with participants the story of how his company started and has developed to date, focusing on creative engineering to deliver practical solutions in the aquaculture production sector.

Invited panellists for each half-day session listened to the pitches and gave their feedback, insights and advice to the pitchers. Pannellists included Lucille Bonnet - senior investment manager at High-Tech Gründerfonds Management, Dominik Ewald – CTO of German Startups Association and Monitorfish, Angela Schultz-Zehden – founder and manager of s.Pro -sustainable projects, Margriet Drouillon – senior business developer at Ghent University, Robin Shields – senior aquaculture

innovation manager at Scottish Aquaculture Innovation Center, Viggo Halseth – chief innovation officer at Nutreco, Johan Verreth – emeritus professor aquaculture and fisheries at Wageningen University and Research, the Netherlands, and Harald Sveier, manager at Lerøy SeaFood Group.

#### **Our Aquaculture Europe 2019 Innovation Forum finalists:**

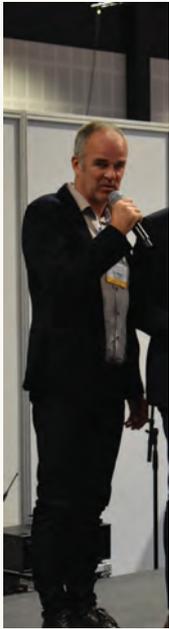
- **Microbia Environment**, presenting 'Innovative early warning systems to anticipate toxic microalgae blooms and secure aquaculture farms'
- **Tellspec**, presenting 'Fish quality control and fraud'
- **Watergenics**, presenting 'A new sensor technology for measuring dissolved oxygen and nutrients in water'
- **Inalve**, presenting 'Microalgae Biofilm technology'
- **SEAentia**, presenting 'Meagre sustainable production in RAS'
- **Arbiom**, presenting 'SylPro® : Protein-Rich Ingredient for Aquaculture Feed Produced from Wood'
- **Gaskiya Diagnostics**, presenting 'Rapid, low-cost, and easy-to-use diagnostic tests for aquaculture'
- **Symbrosia**, presenting 'Commercialized *Asparagopsis taxiformis* culture (red macroalgae) for methane reductions'
- **UNIVIV**, presenting 'FloraVerse'
- **Dynaspace**, presenting 'InsightSPHERE'
- **Nitrogen Sensing Solutions (NS2)**, presenting 'NoxAqua'
- **Genetirate**, presenting 'Novel test to predict feed efficiency in marine species, as an indicator of faster growth'
- **Aquaculture Health Laboratory**, presenting 'Rapid diagnostics to assess fish health in Aquaculture'
- and **TUNATECH**, presenting 'Blue Biofouling Bioresources – for Integrative Multi-Trophic Aqua/Terra-Culture'

They each had just 8 minutes to present their innovative solutions to the diverse challenges facing the aquaculture industry today. Each panellist then judged the pitches in their session, resulting in the selection of two winners of the AE2019 Innovation Forum. Choosing the winners was not an easy decision to make.

After deliberation, the winners were Inalve and Aquaculture Health Laboratory, and each will have a courtesy stand at our AE2020 event in Cork, Ireland next year.



The success of this inaugural Forum, the interest of the pitching teams to submit their innovation to it and the high level of participation has confirmed to EAS the need to repeat this at AE2020 and to enshrine the AE Innovation Forum as an integral part of our future events. Looking forward, therefore, to seeing you next year in Cork!



# INNOVATION FORUM



**Chairs: Klaus Kohlmann (IGB im Forschungsverbund Berlin, Germany) and Ross Houston (Roslin Institute, University of Edinburgh, UK).**

Genomic research, the development of appropriate tools and their practical application are of increasing importance for a sustainable and competitive European aquaculture sector. This trend was also impressively demonstrated at this session which had a good attendance. The 16 oral presentations and about 26 posters covered not only the economically most important finfish species such as Atlantic salmon, rainbow trout, seabream and seabass but also newly emerging candidate species, e.g. pike-perch, European catfish, flatfishes, lobster and shrimps. Similar to the wide range of species the subject areas and applied tools showed a wide variation, too. Subject areas included for example lipid metabolism regulation, disease resistance and tolerance in Atlantic salmon, microRNAs as non-invasive biomarkers of nutrition and reproduction in female rainbow trout, muscle transcriptome response to fasting-refeeding in sea bream, egg quality in pike-perch, a new draft genome of European catfish, heritability of growth traits in lobsters and sex-related genes in shrimps. Tools applied included genome and transcriptome sequencing, studies of gene expression, function and evolution, QTL and eQTL analyses, SNP markers and arrays as well as molecular identification of species. An interesting and innovative approach is the combination of metagenomics with artificial intelligence (e.g. machine learning) to monitor the environmental impacts of marine finfish farms. Following most presentations there was active question and answer sessions, highlighting the audience interest and interactive nature of the session.

It was clear from the session that the genomic toolbox is expanding rapidly for all aquaculture species. For the most advanced aquaculture sectors, such as Atlantic salmon, there is now a focus on applying the genomic tools to answer interesting research questions and to apply the tools to benefit the industry. One of the most obvious ways that genomics is benefitting the industry is via the use of genetic markers (usually SNPs) in selective breeding programs. Markers have been used for parentage assignment for many years, but now SNP markers are routinely applied in several major finfish breeding programs for both marker-assisted and genomic selection. This is most evident in salmon, but the development of SNP arrays for sea bass and sea bream are enabling genomic selection in these smaller, but very important sectors for European aquaculture. The application of other genomic tools to the industry, such as transcriptomics or metagenomics, appears to be further away, but holds potential.

It is also clear for the smaller aquaculture sectors, that perhaps don't benefit from the same amount of investment into research and development as e.g. salmonids and tilapia, that genomic tools are not as advanced. However, genomics techniques and technologies tend to translate readily across sectors. Techniques such as genotyping by sequencing, RNA-sequencing, and long-read genome sequencing are being used in several species. For all species, the rapid reduction in costs of sequencing have resulted in a greater availability of genomic tools, and easy-access bioinformatics tools are helping researchers to utilize these to answer biological questions related to their species of choice. Genomics is a data-intensive subject, and it is clear that the current generation of researchers are adapting to this, and the need to improved computing and software will continue. Likewise, the application of genomic tools is most useful if the technology to accurately measure and assess phenotypes continues to advance, and this will also be a priority.

**Chair: Marija Banovic (Aarhus University, Denmark).**

There are a few important issues facing European aquaculture that the value addition and marketing session has tackled. First, it looked at the existing environment-friendly trends and need for circular economy where sustainability is sought not only by the consumer but also throughout the value chain by ensuring use of waste as by-products in aquaculture. Second, it considered the hypersaturation of the fish market, need for diversification, consumer information overload, and invisibility of aquaculture products, pointing to production and company risks when developing new aquaculture products. Third, it discussed the need for better, more specific communication efforts to nudge consumer into buying aquaculture products, pointing to credible, specific messages related not only to the European aquaculture in general (as it was done so far) but to the diverse and specific production methods already existing within European aquaculture.

Aquaculture production is expected to fill the future gap in food and protein supply, but the problem lays in finding best economical, social, and most importantly environmentally sustainable solutions to deliver new aquaculture products to the market that will both contribute to the eco-intensification of the European aquaculture, and be accepted by the consumer (Johansen, Svenningsson & Baarset, 2019). For example, as Müller-Belecke, Borchert, Valbuena, & Erdös (2019) pointed out processing of freshwater fish gives around 50% of by-products that have a potential for reutilization as fish feed ingredients. This was especially found important in small-scale operations where ensilaged fish processing by-products can be stored in a sustainable way for a longer period and work well as the ingredient for rainbow trout diets. Ramírez-Bolaños et al. (2019) gave another example of using by-products emphasizing on sustainable practices with novel banana by-products. They found that banana pulp and flower used in seabass diet gave good results on fish performance pointing to new ways of reusing waste.

The future of aquaculture lays in obtaining higher resource efficiency, reduced environmental impact by using more sustainable practices aiming at the continual use of resources and eliminating waste through-out the product chain. This is imperative having in mind that 30% of fish and seafood harvested in Europe is lost and wasted throughout the food supply chain (FAO-WHO, 2011). The key here is valorisation as the resulting products could have an added value to the consumer, but also provide incentives for the aquaculture industry to invest in environmental technologies and increase resource efficiency. Consequently, make first steps in facilitating circular economy and grow the likelihood of consumer acceptance of new aqua-culture products.

The hypersaturation of fish market, consumer information overload, and invisibility of aquaculture products (EC, 2017) coupled with environmental conditions of aquaculture production and fluctuations in input prices can bring additional pressure to the commercial production of aquaculture products, as shown in study by Brande et al. (2019). Having in mind above challenges, Brande and colleagues found that aquaculture farms with a lower production volume (less than 5,000 m<sup>3</sup>) have a higher financial risk (about 88.3%), while farms with a higher production volume (above 5,000 m<sup>3</sup>) have medium to low financial risk (approximately 48.3%) when entering the market. They further suggest that with current state of the fish market, farms with higher production volume could be more profitable and sustainable. Banovic et al. (2019) also pointed out that what makes new aquaculture product successful in the market is adding unique benefits that should be recognizable for the “right” target consumer; hence generating better competitive

advantage and not wasting the marketing effort. Simons and colleagues (2019) confirmed the above by pointing out need for better marketing and communication efforts to the “right” consumer. This is mainly because their study shows that the image of fish (and aquaculture) can be further damaged if the additional effort is not put in-to communicating about possibilities and consequences of using fish in everyday diet, thus influencing market performance of the aquaculture products.

The need for better communication around aquaculture seems to be still echoing and is something that should be tackled sooner than later. As Franco et al. (2019) pointed out negative public perception of aquaculture cripples the expansion of European aquaculture, as it shapes not only consumer attitudes and subsequent fish purchases, but also public support for the aquaculture industry. Simmons and colleagues (2019) also added that the existing consumer concerns should be answered through aquaculture practice requirements. This should further be communicated to the consumer to bridge the gap between scientific arguments (about European aquaculture production) and consumer’s perceptions of aquaculture.

The puzzle of adding value to aquaculture products could be thus solved by appropriate communication, using both personal and impersonal channels to reach the target consumer. The targeted communication should further be supplemented by implementation intentions and ‘if then plan’ pointing to health and sustainability benefits (among others) as positive rewards/outcomes consumer can attain ‘if’ consuming aquaculture products. The messages should show more proximal and specific goals attached to the specific context such as health (e.g. keeping yourself healthy) or environment (e.g. keeping environment healthy) bringing forward plan of action and reinforcing the consumer learning process about aquaculture products. The above seem straightforward but there is a still long way for European aquaculture to be able to reach this point and create predictable habitual consumer behaviour with regards to aquaculture products.

Consumer should be playing pivotal role in expansion of European aquaculture. Aquaculture industry could offer brilliant market-ready products poised for success, but lacking to involve the consumer and without consumer ability to recognize, understand, and remember these products, they are marked to fail. To allow for further expansion, aquaculture industry needs to enable consumer to make more informed choices that carry positive incentives/outcomes so that consumer is attracted by good opportunities to act and have more responsible and sustainable behaviour.

#### References:

- Banovic, M., Reinders, M.J., Claret, A., Guerrero, L., & Krystallis, A. (2019). What separate winners from losers? Evidence from a cross-country investigation on consumer acceptance of new aquaculture products. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Brande, M.R., Bueno, G.W., Fialho, N.S., Godoy, E. M., Ojeda, P.G. , & Roubach, R. (2019). Financial risk evaluation of commercial production of Nile tilapia (*Oreochromis Niloticus*) in net-cages, São Paulo, Brazil. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- EC, 2017. Special Eurobarometer 450: EU consumer habits regarding fishery and aquaculture products, Directorate-General for Communication.
- FAO-WHO, 2011. Report of the joint FAO-WHO expert consultation on the risks and benefits of fish consumption, Rome, Geneva: Food and Agriculture Organization of the United Nations, World Health Organization.
- Fernández Sánchez, J.L., Fernández Polanco, J.M., García, I.L., Díez, E.B., Zamanillo, M.D.O., García, M.L., & Sotorrío, L. (2019). The effect of price and production changes on firms’ profitability and risk: A simulation with European producers of cultured sea bass and sea bream. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.

- Franco, S.C., Kuznesof, S., Simões, B., Clark, B., & Jackson, P. (2019). Towards improved communication in aquaculture: Exploring consumers' perceptions and attitudes. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Johansen, J., Svenningsson, L. & Baarset, H. (2019). Ecointensification of aquaculture: Capture and valorisation of sludge from aquaculture wastewater. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Müller-Belecke, A., Borchert, N., Valbuena, R., & Erdös, A. (2019). Fishmeal from ensilaged freshwater fish processing by-products in a rainbow trout diet: Growth performance, product quality and environmental impact. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Ramírez-Bolaños, S., Díaz, S., Díaz-Padilla, N., Ventura-Castellano, A., Quirós-Pozo, R., & Robaina, L. (2019). Novel banana by-products in seabass (*Dicentrarchus labrax*) diets. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Simons, J., Vierboom, C., Ley, M., & Johnigk, S.-A. (2019). Fish quality: A psychological perspective. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.
- Simons, J., Vierboom, C., Ley, M., & Johnigk, S. (2019). Challenges of consumer oriented communication about scientifically based sustainability standards for aquaculture. Presented at the AE2019 - Value Addition and Marketing session, 7-10 October, Berlin, Germany.

## FUNCTIONAL AQUAFEEDS

**Chairs: Pedro Gómez Requeni (BioMar A/S, Denmark).**

**Session Sponsor: BIOMAR**

The session "FUNCTIONAL AQUAFEEDS" sponsored by BioMar compiled a very interesting set of 9 oral presentations focused on the effects of different feed additives (i.e., beta-glucans and astaxanthin) and raw materials (i.e., insect meal, seaweeds and marine micro- and macro-algae) on the immune properties, gut health and microbiota (among others) of salmonids, marine fish (seabream and sea bass) and shrimp. Presenters came from different research groups all over the world (Norway, Spain, Belgium, Greece, Brazil, Portugal and Malaysia).



With the increasing use of alternative raw materials to fishmeals and fish oils we also need to increase and improve our understanding of the intestinal immune responses, the epithelial barrier and the digestive function. To address these issues, the session was initiated with an interesting study by Wang et al. that established the suitability of a rainbow trout intestinal epithelial cell line (RTgutGC) as in vitro model for studies of immune function. Among all the feed additives the authors tested (lipopolysaccharide, nucleotides, mannan oligosaccharides and beta-glucans), MOS was the most potent modulator of RTgutGC immune and barrier functions. Two other presentations evaluated the potential effects of beta-glucans on the anti-inflammatory properties and survival of Atlantic salmon. In general, beta-glucans are considered as effective immunostimulants that may improve the immune status of the organisms and disease control in fish rearing. Results shown in smolts and post-smolts salmon by Midtlyng were very conclusive and showed that the supplementation of 0.1% of a beta-1,3/1,6 glucan derived from *Saccharomyces cerevisiae* (MacroGard®) may reduce the inflammatory damage caused by infections of major relevance during fish rearing. In this line, Tallarico et al. also proved that increasing supplementation (up to 1000 ppm) with 1,3 beta-glucans derived from the freshwater microalga *Euglena gracilis* increased

the survivability of salmon in a challenging environment. Astaxanthin was also evaluated as feed additive with potential health benefits partly related to its free radical scavenging, singlet oxygen quenching and antioxidant properties. Thus, Kalinowski et al. aimed to compare the liver oxidative status of rainbow trout fed an astaxanthin depleted diet versus an astaxanthin diet, under normoxia conditions and in response to episodic hyperoxia. Thus, the authors showed that dietary astaxanthin (approx. 60 ppm; analysed values) up-regulated important hepatic enzymes for restoration of reduced forms of glutathione and thioredoxin which invites to think that dietary astaxanthin may enhance rainbow trout liver antioxidant response. Skin and muscle coloration (redness) were also positively affected by the inclusion of astaxanthin in the diet, as it could be expected, both in normoxia and hyperoxia conditions.

In the last decade, insect meals are playing an important role in aquaculture as potential alternative protein sources since insects are part of the natural diets of carnivorous and omnivorous fish, particularly during the larval and fingerling stages of development. In addition of being a good source of protein, insect meals are also a source of antimicrobial peptides with activity against pathogenic bacteria and may exert selective immunomodulatory effects. In this context, Li et al. evaluated the gut health of 1-kg seawater Atlantic salmon fed with black soldier fly larvae meal (*Hermetia illucens*) replacing all the fish meal in the control diet. Interestingly, authors found that total replacement of fish meal with black soldier fly larvae meal did not negatively affect the fish gut health and function. Insect meal inclusion was also associated with increased submucosa cellularity in the proximal intestine and lower degree of enterocyte hypervacuolization in the proximal intestine, which would suggest lower lipid accumulation. Due to the relevance of insect meals as potential alternative ingredient to fishmeal in aquafeeds, it is tempting to say that their inclusion in diets for a wide range of fish species at different stages of development and the evaluation of their potential effects on the gastrointestinal health and immune status will be an object of study in the coming years.

Another raw material that brought the attention in the session were the brown seaweed and other marine micro- and macro-algae (*Nannochloropsis* sp. and *Gracilaria* sp., respectively). In several studies these ingredients have shown high antioxidant activities, high potential to stimulate antioxidant defences and immune-modulatory effects in fish. Schleder et al. tested different combinations of 2 brown seaweeds (*Sargassum filipendula* and *Undaria pinnatifida*) and evaluated growth parameters and thermal shock resistance of Pacific white shrimp PL reared in a biofloc system. Their results showed that a 1:2 combination of *S. filipendula* and *U. pinnatifida* improved PLs resistance to acute thermal stress; results that may be very relevant for the industry considering the environmental stresses (including thermal stress) that shrimp PLs experience after the nursery phase when they are transferred to grow-out tanks in the farms.

In a different species, the European seabass, Pereira et al. selected *Nannochloropsis* sp., and *Gracilaria* sp. to be included in an 8% (total feed) or a 4%:4% blend of both algae in diets for juveniles of this fish species. To document the potential use of these marine algae (individually supplemented or as a 1:1 blend) to replace fishmeal, authors concluded that the antioxidants provided by the dietary algae blend (rather than the algae supplemented individually) seem to lessen the need for endogenous hepatic biosynthesis of peroxidases in addition to providing antibacterial protection. However, this specific trial lacked a proper challenge trial to fully support these conclusions.

To summarize, with the development of new alternative ingredients aiming to replace fishmeal while at the same time meeting the physiological requirements of the organisms, the increasing number of species as potential targets for the aquaculture industry, the increasing rearing densities to maximize productions and challenging environmental conditions, there is an urging need to investigate the use of a wide range of functional ingredients that may improve and stimulate the immune system of the organisms (fish and shrimp) and protect the gastro-intestinal health.

Still, extensive and rigorous research is needed to validate the benefits of such ingredients in each individual target species. It is essential at the same time to foresee and guarantee the production of these potential functional ingredients at industrial scale, which is not always the case, in order to use the resources available (both public and private) wisely. Finally, as a general note for this type of trials, we need to be critical with our own research and guarantee that the results we share are obtained in feeding trials where the performance of the fish has been optimal, which is not always the case either (with the exception perhaps of challenge trials). Otherwise, results obtained in under-performing fish where the full growth potential of the fish is not achieved might lead to the wrong conclusions.

## GENERAL BIOLOGY OF FARMED SPECIES

**Chair: Ivo Monteiro (IPMA-EPPO, Portugal).**

In this session “General biology of farmed species”, eight presentations, covering an eclectic range of subjects, were given by experts from different research institutes and Universities. The quality of the presentations was high, the session was very well attended and the topics were very general and including biological development, health, genetics, macroplastics impact on fish farms and nutrition (insects as a fishmeal substitute). The audience had several questions to the speakers in general, which indicates that these topics were interesting and important for the sector.



**The following summary is structured according to the session order:**

The session was initiated on time, with “Biological performance of *meagre* *Argyrosomus regius* under high temperature” presented by Orestis Stavrakidis-Zachou, from the Institute of Marine Biology, Biotechnology and Aquaculture, Greece. This study investigated the thermal tolerance and the biological response of meagre towards the upper edge (24-34°C) of its temperature tolerance range.

Dieter Steinhagen bring us “The Multifunctional gill –The Achilles Heel of fish health”, about the implications of branchial disease on common carp, *Cyprinus carpio*, health, caused by the infection of gills with the poxvirus carp endema virus (CEV), often associated with severe clinical signs like lethargic behavior and may resulting in the death of infected individuals.

In order, Smaragda Tsairidou presented us her work “Optimizing genomic selection with low density markers in farmed Atlantic Salmon”. The aim of this study was to evaluate strategies for the use of low density SNP panels and genotype imputation in Atlantic salmon breeding programmes. Their study focuses on two economically important traits, namely resistance to sea lice (sea lice count) and body weight. Sea lice is the most costly disease-related problem in all major salmon-producing countries. Previous studies have shown the existence of genetic variation in resistance to sea lice (heritability of 0.22-0.33) and body weight (heritability of 0.5-0.6), and both traits were found to have a polygenic genetic architecture, hence lend themselves to genomic selection.

The fourth presentation “Identification of factors explaining the growth-out performance of European Seabass *Dicentrarchus labrax* and Gilthead Seabream *Sparus aurata* in the Mediterranean”, was made by Benan Gulzari. Their study focuses on the zootechnical performance of cultured Seabass and Gilthead Seabream impact in the productivity and profitability of Mediterranean fish farms. The objective of this study was to quantify variation in zootechnical performance and to identify variables that explains this variation.

“Advanced selective breeding for disease resistance in European Sea Bass *Dicentrarchus labrax*”, presented by Sergio Vela-Avitúa shown results of the use of new tools for marker assisted selection (MAS) on selective breeding of Seabass to implement individual selection to accumulate genetic gain on a desired trait that increase the resistance to viral nervous necrosis (VNN) also known as viral encephalopathy and retinopathy (VER). Their study were performed during two consecutive years in a commercial European sea bass programme and compared with traditional methods to prevent this disease.

Laureana Rebordinos presented us his, and colleagues, work “Construction on an integrated genetic map of benefit to the *Solea senegalensis* Aquaculture” where shown the updated integrated map in the Senegale sole and the characterization of relevant genes for aquaculture as some involved in sexual determination, differentiation and maturation, immunology and metamorphosis.

Carlos Andrade, brought us the problem of macroplastics and their impact on fish farms “Monitoring the impact of macroplastics in Madeira island’s offshore fish farm of *Sparus aurata*”. The preliminary results showed that out of a total of 62 videos samplings that were analyzed, they were able to identify in 12 videos, plastic fragments inside of the cage, most of them plastic bags, but also ropes and fragments of the cage’s structure. They concluded also that the weather conditions affect the presence of plastics on the cages.

The session ended with Maria Mastoraki and colleagues’ work “The effect of fishmeal substitution with three different insect meals on growth performance, nutrient utilization and digestibility of Gilthead Sea Bream *Sparus aurata*”. She brought us the trendy theme of insects as fishmeal substitute. They compared the use of *Tenebrio molitor*, *Hermetia illucens* and *Musca domestica* meals in experimental diets and to examine their effect on growth performance, feed conversion, somatic indexes, whole-body composition, nutrient utilization and digestibility of gilthead sea bream.

### **Chair: Antti Kause (Luke, Finland)**

In recent years, advancements in enabling technologies have led to completely novel innovations that are now being implemented within the aquaculture industry. This session covered the latest developments in the interacting fields of digital information technology, genomics and circular economy applied in farm management and monitoring, fish nutrition, feeding and selective breeding. The results originated from three Horizon 2020 EU-projects, AqualMPACT, FutureEUAqua and iFishIENCi, funded under the topic 'Sustainable European Aquaculture 4.0: Nutrition and Breeding Innovations'.

The session was the first common outreach action between these three recently started projects, and also the 'NewTechAqua: New Technologies, Tools and Strategies for a Sustainable Resilient and Innovative Aquaculture' project starting in January 2020. The session started with an overview of the projects after which each project contributed scientific presentations with the first results.

### **Genomic selection becoming the industry standard**

The session introduced genomic selection that is developing fast to become the industry standard for aquaculture breeding programmes. Genomic selection means that the DNA profile of an individual is used to predict its potential to transmit genes of preferred traits to the next generation. Implementation is pioneered by the Atlantic Salmon industry. For any breeding programme, a major obstacle is to reduce genotyping costs and to create cost-effective phenotyping of thousands of individuals under commercial conditions for challenging traits such as fillet pigmentation, disease resistance and feed efficiency, the traits that benefit the most from genomic selection. The session demonstrated that optimization work and power calculations can be used to find economically feasible production plans and experimental designs for both industry and research use.

### **Nutrition to match fish genetics and production types**

Since 2000, there has been an increasing demand for seafood that has been farmed according to certified organic standards, notably in European countries. The session portrayed the need to design commercially relevant, safe, nutritionally adequate feeds with low environmental impact for organic aquaculture using feeding protocols that match the natural feeding behaviour and origin of fish stocks. The session further reviewed the evidence that breeding programmes change fish traits that are related to nutritional requirements. These traits include growth, feed conversion ratio, lipid deposition and fillet%, but also specifically lipid metabolisms, protein retention and adaptation to plant-based diets. Feeds hence need to be matched to the genetic characteristics of fish from breeding programmes.

The data from rainbow trout farms showed that breeding and feed development has had a strong favourable impact on economics and environmental footprint at farm-level (up to 70% reduction in nitrogen and phosphorus loading to water from 1980's onwards). Further improvements can be obtained, for example, by genomics and novel nutritional innovations describe above as well as by digital technology.

## Emerging digitalisation technologies

The session illustrated that integrating internet-of-things technologies (IoT), such as semantic Web and artificial intelligence and sensors in aquaculture farms provide possibilities for a new era of connected, responsible and efficient aquaculture. On-line connected sensors can, in one hand, record environmental and water conditions, oxygen, temperature, salinity, sea current, pH, wind and CO<sub>2</sub>, and on the other hand, fish condition and performance such as biomass, moving activity, oxygen consumption, and standard metabolic rate. This compels the development of new IoT oriented applications in order to collect and control data from heterogeneous sources and organise it in an inter-operable way to improve the decision-making, production control and management for fish aquaculture systems.

## The dialog and the wrap-up

The presentation on Life Cycle Assessment (LCA) of emerging technologies and circular economy induced active conversation among the audience. Increasing the consumer awareness on aquaculture processes and products is one major goal that will benefit from dialog between industry, consumers and other stakeholders. The three Horizon 2020 EU-projects are motivated to be part of the dialog.

The three projects in question are:

- **AquaIMPACT** - Genomic and Nutritional Innovations for Genetically Superior Farmed Fish. Twitter: @aqua\_impact
- **FutureEUAqua** - Future growth in sustainable, resilient and climate friendly organic and conventional European aquaculture. Twitter: @futureeuaqua
- **iFishIENCi** - Intelligent Fish feeding through Integration of Enabling technologies and Circular principles. Twitter: @iFishIENCi

In these projects, researchers and companies together develop aquaculture practices for more robust, healthy, nutritious and resource-efficient farmed fish corresponding to the UN's Sustainable Development Goals.

**Chairs: Synnøve Helland (NOFIMA, Norway) and Rob Fletcher (The Fish Site, UK).**

**For the first time at Aquaculture Europe, a special session was dedicated to the opportunities and challenges facing women in aquaculture.**

Organised jointly by EAS and The Fish Site, the hour-long session was co-chaired by Nofima's Synnøve Helland and The Fish Site's editor, Rob Fletcher, who had brought the topic to the fore in a series on the website, as well as a number of complementary events. The session was designed both to highlight the opportunities available to women in the aquaculture sector and to offer practical routes to achieving their aquacultural ambitions.

In order to do this, a strong panel from both the aquaculture industry and academia was assembled. Consisting of three men and three women, they considered ways to ensure greater gender diversity at all levels of the aquaculture sector and delivered a range of insights into how women can overcome perceived gender-related obstacles and build thriving careers across the aquaculture sector.

The panel consisted of Lara Barazi, CEO of Greek seabass and sea bream producer Kefalonia Fisheries; Ole Christiansen, vice president and member of the executive committee of BioMar; Birgit Schmidt-Puckhaber, managing director of the DLG expert board on aquaculture of the DLG (German Agriculture Association); Javier Ojeda, general manager of the Spanish Aquaculture Producers' Association (APROMAR); Selina Stead, director of Stirling University's Institute of Aquaculture; and Matthijs Metselaar, senior veterinary specialist for Benchmark Animal Health.

The audience heard that while 70 percent of the aquaculture workforce is female, there is a chronic lack of women in executive roles, despite the fact that gender imbalance at a high level has been shown to be detrimental to the economic performance of companies.

Lara Barazi explained that she had faced many challenges in her career and revealed that without continuous work, learning, persistence and family support she wouldn't have been able to succeed and be where she is now. She added that it's hard for women to reach high level management, let alone join the board of directors, and that women are often not even considered for board room positions.

Ole Christiansen noted how women have enriched the work environment in BioMar, and said that he always tries to give women a chance to thrive, to show their abilities and to grow in the company and in the sector. He argued that women have a different way of thinking in solving problems and many approach tasks in a different way to men, which can be very valuable, but reflected that they should be more direct and speak up more when it comes to seeking promotion.

Matthijs Metselaar, senior veterinary specialist for Benchmark Animal Health, noted a rise in female vets, but added that women still face problems related to balancing work and raising a family – a theme that recurred on several occasions. Selina Stead said that she is supporting mothers (and fathers), by giving flexible hours to her employees of both sexes. Lara added that she introduced a kindergarten in her company for her employees.

Birgit Schmidt-Puckhaber gave some insights into her own career, running a family-owned trout farm in the north of Germany, together with her husband and three children. She said she was fortunate enough to be able to work on the farm in the morning and take part in DLG activities in the afternoon. She observed that women are balancing work and family much better nowadays (compared to the past).

Selina Stead gave a special mention to Lindsay Laird, the former EAS stalwart, as one of the most inspirational women in her career. Both a role model and mentor, she encouraged Professor Stead to succeed and also persuaded her to become involved with EAS, which she did – going on to become its president from 2008 to 2010. In her opinion, women should spend time learning and developing their knowledge and skills in areas that they are not too familiar with.

Metselaar pointed out that women often don't apply for jobs, unless they feel that they fit all the requirements, while men might do so even if they only fit 60 percent of the job specifications. He therefore encouraged women to do likewise and apply for any job without necessarily 'ticking all the boxes' listed in the job advert. This was confirmed by a seafood recruitment specialist during the Q&A at the end of the session.

Javier Ojeda said that more women in Spain are working in the aquaculture industry today, compared to 10 years ago and welcomed the apparent trend towards more women applying for higher level roles. He also noted that the laws in Spain were changing, meaning that men now had to take more time off for parenting duties, thus helping to even out the childcare balance a little.

The panellists also agreed that joining societies like EAS and networking can be door-opening for job opportunities.

The session finished with a series of questions from the audience, which extended the session by nearly half an hour, and allowed for a number of other issues to be discussed.

Reflecting on the event, co-chair Rob Fletcher said: "I was very pleased how the panellists were able to use their own experiences to illustrate how it is possible – albeit not always easy – for women to succeed in the sector, with plenty of practical tips for those present. I was also heartened by the level of audience engagement during the Q&A.

*"Since the event I have received a great deal of very positive feedback and have also been contacted by people who are looking to initiate their own programmes to support women in aquaculture – notably one in Iceland and another in Ethiopia. We were determined that this event would have practical outcomes and help to generate momentum for the initiative and I think this has definitely been the case".*  
Rob Fletcher. *The Fish Site*.

Synnøve Helland added: "The panellists shared their experiences and gave us all valuable tips on how employers can help women in their careers in aquaculture, and also how women can help themselves. Both the panellists and some of the audience shared their stories, some never before told in public. These moving stories gave us all valuable insights. The turn-out and the level of engagement from the many people present was uplifting and inspiring".



 The Fish Site

 Women in Aquaculture

 european aquaculture society



**Chairs: Oivind Bergh and Ingrid Johnsen (both IMR, Norway).**

This session comprised seven presentations covering impacts of aquaculture on ecosystems, and attempts to monitor and to some extent, mitigate effects on ecosystem level.

Several different approaches have been suggested and discussed for risk analysis of marine ecosystems and marine aquaculture activities. Risk analysis, as a scientific field is young, not more than 30-40 years old. Risk assessment in the aquaculture industry is, however by comparison still in its infancy. The approaches adopted to analyze aquaculture-risk are for the most part driven by statistical analyses of available hard data where inclusion of expert knowledge and opinions are thought to introduce subjectivity and uncertainty to the end risk results. Lack of hard data is common and may thus lead to inability to perform a risk assessment on the subject at all. The objective of risk assessments is, however, not to accurately calculate risk, but to provide the best foundation for risk-based decisions. Grefsrud et al. (Presented by T. Svåsand) documented the Norwegian work on a new risk assessment framework that is tailor-made for risk-based governance of aquaculture and in line with the new perspectives on risk analysis. Documenting knowledge strength, evaluating assumptions and systematizing risk sources, consequences and associated uncertainties in hierarchical and intuitive structures contributes to risk understanding and improved decision making. Bayesian Networks allow combinations of hard data and expert knowledge on the input side and highlights and documents the results in terms of hierarchical structures of risk sources and consequences. Contrary to some other methods such as deep learning or purely data-driven methods, Bayesian networks combines data and expert knowledge as well as support explanation of results.

Carvajalino-Fernandez et al. performed controlled lab experiments using tubular flow raceways to determine near-bed flow conditions necessary to resuspend fish faeces over the most common bottom types in existing aquaculture locations in Norway. These novel parameters will help to expand existing modelling tools for the farming industry. Faecal material discharged from open ocean salmon fish farms generates a direct impact to the bottom dwelling communities, modifying both population structure and diversity via organic enrichment. Therefore, accurate modelling of such particles is critical

Stoeck et al. described novel methods, by eDNA to study and monitor impacts on population level. In contrast to macroscopic faunistic methods, eDNA allows including microbial populations to this monitoring. They showed that clustering of sample sites obtained from monitoring transects of salmon farms provided excellent pattern-matching between bacterial eDNA patterns and microscopy-derived macroinvertebrate patterns. Clustering of sites based on bacterial eDNA correlated significantly among others with distance from cage edges, macroinvertebrate-derived metrics and indices, and with ecological quality. This near-real time management could be used to prevent a severe ecological impact beyond the allowable zone of effect (AZE).

Bergh et al. demonstrated by means of stakeholder surveys and GIS-based conflict analyses that (in particular) shrimp fishermen were affected by environmental changes believed to be associated with fish farming. Shrimp fishing grounds inshore were little used. In contrast, saithe fishermen gave more diverse responses. In general, they reported reduced quality, especially when large numbers of

farmed salmon were present in the vicinity. Others also reported that the catches were generally high, probably due to increased biomass.

The aquaculture industry stakeholders all acknowledged that environmental constraints hampered growth, and they emphasized the need for technological development. In general farmers operating inshore considered that closed systems were the best solution, whereas some farmers believed more in offshore systems. Most companies were involved in technological development projects.

Harmful algal blooms (HABs) are worldwide deleterious ecological phenomena that can severely impact shellfish ecosystems, fisheries, and human health, thus monitoring HABs, and managing aquaculture in accordance to that, is essential. Gernez et al presented a novel detection and quantification method based on high spatial resolution satellite remote sensing.

Several species of the genus *Dinophysis* are known to produce lipophilic toxins, which can accumulate in suspension feeding bivalves and intoxicate consumers of contaminated shellfish. Since *Dinophysis* is an obligate feeder of *Mesodinium rubrum*, the detection of *M. rubrum* could be used as an early warning system. *M. rubrum* is a globally distributed mixotrophic marine ciliate known to form ephemeral and massive red tides in coastal areas, such as estuaries, fjords, and upwelling zones. Detection, sampling, and quantification of such red tides is notoriously challenging, however, due to the speed at which the ciliate can grow, swim, aggregate, disaggregate, and/or be consumed.

Results demonstrate the advantage of using Earth Observation, not only to monitor HABs in aquaculture sites, but also to better understand their spatiotemporal dynamics, and link their formation and duration to environmental forcing mechanisms.

Eco-intensification of European aquaculture is a challenge that requires the integration of scientific and technical innovations, new policies and economic instruments, as well as addressing social considerations, in order to promote the implementation of the principles of circular economy in aquaculture. Pastres et al. described the The Green Aquaculture INTensification in Europe (GAIN) project, aiming to enhancing eco-intensification. The different components of GAIN will allow farmers to grow more within the space currently available, and an economic analysis of the performance of farms will help build trust in the innovative products that GAIN will make available.

As was also pointed out by the GAIN project, Blue Mussels (*Mytilus edulis*) have for decades been recognized as a potential mitigation tool to remove nutrients while at the same time being a source of fatty acids and marine protein. Lyngsgaard et al. followed the biomass production and the effects from the farm on water transparency. The ecosystem service of nutrient removal provided by harvesting blue mussels is estimated. It was concluded that the large-scale “Blue Biomass” mussel farm in Limfjorden, Denmark produces large amounts of marine protein and increases the visibility of the water



# AE19 PRESIDENTS RECEPTION

with an Oktoberfest theme



**Chairs: Åsa Espmark (NOFIMA; Norway) and Hans Bjelland (SINTEF Ocean, Norway).**

The aim of this session was to highlight two alternative future sustainable technologies for aquaculture production; **closed containment aquaculture (CCS)** and **offshore aquaculture**. Nine abstracts were submitted to this morning session, while seven were selected for oral presentation. Further five posters were presented. This report focuses on the oral session.

Despite the early start after the Presidents reception the evening before, the room was almost full throughout the session, and all presentations were followed by a significant number of questions and comments. The session was quantitatively biased towards CCS. This might be explained with the fact that there is more ongoing biology research in CCS since there are not many offshore solutions that have gained production experience yet.

For CCS we had contributions covering both RAS and semi-closed containments. For RAS Sharada Navada (NTNU/Krüger Kaldnes) gave an overview of her recent results from her PhD where she explained how the biofilter can be adapted to saltwater by training it with salinity, and how this may improve ammonia removal from the RAS water. John Davidson from Freshwater Institute described the concept of membrane biological reactor (MBR) together with RAS and showed results like reduced water usage and improved water quality with MBR. Then we had two presentations about factors triggering early sexual maturation in RAS. First, PhD student Enrique Pino Martinez (Norce) showed that water temperature of 18°C, compared to 8 and 12.5°C resulted in 15-fold increase in GSI levels. Reduced feed ration had very little effect on maturation. On contrary, Chris Good (Freshwater Institute) showed that reduced feed ration reduced maturation, but these fish had low condition factor. The best condition factor and growth were observed in the fish receiving LD24:0 and full feed ration. These fish additionally showed some maturation. He also showed the difference in maturation between diploid and triploid fish.

Khurram Shahzad (Nofima) presented computational fluid dynamics modelling (CFD) as a promising tool to investigate and plan the hydrodynamics of large systems. In his presentation he showed how different orientations of the water inlet nozzles give different water velocities in the tanks and thus potential different distributions of particles, water quality parameters and fish.

Two presentations described results and ideas related to exposed farming. Heidi Føre gave a presentation on behalf of her colleague David Kristiansen (Sintef Ocean) about the stability of closed cage designs when sea forces are acting upon them. During the presentation several external and internal factors with high probability of affecting the design were presented. In the last presentation by Uwe Waller (Htw Sar), the ideas for fish farming on a large sail ship was presented. The ship, powered by renewable energy, is meant for producing salmon. The idea is to limit the effect of increasing effects of higher temperatures in-shore. The transport route is planned to be in the North of the North Atlantic during summer and in the South during winter.

In summary, the session was well attended and considering the following discussions the audience was a mixture of experts and people with general interest in the issue. New technologies will continue to be developed. At present many of the new technologies have not been tested with fish, and some of these technologies were most likely not present at the AE2019 in Berlin. As more

technologies proceed with fish, we anticipate that more will be interested to present their results, and we encourage the EAS management to continue with sessions where new and sustainable technologies and the fish performance in them are presented.

## BALTIC AQUACULTURE

### **Chair: Mathis von Ahnen (DTU Aqua, Denmark)**

The Baltic Sea is a nutrient-sensitive area where growth of aquaculture is only possible when nutrient discharges are reduced. As nutrient output from aquaculture production to the Baltic needs to be limited, future aquaculture farming in the Baltic region must be based on sustainable production technologies such as recirculating aquaculture systems. Presentations within the Baltic Aquaculture session were given on white leg shrimp production in RAS in Poland as well as on geosmin producing microbes in RAS. Furthermore, the Baltic Aquaculture Session contained three presentations focusing on novel approaches for the removal of both nitrogen and phosphorous from RAS effluents. Finally, a new way to treat columnaris disease as well as a new site selection method for mussel farming were presented.

Monika Normant Saremba from the Institute of Oceanography, University of Gdansk, presented experiences from production of white leg shrimp *Litopenaeus vannamei* in an experimental land-based RAS in Poland. She reported that cannibalistic behavior was observed, which resulted in increased mortality, mechanical damage to appendages. However, despite these challenges and system failures, the overall experience was positive with satisfactory weight gain during the study period giving a positive demonstration of the possibility to culture whiteleg shrimp in RAS in Poland, making the country potentially less dependent on imports.

Xiaoyu Huang from the Technical University of Denmark presented results from a laboratory experiment performed within the BONUS CLEANAQ project, where step fed batch reactors operated under external and internal carbon sources to remove nitrogen from RAS water. According to his results acetate showed the highest removal nitrate removal rates ( $57.64 \pm 6.55$  mg N/h/g bacteria) in SFBR followed by propionate and ethanol.

Gunno Renman from the Royal Institute of Technology in Sweden investigated reactive filter media within the BONUS CLEANAQ project and found that they were effective at removing phosphorous from RAS effluents. In the laboratory upflow packed bed columns Polonite removed low phosphorous levels to near-zero. The performance of Polonite was followed by Sorbulite and Vermiculite, which showed a lower removal efficiency for phosphorous. He pointed out that once the Polonite is saturated with phosphorous, it can be directly applied as a valuable fertilizer on land where it slowly releases phosphorous to the fields.

Sanni Aalto from the University of Jyväskylä, Finland investigated the microbiology of denitrifying woodchip bioreactors in freshwater, seawater and with or without additions of bicarbonate. She concluded that efficient nitrate removal in woodchip bioreactors treating saltwater requires favorable conditions for autotrophic denitrifiers, e.g. through inorganic electron donors or using H<sub>2</sub>S produced in sulfate-rich saltwater RAS.

In a following presentation, Sanni Aalto replaced her former colleague Suvi Suurnakki presenting a study on identifying the key microbial groups in commercial RAS farms. The main producer of geosmin in RAS was found to be *Sorangium* but also *Streptomyces*, *Myxococcales* and cyanobacteria producing geosmin were identified.

A presentation on columnaris disease, studied within the BONUS FLAVOPHAGE project, was given by Anniina Runtuvuori from the University of Jyväskylä, Finland. She demonstrated that, as an alternative to antibiotic treatment, which inherits the danger of antibiotic resistance strains spread, bacteriophages could effectively treat *Flavobacterium columnare*. In her study 126 bacterial strains and 64 new bacteriophages were successfully isolated from 10 different fish farms in Finland and Sweden. Isolated phages were able to inhibit more than 90% of 229 bacterial strains. With these results, a phage therapy against *Flavobacterium columnare* is now planned to be implemented.

The Baltic Aquaculture session was rounded up by a presentation on mussel site selection in the south-western Baltic Sea using GIS suitability analysis given by Miriam von Thenen from the Leibniz Institute for Baltic Research, Warnemuende in Germany. The study showed that large parts of the investigated area were unsuited for mussel farming due to spatial restrictions and unfavorable environmental conditions. The GIS analysis was found to be a suitable tool for mussel site selection and it will be converted into a user-friendly tool as part of the decision-support system developed by the BONUS BASMATI project.

## GOVERNANCE, POLICY, REGULATIONS AND STRATEGIC PLANNING

### Chair: John Bostock (University of Stirling, UK)

It is widely understood that for commercial aquaculture to develop and contribute towards food security and economic development, an enabling regulatory environment is needed which secures access to essential resources (space, water, environmental services etc) whilst also balancing the interests of other potential users of those resources and the interests of the wider public. It may also be necessary to consider long-term interests vs short-term benefits with respect to issues such as sustainability and biodiversity.

***Developing the required overarching policies, regulatory frameworks and administrative capacity to achieve this general objective is always a challenge; so, sessions such as this provide a useful forum for exchanging ideas and experience. The complexities of governance and the diversity of contexts also makes this an important area for academic research to better understand the social and environmental dynamics and contribute to optimal solutions.***

The session included consideration of cage-based salmon farming which has a substantial record of public scrutiny and regulatory development, although case examples were also drawn from other fish and shellfish species and temperate to tropical environments. The session also opened with a broader perspective on aquaculture and fisheries links and closed with a focus on freshwater trout production in Germany.

The first presentation by Keith Jeffery (CEFAS, UK) considered the attitudes and behaviour of UK inshore fishing communities in relation to adopting aquaculture practices or interacting with the aquaculture industry. Survey work revealed four basic groups which were labelled “Traditional fishermen”, “The worrier”, the “thrill seekers” and “the inexperienced”. Social factors were found to be more important than technical or economic drivers with respect to their attitude to aquaculture. Although significant barriers were identified, so were examples of positive interaction e.g. through the supply of cleanerfish from fisheries for lice control in salmon aquaculture.

The broad issues of competition for space and resources and social commitment were the focus of the second presentation by Øivind Bergh (IMR, Norway). This contrasted the limited development of aquaculture in the EU with the faster growth in Norway, Turkey, China and New Zealand. Drawing on sixteen case studies and stakeholder meetings concerning resource-use conflicts and regulatory practices, Dr Bergh suggested that further growth requires societal willingness to allocate space for aquaculture. This is likely to be challenging where that is perceived to be contrary to wider environmental objectives. Some of the smaller industry case studies indicated showed that where aquaculture was more familiar locally as a source of food and employment, public support could be stronger.

Approaches to resolve resource-use conflicts were the focus of the following two presentations which particularly considered policy frameworks, modelling tools and regulatory mechanisms. The first of these was given by Jenny Weitzman (Dalhousie University, Canada), specifically on the ecosystem approach to determining carrying capacity as a means of supporting industry scale and siting decisions. This considers aquaculture as not so much an activity impacting on the environment, but a component with both positive and negative interactions with the wider ecosystem in which it is practiced. Furthermore, aquaculture is a component within a wider social and economic system. Developing a practical model that integrates these objectives with the aim of optimising overall sustainability was the focus of the work described. Once again social acceptability was found to be a key issue that is currently under-researched and integrated with existing models.

Building further on these themes, Trevor Telfer (University of Stirling, UK) presented work and outputs from the EC funded Tapas project which is developing an “**Aquaculture Sustainability Toolbox**” to support flexible licensing and regulation of aquaculture in Europe. The project has developed rapid assessment tools for prospective environmental risk assessments and contributed to near-field and far-field models for aquaculture regulation. It has also worked on environmental monitoring and methods for quality control of large data streams. The toolbox makes these results available together with best practice guidelines, examples and a data repository. For long-term utility, mechanisms will be needed to continually update and enhance the toolbox, which could be achieved locally, nationally or Internationally.



*Photos: Professor Telfer presenting during the session on Governance, Policy, Regulations and Strategic Planning*



Gudrun Olafsdottir (University of Iceland) changed the focus to governance of the value chain with a presentation on findings from the EC funded VALUMICS project. This examined salmon production in Norway and export to the EU for secondary processing and marketing, and the power exerted by participants at different levels through the value chain. This led to the characterisation of those vertical relationships into five main types: Market, Modular, Relational, Captive and Hierarchy. Examples of most of these were found within the salmon value chain examined. The regulatory environment is considered as “horizontal governance” in this analysis, but this is further augmented through the influence of international organisations and civil society represented through non-government organisations. These can have very direct impacts e.g. through the development and implementation of standards and certification schemes. This analysis shows a complex network of governance and types of relationships between the organisations involved which is evolving as “hybrid governance” with questions raised about how these will develop further in the future and the extent to which future industry governance will be led by the market, the state or civil society organisations.

The final presentation from Tim Knopf (University of Gottingen, Germany) addressed the efficiency of rainbow trout production in North-West Germany. This provided an interesting case study with potentially important messages for the wider EU aquaculture sector as production there is stable with growth considered to be constrained by strict and complex environmental and building regulations, access to water and strong competition from imported products. However, some farms show high growth rates. The study authors used data envelopment analysis to measure production

efficiency across a sample of 39 trout farms. Overall efficiency was found to be high and robust but confidence low due to problems caused by drought. Ultimately, investment and growth within individual enterprises appeared to be driven more by individual farmer assessment of prospects than substantive performance differences.

The take-away messages from the session was of the complexity of governance and the need to understand the interaction of government, investors, industry, traders and civil society bodies and how these are influenced by political discourse and more direct consumer purchasing behaviour. However, tools that enable the values and objectives of the stakeholders to be clearly defined and then used to develop models that help with establishing suitable rights and obligations for operators are increasingly available. These also enable subsequent performance to be measured and monitored for management purposes. Further development is needed to better integrate these tools and particularly include issues arising from value chain analysis and emerging hybrid governance. A common concern across the presentations was the question of public acceptance of, and support for aquaculture production, particularly when this appears to conflict with other social objectives or priorities for natural resource use. It was clear across the presentations that social narratives are hugely important in shaping industry governance and outcomes, so further study in this area is highly recommended.

## ESCAPES/INTERACTION OF FARMED AND WILD FISH

**Chair: Kjetil Hindar (NINA, Norway).**

The Session on escapes from fish farms and interactions between farmed and wild fish assembled 7 speakers and an audience of up to 40 participants.

The focus of the speakers was on salmonid fishes in Norway/Europe (Atlantic Ocean) and on the west coast of Canada/North America (Pacific Ocean). Six presentations from Norway gave a state-of-the-art report from the QuantEscape project (Quantifying genetic and ecological effects of escaped farmed Atlantic salmon on wild salmon populations), which has been supported by the Research Council of Norway since 2012. This project has genetically analysed 40,000 individuals with Single Nucleotide Polymorphisms (SNPs) and quantified genetic introgression from escaped farmed to wild salmon in 225 Norwegian rivers.

Introgression rates in population samples vary from none observed to more than 50% and are on average more than 5% in (wild-looking) adult salmon, i.e. in fish that have performed a whole life cycle in the wild. Evidence was presented that at the individual level, introgression from farmed to wild salmon leads to increased growth rate in the sea and changes in life-history traits such as age at sexual maturity.

A limited number of whole-river experiments have been carried out over one to two Atlantic salmon generations in Ireland and Norway. The experiments typically show reduced spawning success of escaped farmed salmon and a reduced survival of their offspring in the river as juveniles (until outmigration as smolts) and in the ocean as post-smolts and maturing salmon. Some experiments with early free-living life stages suggest that there may be periods in the life cycle of Atlantic salmon

when it may be beneficial to have one or two farmed parents in competitive interactions with wild salmon. On the other hand, the presence of a potential predator on early salmon juveniles, like brown trout, changes early-life survival in favor of wild offspring.

From those experimental results, the question may be raised whether the apparently mal-adapted farmed salmon have an effect on the better-adapted wild salmon. Models show reduced average fitness in populations and meta-populations receiving escaped farmed salmon and also in general, but not always, show a relatively rapid rebound of average fitness if escapes can be stopped.

A recent review paper by Kevin Glover et al. (2017) in *Fish and Fisheries* 18: 890-927 provides references to many of the results presented. Among the remaining knowledge gaps are knowledge about how introgression varies over the lifetime of a wild salmon cohort, how it varies spatially and temporally among the many rivers that hold wild salmon, and if there are threshold rates of escapes that some wild populations might tolerate. The industry still needs to focus on preventing escapes and/or preventing salmon that escape to spawn in the wild.

One speaker (Tony Farrell) presented a physiological study on how Atlantic salmon and sockeye salmon react to viruses whose impact on wild salmon remains contentious. A respiratory performance model was used to investigate how individual fish reacted to a piscine orthoreovirus infection. The study provides an example on how physiology can provide science advice to aquaculture and fisheries management.

## SELECTIVE BREEDING

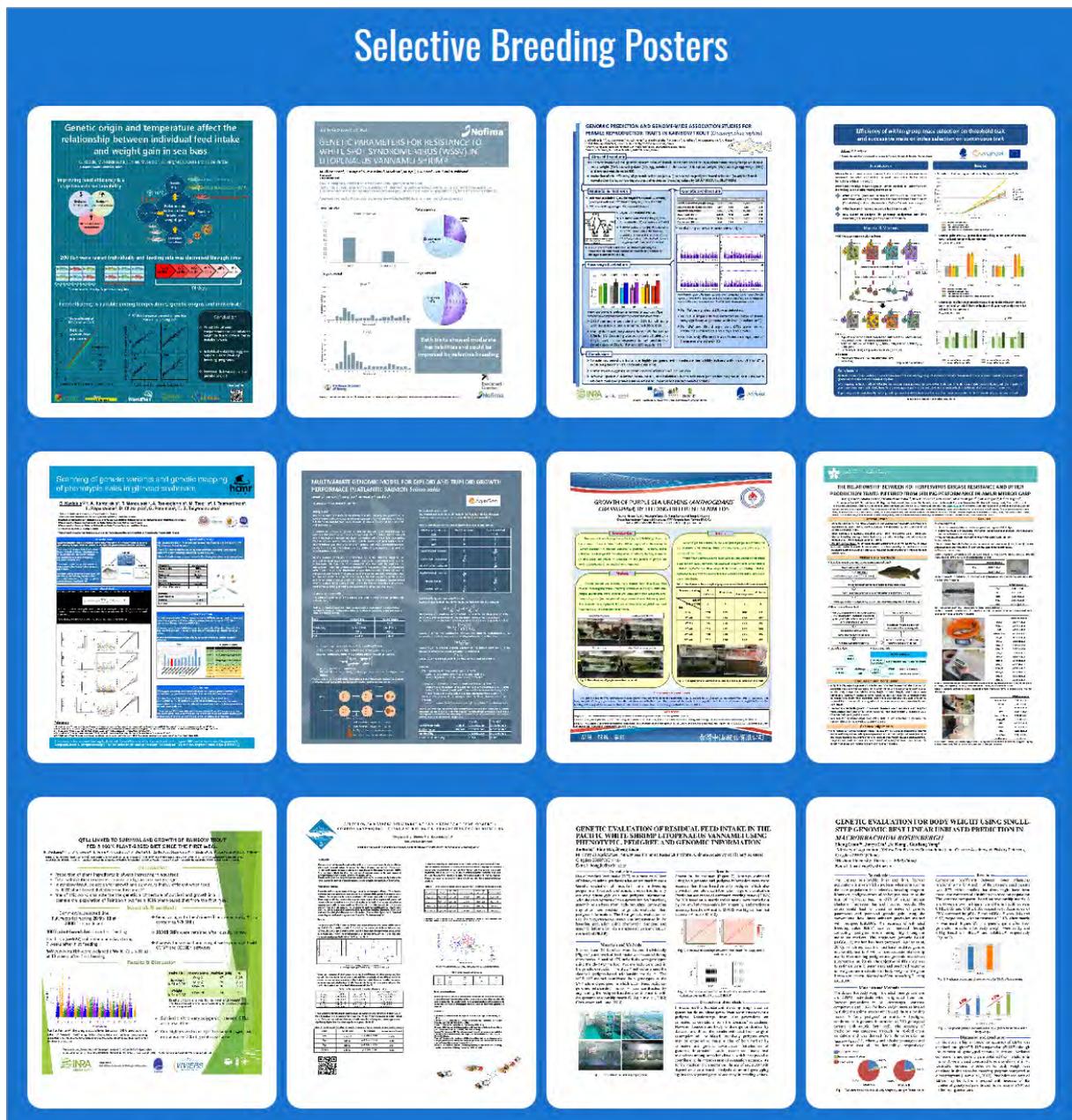
**Chairs: Christos Palaiokostas (SLU, Sweden) and Marc Vandeputte (INRA, France).**

The selective breeding session covered a wide range of genetic and genomic approaches aiming to improve some of the most important aquaculture species globally, including Atlantic salmon, Nile tilapia, European seabass, gilthead seabream, King prawn and Pacific oyster. During the session novel approaches of phenotyping, genotyping and prediction models were presented. The traits of interest included growth, feed efficiency, fillet yield, slaughter quality traits, disease resistance and general robustness. Novel phenotyping approaches were introduced for recording feed efficiency traits with the assistance of video recording or stable isotopes, and for monitoring slaughter quality either with the usage of computerized tomography in the case of Atlantic salmon or using digitized morphological predictors in the case of common carp.

The aforementioned traits were studied using a variety of genotyping strategies. In particular, presented studies utilized either SNP arrays or genotyping by sequencing approaches to either identify genomic regions associated with the trait under study or for genomic prediction purposes. In all presented cases there was a significant advantage of genomic tools for breeding value prediction compared to the traditional pedigree-based methodology. The advantage of genomics was higher in cases where the trait could not be recorded in the selection candidate per se, as was the case in disease resistance studies. Furthermore, low coverage genotyping by sequencing was applied in the case of Arctic charr as a cost-effective alternative for applying genomics in small to medium sized aquaculture breeding programs.

During the session commonly encountered statistical models from the area of animal breeding were applied and compared in a wide range of traits. In general, the robustness of genomic best linear unbiased prediction (GBLUP) was confirmed, with occasional small differences regarding prediction accuracy with the Bayesian regression alternatives. Finally, novel machine learning models were utilized for predicting *pasteurellosis* resistance in gilthead sea bream, and growth potential in the same species. These models included the support vector machines (SVM) and linear bagging. Both of the above models were compared to Bayesian regressors that are commonly utilized in animal breeding studies. Especially, in the case of *pasteurellosis* resistance, application of machine learning resulted in significantly higher accuracy.

Overall, this session gave an overview of the latest applications and of novel approaches in selective breeding with an excellent scientific level.



**Chairs: Camille Saurel and Pernille Nielsen (Danish Shellfish Centre, DTU-Aqua, Denmark).**

The Mollusc production and restoration session included 13 oral presentations and 13 Eposter covering 9 countries including New Zealand. All presentations dealt with bivalves. Most of them presented new interesting results that sparked interest and excellent questions from the audience. The average attendance was between 20-40 people. The session covered various issues related to culture innovation for restoration and production, nutrition, use of biomolecular tools and eco-physiological modelling and mussel mitigation culture for nutrient removal.

### **Restoration and innovation**

Initiatives for flat oyster restoration have increased over the past years and are now well represented under the NORA network. A presentation described the flat oyster (*Ostrea edulis*) population in Denmark as stable and colonizing new areas. However, new challenges and risks were discussed in relation to restoration initiatives, such as genetic biodiversity, biosecurity, predation and mixed beds with Pacific oysters.

In the Netherlands, several initiatives have already started for flat oyster restoration, in particular population enhancement for scour protection of offshore windfarms. Results on substratum preference for larvae settlement in Ireland and Netherlands were discussed in view of optimizing oyster deployment in offshore conditions, with the best settlement on mussel shells. Larvae settlement is a bottleneck in hatchery production where neurotransmitters are often used to induce metamorphosis. One presentation investigated new promising pathways regulating bivalve metamorphosis to induce synchrony and reduce mortality of larvae in view of optimizing hatchery productivity. Another presentation investigated how the C/N homeostasis in fast and slow growing juvenile manila clams (*Ruditapes philippinarum*) from different families was affected by dietary N content. Fast growing seeds were able to maintain C/N homeostasis, whereas slow growing seeds had different degree of homeostatic regulation of C/N composition between families.

### **Threats and culture practice**

Culture practice can be challenged by predators and commercially damaging species and require new tools and data for a better management. The Asian oyster drill (*Ocenebrellus inornatus*) has become a pest in the Netherlands where up to 80-90% of cultivated oysters are lost. New data on feeding behaviour and mobility were gathered in order to propose a solution to prevent high oyster mortality, such as using mussels as “bio-barriers” to reduce the oyster drill progression to the oyster beds. In the UK, new tools to identify the commercially damaging mussel species *Mytilus trossulus* and fight against its spread were developed. The tools included a combination of morphological data, shell strength and shape assessment that were supported by genetic analysis.

### **Low-trophic organisms culture optimization**

Modelling tools can support pilot studies and further economic analysis for the development and implementation of sustainable aquaculture of low trophic organisms. In a presentation, eco-physiological models for *Mytilus edulis* and *Ciona intestinalis* (Dynamic Energy Budget, DEB) were coupled with a spatial model including nutrients, phytoplankton, zooplankton in order to evaluate the ecosystem effects and potential biomass production of the two species in a specific upwelling

forced system in Norway. Results indicated that tunicates were more efficient than mussels to remove phytoplankton and grow biomass.

### **Mussel mitigation cultures**

Six presentations focused on the production potential of mussel (*Mytilus* sp.) farming in the Baltic Sea and UK as a mitigation tool for removing nutrients and improve water quality. Optimization of culture practices, via farm configuration, mussel density and substratum showed the capacity to remove up to 2.5t N/ha in Danish waters in 6 months, with smaller mussels intended as feed rather than food. In the UK, mussel longline culture had a higher nutrient removal potential above 8 kg N/t of fresh mussel in comparison with bottom culture. In the Baltic Sea under variable and low saline water regime, using DEB modelling for individual growth in function of key environmental parameters, it was shown that mussel production was possible and should be complemented with economic studies to assess the best size for the end product of such farming.

The spatial modelling of blue mussel farm production potential in the Western Baltic Sea was conducted by integrating mussel growth field data and DEB modelling, national monitoring data, numerical, statistical and spatial modelling. The use of Zebra mussels (*Dreissena polymorpha*) was also discussed in relation to water quality improvement in the Baltic Sea and as an option for blue growth and water policy implementation. In the Oder Lagoon, potential for local use and water transparency are of interest by local stakeholders. Social and local acceptance was the focus of another study comparing Danish to German locals' views on mussel mitigation farming in their back garden. Local history and the level of ignorance regarding mitigation farming played a strong role in the acceptance from local citizens. Emphasis on water quality and inclusion of local stakeholders in all the steps of mussel farming implementation could improve acceptance.

### **Conclusions**

No plenary discussion was held as a conclusion of the session. The session highlighted how mollusc aquaculture is dependent on environmental conditions and how it can offer various ecosystem services with good management. This interdependence brings vulnerability to mollusc aquaculture coming amongst other from natural food supply, recruitment conditions and major threats such as predators, diseases and climate change.

An ecosystem-based approach including innovation in culture and hatchery practices, with the help of different tools (modelling, genetic, molecular) for a better understanding of physiological and growth mechanisms and threats are keys for improving low-trophic species production such as molluscs; these topics would be worth to be addressed in future EAS conferences.

**Chair: Daniel Źarski (Institute of Animal Reproduction and Food Research of Polish Academy of Sciences, Olsztyn, Poland).**

The focus of the session included a wide range of topics related directly to the intensified production of percid fish, at a European level primarily on established production of Eurasian perch (*Perca fluviatilis*) and pikeperch (*Sander lucioperca*). The session included 14 presentations presented by researchers from 6 countries, where aquaculture of percid fish is of increasing importance.

The session started with an overview on the possibilities of application of chromosome set manipulations and sex control in Eurasian perch, presented by Carole Rougeot from University of Liège (Belgium). This presentation provided background for a discussion on how alternative production strategies could contribute to the expansion of sector. The next talks focused on different factors which have a direct effect on the reproductive outcome. Marcus Stueken (Mecklenburg-Vorpommern Research Centre for Agriculture and Fisheries, Germany) with his research addressed the effect of light spectrum on the gonadal development of pikeperch giving a significant insight into the standardization of broodstock management of this species in RAS.

Next, Oleksandr Malinovskyi (University of South Bohemia, Czech Republic) presented research aimed at finding the most optimal substrate for spontaneous spawning of pikeperch in the ponds. Leila El Mohajer (University of Lorraine, France) presented an in vitro study aimed at finding a suitable maturation inducing steroid, which could be potentially used in synchronization of ovulation in Eurasian perch. In the following talk Uros Ljubobratovic (NAIK HAKI, Hungary) supplemented the knowledge on hormonal control over ovulation by presenting recent results on different hormonal induction strategies on gamete quality in pikeperch during out-of-season spawning. This presentation was supplemented by the presentation of Daniel Źarski (Institute of Animal Reproduction and Food Research of PAS, Poland) who focused on the immune and stress response of pikeperch males to hormonal stimulation, being an important aspect in determining the choice of hormonal therapy to be used in cultured broodstock.

The morning session was closed with the presentation of Gergely Bernath (Szent Istvan University, Hungary) who focused on the methodical improvement of sperm cryopreservation in Volga pikeperch (*Sander volgensis*), which is a potential new candidate percid species for the European aquaculture sector.

The afternoon-part of the session began with a presentation by Edson Panana (INAGRO, Belgium) on the effect of photoperiod on the larval performance of pikeperch reared under the intensive culture conditions. In the next talk Aiman Imentai (University of South Bohemia, Czech Republic) focused on the possibility of application of rotifers (*Brachiuonus plicatilis*) in the feeding of pikeperch larvae, having potential for improvement of larval performance during intensive culture.

Another presentation, given by Katarzyna Palińska-Źarska (University of Warmia and Mazury, Poland), shed light on the adaptability of Eurasian perch larvae to the compound diet by an experimental approach involving the nutritional challenge of the larvae coming from either domesticated or wild stocks. The nutrition challenge of pikeperch juveniles with compound feeds containing alternative protein sources was the research question addressed by Sandra Langi

(University of Ghent, Belgium) highlighting the importance of fish meal replacement in pikeperch aquaculture.

The next two talks came from researchers at Mecklenburg-Vorpommern Research Centre for Agriculture and Fisheries (Germany) where the aspects of light colour (presented by Stefan Heidemann) and feeding management (presented by Tobias Rapp) in intensive culture of juvenile pikeperch highlighted the huge plasticity and/or adaptability of this species to different farming practices. The last talk, given by Alain Pasquet (University of Lorraine, France), provided the first scientific insight into the possibility of polyculture of different species (such as sturgeons or common tench) together with pikeperch in RAS, being a potential strategy toward the enhancement of economical efficiency of production.

Each presentation stimulated lively discussion and an interesting exchange of knowledge among the participants constituted by representatives of research organizations and private stakeholders. This highlights the importance of open communication within the sector based on scientific achievements. It should be pointed out, that all the research findings presented during this session were strictly applicable and of commercial relevance. This indicates, that the research activities in the field of percid fish has shifted considerably, during the last few years, from determining the basic culture protocols toward industry-oriented applied sciences.

However, it has to be emphasized that the scientific data presented during the session were still addressing the establishment of robust, consistent production technology by exploration of the effect of various factors (such as light colour, type of food or hormonal stimulation) on the physiological status, overall performance and/or adaptation of the fish to the culture condition, without addressing the selection strategy and/or breeding programs being carried out (or planned to be implemented).

This indicates that the production technology of percid fish, although established in Europe, is still in its development stage. On the other hand, the kinetics of changes observed and overall knowledge already acquired clearly highlight the potential for future expansion of this emerging sector. The discussions carried out during the session as well as behind the scenes indicates that the pace of development will strictly depend on the degree of collaboration between the stakeholders (both, research organizations and private entities), being an indispensable element of expansion of percid aquaculture.

**Chair: Laszlo Varadi (NACEE, Hungary).**

Supported by NACEE



This was the first time in the history of EAS conferences when a special session on Eastern European aquaculture was organised. The session had two parts: a scientific session with presentations and a panel session with keynote presentations and open discussion. The session was organised by the Network of Aquaculture Centres in Central and Eastern Europe (NACEE).

The event was attended by speakers and participants from Croatia, the Czech Republic, Germany, Hungary, Italy and the Russian Federation. In the six oral and six poster presentations of the scientific session, new results of ongoing and recent research aiming at the development of freshwater aquaculture were discussed. The presentations demonstrated well that there are new opportunities in freshwater aquaculture through the modernization and sustainable intensification of traditional cultivation of carps in ponds and trout in raceways. There are good examples for the application of biotechnology and precision farming in pilot systems in the freshwater aquaculture sector.

**During the panel session, the participants discussed a number of issues including the trends of aquaculture development in the CEE region and in individual countries, environmental services provided by pond systems and their quantification, environmental status of fish ponds, food safety issues, genetic properties of individual fish species and precision farming in intensive farms.**

The participants took note of the ongoing revision of the 2013 Commission Strategic Guidelines for the sustainable development of EU aquaculture, and underlined the importance of adequately representing the environmental, social and economic role of pond aquaculture in the new Strategic Guidelines. It was noted that the economic potential of pond aquaculture was largely overlooked in the EU, although there were many innovative solutions available for the sustainable intensification of its production. It was also highlighted that pond aquaculture, especially in combination with intensive production (combined intensive-extensive systems), could be an efficient and sustainable biomass-producing sector with a significant potential for waste minimization, and could play an important role in reaching the EU's strategic objectives of climate neutrality, preservation of rural areas, improving the quality of surface waters, developing circular economy, improving employment in inland areas and providing the population with nutritious, affordable and safe food. The participants also reiterated the importance of further developing recirculating aquaculture systems (RAS) for a safe, controlled and continuous production of high-value species, as well as the need to further improve fish marketing and processing in the region.

One of the findings of the panel session was that further efforts were needed to improve the involvement of stakeholders of the freshwater aquaculture sector in the Central and Eastern European (CEE) region in European aquaculture programs and projects and to strengthen the

collaboration between the Western European and CEE regions. NACEE will continue and strengthen its activity to bridge the gap that still exists between these regions.

The findings and recommendations of the session were summarized in a draft Position Paper that will be distributed among stakeholders of European aquaculture sector after finalization.

## PATHOGENS, DISEASES AND TREATMENT

**Chair: George Rigos (HCMR, Greece).**

The PATHOGENS, DISEASES & TREATMENT session included 14 oral presentations and more than 70 posters, representing one of the most targeted aquaculture disciplines for knowledge dissemination in this Conference. Presenters originated from several countries such as Chile, Turkey, Norway, Portugal, Germany, Spain, Norway, Mexico, Italy, Greece and UK. Since this session was scheduled for the last day of the Conference, participation was inevitably relatively small. However, the selected talks stimulated several questions from the audience and a pleasant brainstorming was taken place.

Talks included:

The role of epidemiology in the surveillance and control of prevalent fish diseases – the case of sea lice in farmed salmonids in Chile presented by Gabriel Arriagadahe. This talk highlighted the role of epidemiology as a tool in surveillance and control of sea lice. Epidemiological quantitative methods have been successfully used to: a) evaluate the field efficacy of antiparasitic drugs on different sea lice developmental stages (i.e. juvenile, adult males, gravid females); b) to provide the first evidence of the sensitivity loss of sea lice to the organophosphate azamethiphos; and c) to demonstrate the beneficial effect of the synchronization of antiparasitic treatments among farms within an area.

Enterobacter infections of cultured rainbow trout *Oncorhynchus mykiss* presented by Dilek Okmen. This study aimed at the determination Enterobacteriaceae infections of rainbow trout cultured in freshwater cage farms by using conventional bacteriologic, molecular and histopathological methods. The need for the use of molecular methods in the identification of fish pathogenic Enterobacteriaceae species and the detailed differences of pathologies these emerging pathogens in rainbow trout were demonstrated by using histopathological methods.

Robust salmon skin – is there a genetic component given by Trina Galloway. This work investigated the effect of genetics on wound healing and resistance to this bacterium, in order to improve skin robustness in Atlantic salmon. It was stressed that wounds caused by mechanical injuries and/or pathogens and create welfare issues for farmed fish and economic problems for fish farmers. Even gentle handling increased the pathogenicity of *Moritella viscosa*. The present study also showed that healing of mechanical wounds and *Moritella viscosa* mortality can be improved by breeding. The results seemed promising and will be supplemented with genomic selection, fine mapping and transcriptome studies, and studies of the combined effects of genetic selection, optimal diets and optimal vaccines on improved salmon skin robustness.

The multiple functions of piscidins in the European sea bass *Dicentrarchus labrax* by Carolina Barroso. This study characterized the piscidin family in sea bass. The expression of piscidin genes is evaluated under different stimuli, as well as the antimicrobial activity of piscidin peptides against several fish pathogens. The findings indicated that, in vitro, piscidin peptides have a direct effect against pathogens. However, different outcomes were observed for the piscidin genes during experimental infections.

Comprehensive approach to development of common carp strains resistant to diseases caused by infections with CYHV-3, CEV and SVCV presented by Mikolaj Adamek. The results confirm a wide geographical distribution of both PRV-1 and PRV-3 in Atlantic salmon and rainbow trout in Germany but also in continental Europe. However, a clear association with disease was hampered by the presence of an *A. salmonicida* co-infection. Furthermore, PRV-3 is present in German brown trout populations but is not the causative agent of PDS. Nevertheless, potential diseases induced by PRVs should be considered when investigating mortalities in salmonids.

Familiar variation explains reduced protection of commercial vaccines against bacterial pathogens in Atlantic salmon by Jose Gallardo. The objective of this study was to provide evidence that supports that the effectiveness of a commercial vaccine against *P. salmonis* in Atlantic salmon mainly depends on the host's genetic variation. It was concluded that manufacture of vaccines for salmon should move towards a strategy of precision medicine, including the genetic variation of the host as a key element for the development of effective vaccines against *P. salmonis*.

Vaccines induce a significant immune response but not a robust neuroendocrine reaction in brain and pituitary tissues of seabream *Sparus aurata* by Lluís Tort. Overall, it was stated that vaccination procedures, although showing a clear cortisol response, did not induce other major stress responses in brain or pituitary, regardless the administration route and the type of vaccine at the doses tested. Moreover, from the results obtained in this work, it is also clearly demonstrated that the immune system maintains a high activity in both brain and pituitary tissues after vaccine injection, as shown by the enhanced activity of the relevant immune associated cytokine genes as well as the innate immune genes assessed in these tissues.

Nucleic acid vaccines are effective for control of viral infections and disease in salmonid aquaculture by Paul Midtlyng. Recent information and results emerging from the use of DNA vaccines against IHN, PD and other viral infections of salmonids in clinical trials and in the field were summarized and discussed in this talk. All of the viral infections mentioned are widely spread in European aquaculture, yet the transfer of highly successful research into vaccination practice is slow or non-existent. The reasons for and potential ways to remedy this situation were discussed in detail.

Use of bacteriophages to control *Yersinia ruckeri* in salmon farming by Hans Petter Kleppen. The study presented data from field trials carried out at salmon farms in Norway, showing that a novel bacteriophage-based product, CUSTUS™YRS, can effectively control infection pressure from *Yersinia ruckeri* in water.

Antiviral effects in *L. vannamei* of feed additive of microencapsulated phenolic extracts of *M. umbellata* by Hector Abelardo Ocampo. The aim of this study was to determine the stimulation of a microencapsulated *Malpighia umbellata* phenolic extract of the immune response of *Litopenaeus vannamei*, in laboratory conditions, against the white spot syndrome virus (WSSV). The outcome revealed that the addition of microencapsules containing leaf extract of *M. umbellata* stimulated the

expression of antioxidant enzyme genes, mainly at 48 h and especially proPO. The addition of microencapsulates containing leaf extract of *M. umbellata* had no effect on the Shrimp Specific Growth Rate. On the contrary, it had a positive effect on the survival and prevalence of SVMB, mainly at 30 days of bioassay. Overall, *M. umbellata* represents an alternative for the prevention and treatment of SVMB of shrimp *L. vannamei* that can contribute to improve the culture and production of this crustacean.

1-monoglycerides of short- and medium-chain fatty acids proved to be effective in decreasing the mortality caused by *Flavobacterium psychrophilum* and in reducing the antibiotic treatments in rainbow trout *Oncorhynchus mykiss*, with favorable economic return for the fish producers by Parini Manuela. It was concluded in this talk that the 1-Monoglycerides composition proved to be effective in decreasing the mortality caused by *F. psychrophilum* and in reducing the antibiotic treatments in the trout hatchery phase, with positive economic return for the fish producers. It can be taken into consideration as a valid and promising alternative approach, complying with the EU and global policy for antimicrobial resistance reduction.

Toxicity of peracetic acid (paa) products: impact of water quality, product composition and fish species by Dibo Liu. This presentation addressed 1) how water parameters affect the degradation of PAA, 2) how composition of PAA products affects their toxicity to aquatic animals and 3) how fish species differ in their sensitivity to PAA. It was stated that the complex influences of several biotic and abiotic factors on the toxicity of PAA. For this reason, strategies for successful prophylaxis with PAA in aquaculture facilities should be customized according to the onsite situation.

Pharmacokinetic comparison of different dosing strategies of in-feed administered praziquantel in greater amberjack *Seriola dumerili* by Dimitra Kogiannou. The aim of this study was to investigate the distribution profile of dietary administered PZQ in greater amberjack following a multiple oral dosing as a first step to optimise PZQ dosing regimens for this species. In conclusion, the results of this study revealed that under a 24h dosing interval for 5 consecutive days, the anthelmintic concentrations exhibit significant fluctuations in greater amberjack plasma. Based on the information obtained from the PZQ analysis there is an apparent benefit from the double dosing schedule (split in 2 feedings per day) as seen from the higher achieved plasma PZQ levels and thus this would be the suggested dosing against *Z. seriolae*.

Deltamethrin resistance in salmon lice: mitochondrial and nuclear single nucleotide markers by Claudia Tschesche. Deltamethrin resistant *L. salmonis* was not cross resistant to etofenprox. The allele frequency of the putative kdr mutation a3041g did not correlate with DTM resistance. Thus, DTM resistance in *L. salmonis* seems to be unrelated to target site mutations in Nav1. Significantly higher allele frequencies of all tested mt SNPs in DTM resistant lice than in susceptible lice indicate an association with DTM resistance. However, while SNP t8600c, leading to the missense mutation Leu107Ser in COX1, was present in all DTM resistant lice, it was also found in some susceptible lice.

**Chair: Bela Buck (Alfred Wenger Institute, Germany).**

In the session "CAGE SYSTEMS AND OFFSHORE STRUCTURES" contributions were made on new cage and longline structures that can be used in the offshore (exposed) area and on the multiple use of existing offshore structures, which are already in place and are used for other purposes, but can also be co-used for aquaculture.

An important aspect of working in high energy environments with aquaculture is the robustness of the technologies used. They have to withstand the high loads and at the same time allow easy handling of the cultured aquatic product. The physical parameters at the location, such as significant wave height, current velocities, depth and wind, play an important role.

There are new innovative approaches for longlines for mussel culture, some of which focus on system design, buoyancy (controlled by smart devices) and orientation in relation to wave and current direction. Supportive for site-selection could also be the use of satellite-based data collection.

Site selection is a particularly important aspect for cage systems. The required data sets have to be collected over a longer period in order to determine the maximum loads as accurately as possible. In order to reduce the loads, new technologies must be developed to reduce biofouling, as diving is dangerous and expensive and automatic cleaning systems can damage the culture device as well as the cultured organisms.

It could also be shown that the idea of multi-use aquaculture in already used marine areas (e.g. offshore wind farms) is no longer just theory. Several practical approaches show success on a technical, biological, social and economic level.

For all aquaculture enterprises, which take place far out in the sea, there are a lot of positive innovations, which certainly facilitate the implementation. Nevertheless, there are open questions that need to be solved. These include permissions for implementation or clear legislation, affordable robustness for fish aquaculture systems, as well as a system-design for all candidates, which can easily be submerged and reappeared to surface.

### **Chair: Ignacio Fernández (ITACyL, Spain)**

How to produce enough and good quality juveniles is a cornerstone for sustainable aquaculture production. Depending the biological, physiological and environmental requirements for each fish species different technologies and practices at hatcheries and nurseries should be optimized and implemented.

The session included 7 oral communications and 17 Eposter communications (one not presented). Issue and species covered were very diverse (fish, microalgae, crustaceans, echinoderms, molluscs and other invertebrates commonly used as live preys during the initial stages of exogenous feeding like rotifers, *Artemia* and copepods), reflecting the European aquaculture diversification during the last years and representative of the research work performed by research institutions from European and Mediterranean countries (Denmark, Egypt, Germany, Italy, Norway, Malta, Portugal, Spain, Finland, and United Kingdom).

Although different organisms were studied, some common trends and issues were covered by the presented studies. Rearing water salinity was a major environmental factor covered on this session. Salinity might have a key influence on fish physiology and production efficiency, since working at an optimal salinity, organisms will save energy for osmoregulation. In this sense, Barbara Loi and Sebastian N. Politis showed as optimal salinity will increase growth and survival of grey mullet juveniles and European eel survival during early larval stages, respectively. Molecular studies on gene expression and enzyme activities might identify the clues of the physiological basis by which a particular salinity benefits hatchery and nursery production. Feeding sources (phytoplankton, live preys, and enriching emulsion) regimes (co-feeding) and technologies (microencapsulation) are still the focus from the nutritional point of view. Lipidomics, and percentage of inclusion and how to protect from leaching the protein hydrolysates in microdiets, were two aspects considered in order to identify nutritional requirements for increasing juvenile production of blue mussel and gilthead seabream, respectively (Alessandro Laudicella and Wilson Pinto, respectively). In this sense, the use of high-throughput technologies and physico-chemical properties of several compounds appeared interesting fields to explore in order to improve fish and mollusk nutrition practices.

One of the major outcomes of the session was to verify that in promising species for European aquaculture there is still room for big improvements applying basic research. One example is the study of the feeding regime to be applied during larval rearing. An example is the determination of the co-feeding strategy to improve larval rearing of Ballan wrasse and octopus species just analyzing the survival and growth (Jan Giebichenstein and Stefan Spreitzenbarth, respectively). In this sense, more complex and deeper analysis of different parameters (welfare, stress resistance and/or larval quality) might be required to advance towards an industrial scale production.

Finally, although the Hatchery technologies and practices session was held at the last day of the EAS2019 conference, between 15 and 45 attendants participated depending the oral presentation. Furthermore, they were very interactive, asking further details, exchanging doubts, thoughts and comments regarding the issues covered by the presenters. This demonstrate that there is still interest on collaborating and get updated on recent advances in rearing methods, technologies and protocols, alternative and innovative research lines of improving larval quality and production of different aquatic organisms farmed in European countries.

**Chairs: Laia Ribas (CSIC, Spain) and Julien Bobe (INRA, France).**

This short review summarizes scientific contributions presented during the Aquaculture Europe 2019 Conference concerning laboratory aquatic models and ornamental species for aquaculture research. The session included a total of 16 presentations: seven oral talks and nine posters. Speakers came from all around the world: Europe (Greece, Portugal, Spain, Norway, among others), USA and Japan.

Most of the presented research was carried out on zebrafish (*Danio rerio*) (six out of 16), but medaka (*Oryzias latipes*), goldfish (*Cyprinus carpio*), coral and Chub Mackerel (*Scomber japonicus*) were also represented as model species for aquaculture research purposes. This session covered several areas of aquaculture including reproduction, immunology, growth, genetics and stress.

**Reproduction.** The effects of irradiation with specific wavelengths on the growth and reproduction on sex differentiation was demonstrated by using the transgenic d-rR-Tg (olvas-GFP, strain ID: TG141) medaka. Results showed that the green light was able to induce female-to-male sex reversal in medaka), concluding that that irradiation using middle- to long-wavelength light during early developmental stage induced masculinization (Hayasaka et al., 2019).

**Immunology.** The work presented was the development of a suitable in vivo system to study whether infections occurring in fish during sex differentiation were able to alter the final gonadal phenotype throughout epigenetic changes. Results showed that stimulating zebrafish with LPS altered sex ratios by decreasing the number of males in a dose and family dependent manner in which the methylation and expression mechanisms were interfered in the final sexual phenotypic fate (Ribas et al., 2019).

Another presentation showed the microbiome of mucosal sites (gill, skin, digesta) and compared them between Pacific chub mackerel with that of southern Bluefin tuna (Min et al., 2019). The experiment collected large number of fish, almost of 300. Results showed that microbial ecology of mucosal microbiome from fish mucus revealed that skin and gill communities were more similar to the environment (i.e., water). This study demonstrated how environmental factors, such as temperature, influenced the mucosal microbial ecology and so, by studying the natural microbial variation and genome assembly, effects of increasing temperature stressors on parasite or bacterial infections can be tested to determine tuna health.

**Nutrition:** There is an increasing demand of corals and so it is required to generate a sustainable solution for coral delivery without compromising natural stocks. The study from Portugal tested different prototype diets for coral aquaculture based on three microencapsulated diets formulated by SPAROS. Data showed that tested diets effected growth, photosynthetic efficiency and cellular energy providing a good step forward developing suitable models for coral aquaculture (Costa et al., 2019).

The second talk on nutrition evaluated the possible health-promoting effects of two seaweeds: *Saccharina latissima* and *Palmaria palmata*, in zebrafish (Lokka et al., 2019). Seaweeds are rich in nutrients and contain various bioactive compounds with positive immune effect in both humans and animals. Gene expression profiling demonstrated that both seaweed species were able to induce a mild modulation of stress and immune-related gene expression in the intestine. Further, the capacity of tail fin regeneration between diet groups were also shown.

**Genetics.** The appearance of red eyes in ornamental koi carp is caused not by albino mutation but by another dominant demelanization mutation (R), which has partially decreased the quantity of melanin in both the skin and eyes. The aim of the study presented was to investigate inheritance and expression of red-eye koi mutation in koi x goldfish hybrids. The results showed that the dominant mutation R causing appearance of red eyes in koi resulted in the occurrence of unpigmented larvae with light lenses in hybrids obtained by crossing goldfish males with red-eyed koi females (Gomelsky et al, 2019).

**Stress.** The final presentation in the session, used two transgenic zebrafish lines of two glucocorticoid receptors which showed chronically elevated cortisol levels and anxious behavioural phenotypes. The study tested the behaviour of these transgenic zebrafish lines to assess their response to novel environments and their shoal cohesion. Results based on behavioural observations of fish in novel tanks showed alterations of standard exploration of new environments thus indicating the existence of the effects of gene editing on the behaviour and social perception in adult zebrafish (Theodoridi et al., 2019).

Overall, all presented data at the front of aquaculture research, showed the importance of the implementation of laboratory aquatic models and ornamental species into aquaculture research. The efforts in using model species are important to later transfer the knowledge into the production of cultured species in benefit to aquaculture production.

## EUROSHRIMP FORUM AND SHRIMP

**Chairs: Gregor Jähne and Matt Slater (AWI; Germany).**

A whole day of shrimp sessions was held in Exhibition Room 2, beginning with the Euroshrimp (industry) session and followed by the Shrimp scientific oral presentations session. 116 participants attended the sessions over the day. Thus, murmurs moved rapidly to “bring a chair” once the sessions began. A large and diverse set of speakers were invited and discussion was vigorous and the questions arising rigorous.

The Euroshrimp session began with certification of shrimp product from RAS systems in Europe. Stefan Bergleiter of Naturland, presented results of consumer and retailer survey indicating “bio” labelling is unlikely to be a reality in the near future for RAS shrimp, and Kathrin Steinberg, of the Aquaculture Stewardship council presented the ASC metrics and their aims to certify more shrimp producers in the future.

Improved economic efficiency through reduced salt costs for artificial seawater was presented by Andrew Ray of Kentucky State University, with a convincing new method for domestic salt inclusion. Eric de Muylder of Crevetec presented growth data from zero-water-exchange RAS systems and showed how *Vibrio* infections can be avoided through appropriate biofloc management. Nicola Scalise of Ecoshrimp provided a thorough insight into the hatchery establishment and operation process in Europe with many practical examples and outlined his view of the market and the space for providers of hatchery animals. This was exquisitely added to by an overview of Bernaqua’s Daniel Arana’s experience of larval production of shrimp worldwide. Nerijus Nika rounded off the session

with an overview of the shrimp research facilities in Lithuania at Klaipėda Science and Technology Park, while David Basset gave a highly enlightening (and entertaining) presentation of the EURASTIP platform and its networking of the shrimp sector in Vietnam, Thailand and Bangladesh.

While the discussion was lively, the consensus was that the sector is growing rapidly and enjoying strong investment and interest. There was great desire in learning from other nations, despite differences in shrimp production systems and methods. Warnings to avoid a “gold rush” and investment bubble were heard, and heeded. The importance of high quality European hatchery production in the near future was agreed although many hurdles, economic and otherwise, remain.

**The scientific session** was highly diverse but attracted a great deal of attention and discussion. Joao Reis showed how increased feeding rate over the production cycle could improve feeding regimes when compared with automatic-feeders based on acoustic feedback. Alexandra Segelken-Voigt presented on the optimisation of stocking densities in RAS systems on the basis of experiments conducted in northern Germany at a commercial shrimp farm. Eran Hadas presented data on moulting mortalities at his extremely high-density shrimp farming facility in Israel, with insights into how to reduce mortalities during moulting. Yustian Rovi Alfiansah of Uni Bremen showed the association of specific bacterial groups strongly associated with white faeces disease outbreaks and drew correlations to extreme salinity changes prior to outbreaks. Also addressing disease concerns, Vikash Kumar demonstrated the role of PIRAVB toxin in mediating the pathogenicity of *V. parahaemolyticus* during APHND outbreaks and showed how plant extract inclusion in diet can increase HSP70 production and induce shrimp resistance to APHND. Finally, Ulfert Focken of Thünen Institut in Germany presented data on the benthic infauna in ponds and at pond outlets in Brazilian shrimp pond farming areas, showing significant changes in diversity and density in response to intensive farming as opposed to low-density / organic farms.

The session interest was extremely encouraging. European shrimp farming stands at the threshold of possible ground-breaking expansion. Can it overcome the bottlenecks it faces and avoid being just another flash in the pan? Good, global shrimp science is being created with European inputs. Strong collaborations with colleagues in the global South are driving positive development.

### **Chair: Georgia Bayliss-Brown (AquaTT, Ireland).**

The Education, Knowledge Management, Transfer and Extension Networks session included seven oral presentations and three Eposters. Despite the title of the session, the abstracts submitted and accepted were focused on education and collaborative networks. The presentations sparked some interesting discussions, particularly between those presenting. The average attendance was between 10-30 people. The session covered various issues related to public perception, educational and career development programmes, and the use of technology to support network development. It was wonderful to see that many individuals felt that this session was important enough to stay until the very last minutes of the EAS conference to share their views, experiences and opinions; highlighting the value of this subject.

### **Public Perception**

The perception of the aquaculture sector is sensitive and divided in many countries. One of the presenters showed how the perception of aquaculture students in Spain changed over the duration of the course. Interestingly, the consensus in beliefs was greater before they participated in the course; reflecting a difference in sensitivity towards opinions over time. Among a broader profile of consumers, providing information on aquaculture can positively change perception. The second presenter analysed messages that were being diffused through Portuguese media and found that they were confused, unclear and misrepresenting the sector; commonly presenting mistruths and false imagery. The overriding message of these presentations was that we must be aware of the mixed perspectives within society and ensure that we are transparent in our communication and proactively present evidence-based information about the sector to ensure that perspectives are formed on fact.

### **Value in Collaboration and Knowledge Exchange**

Several examples of long-term and successful collaborations were presented. These activities were global in breadth and reach. The presentations highlighted the importance of developing educational networks and how sharing resources can lead to the enhancement and conception of new, high-quality degree programmes. Examples were provided for universities in South-East Asia in collaboration with European and North American universities and research organisations (e.g. EURASTiP and ASEAN).

Furthermore, technological innovations were shown to be used as educational tools: An app was developed to educate fish farms in Uganda, in collaboration with the USA, and it was observed that using the app strengthened the farming communities and productivity of the sector on the whole; as they shared best practice and management techniques with each other. The session was summed up with an overview of educational projects and programmes in Europe, many of which were presented in detail during the session; however, it highlighted a mismatch between the skillsets that are required by industry and those present in university leavers.

### **Conclusions**

The technical and managerial sophistication of aquaculture production systems and market chains is increasing. To ensure that the sector responds to emerging opportunities and challenges,

educational programmes must align with industry needs. This is occurring independently in some projects and through many knowledge-sharing, mutually-beneficial collaborations. It would be valuable for these projects and programmes to share their learnings, tools and approaches more broadly to accelerate the sector globally. In terms of public perception, it was agreed that it is responsibility of the whole sector - including stakeholders from science, industry and policy - to contribute to developing an informed and aquaculture-literate society.

## COMPOUNDS IN LIPID TRANSPORT

### **Chair: Åshild Krogdahl (Norwegian University of Life Sciences, Norway)**

Four presentations were given in this session, all addressing questions regarding impaired lipid transport across the mucosa of the proximal intestine in Atlantic salmon in seawater. They were all based on results from two, industry driven, projects conducted to generate information on the presence, the underlying mechanisms, as well as possible remediation of the frequently observed syndrome called lipid malabsorption (LMS). Severe outbreaks are characterized by steatorrhea, visible in the environment as floating faeces accumulating on the water surface and nearby seashores. In most cases, the symptoms are less pronounced and only visible upon opening of the abdominal cavity, macroscopically as foamy pyloric caeca, and histologically as hypervacuolation of the enterocytes. The occurrence of the symptoms appears to have increased as level of plant ingredients in the diets has increased, although the most severe symptoms have decreased in frequency.

The first presentation gave an overview of pathways of lipid metabolism in the gut mucosa and the many key components involved. The second described development of symptoms of LMS in six farms along the Norwegian coast from south to north, over one year's production. All farms showed symptoms of LMS, but no clear region differences were observed. Generally, the symptoms were more pronounced in the warmer periods than the cold. The two last presentations addressed possible remediations for LMS and showed results regarding the role of a selection of compounds, considered to play key roles in lipid transport, and which may be deficient in today's high plant diets, i.e. cholesterol, bile salts, phospholipids, choline, methionine and cysteine. The presented results indicated that phospholipids and choline are the first limiting factors for lipid transport across the gut mucosa, and that choline is an essential nutrient not only for the newly hatched, but also for the larger Atlantic salmon. In the last presentation an estimate of choline requirement was presented.

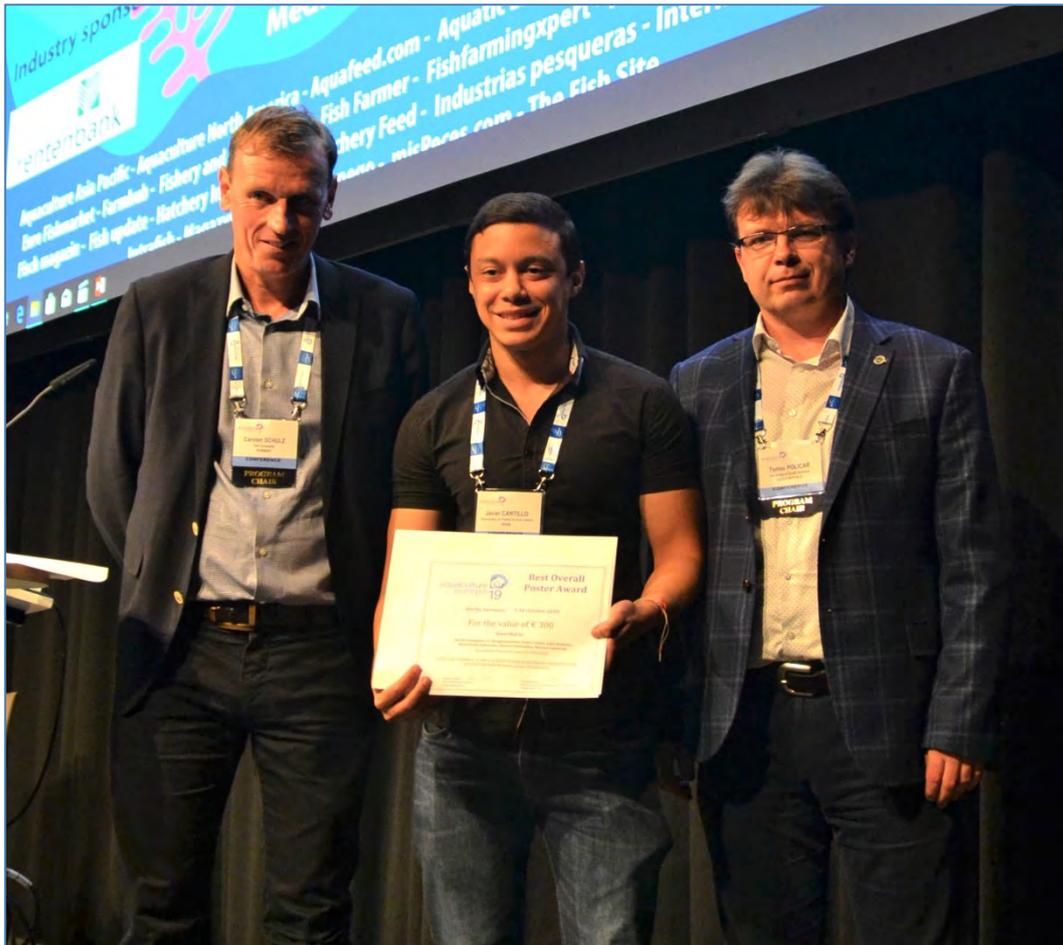
## AE2019 POSTER AWARDS

At each Aquaculture Europe event, 4 Poster Awards are made. In Berlin, the AE2019 Best Poster Award, the AE2019 Best Student Poster Award, the EAS\_Student Group Ibrahim Okumus Award and the AE2019 Lindsay Laird Award were presented.

For the two AE Awards, the posters of each session were assessed by the session chairs, and the best student poster and best poster for each session were attributed. These were then reviewed by the AE2019 Programme co-chairs to select the overall winners.

**Please click on the poster title to see the full PDF**





*Photo: Javier Cantillo (centre) collecting the Best Poster Award on behalf of David Dominguez, with Programme co-chairs Carsten Schulz (left) and Tomáš Polícar.*

## AE2019 BEST STUDENT POSTER AWARD

The AE2019 Best Student Poster was awarded to **Federico Castillo Cascino** of the Istituto Sperimentale Italiano Lazzaro Spallanzani, Italy and co-authors Lorenzo Proietti, Aldo Tava, Domenico Carminati, Marina Montedoro, Luciano Foglio and Katia Parati, for their poster entitled:

### [USE OF SPIRULINA \*Arthrospira platensis\* FOR DAIRY BYPRODUCTS TREATMENT: GROWTH AND QUALITY TRAITS](#)

Unfortunately, Federico was not present to receive his award in person.

## EAS STUDENT GROUP IBRAHIM OKUMUS AWARD

This award, presented at each of the EAS Aquaculture Europe events, honours the life of Professor Ibrahim Okumus (1960-2008) of the Faculty of Fisheries in Rize University, Turkey, and is awarded by the EAS Student Group. The prize money of €300€ was kindly provided by Kunststoff Spranger.

The winner of the 2019 Ibrahim Okumus award was **Diogo Peixoto** of ICBAS/CIIMAR, Portugal and co-authors Wilson Pinto, Rita Nogueira, Joana Silva, João Navalho, Jorge Dias, Luis Conceição, and Benjamin Costas, for their poster entitled:

**INNATE IMMUNE STATUS AND OXIDATIVE STRESS IN SENEGALESE SOLE *Solea senegalensis* POST-LARVAE FED MICRODIETS WITH *Nannochloropsis* sp. OR *Isochrysis galbana* INCLUSION.**



*Photo: EAS Board member Kathrin Steinberg with Diogo and his award.*

## AE2019 LINDSAY LAIRD AWARD

In 2008, AquaTT and Aqualex Multimedia Consortium established an award in honour of Lindsay Laird, Senior Teaching Fellow in the Zoology Department at the University of Aberdeen, for the most innovative poster submitted by a student at the Aquaculture Europe Conference.

The award this year was presented by Lindsay's daughter, Dr. Camilla Priede, and was awarded to **Nicola Rhyner**, from the Zurich University of Applied Sciences, for his poster

### [POST-STOCKING SURVIVAL OF HATCHERY-REARED ATLANTIC TROUT \*Salmo trutta\* L. IN TRIBUTARIES OF A PRE-ALPINE LAKE](#)



*Photo: Camilla Priede presents Nicola Rhyner with the AE2019 Lindsay Laird Award. Inset, Nicola with his certificate.*

**See also this article on the award at [The Fish Site](#)**





# The Blue and the Green



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Cork is a maritime city and port situated on Ireland's south coast. It is situated where the wild Atlantic Ocean meets the wandering gulf stream giving rise to clean and productive growing conditions for shellfish, salmon and sea vegetables. Here, where a traditional green economy rubs shoulders with an ever expanding blue one, we can begin to look into the possible synergies made possible by sharing a productive coastal catchment.

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