european aquaculture society

aquaculture europe 14

azti tecnalia

Adding Value

Donostia-San Sebastián, Spain
October 14-17, 2014

AE2014 Summary Report

Organisers

european aquaculture society

azti tecnalia

Gold Sponsors

BioMar

Supported by

EUSKO JAURLARITZA GOBIERNO VASCO

EKONOMIAREN GARAPEN ETA LEHIAKORTASUN SAILA

DEPARTAMENTO DE DESARROLLO ECONÓMICO Y COMPETITIVIDAD

GOBIERNO DE ESPAÑA MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

EUSKADI BASQUE COUNTRY

Donostia san sebastián TURISMO & CONVENTION BUREAU

Donostiako Udala Ayuntamiento de San Sebastián

Session sponsors

BioMar

AQUASOJA

Tereos Syral

OPE well

SKRETTING a Nutreco company

ARRAINA Advanced Research Initiatives for Nutrition & Aquaculture

IDREEM

AQUA EXCEL

AQUAGAMETE

This document summarises the reports of the AE2014 Parallel Sessions, as received by the session chairs. Only very simple language editing has been made by the EAS secretariat.

Information is also provided on the opening ceremony and the show cooking event organised on the opening day and the winners of the AE2014 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.

Compiled by the European Aquaculture Society secretariat.
November 2014

Photos courtesy of Yves Harache, Turker Boder, Meritxel González Intxausti, Mercedes Fernandez Monge and misPeces.com

Contents

Opening, show cooking and other plenaries

Organised by EAS in partnership with AZTI Tecnalia, Aquaculture Europe 2014 was attended by 1450 participants from 59 countries.

As is customary with AE events the welcome reception took place in the Kursaal Congress Centre on the evening before the conference. The Mayor of Donostia – San Sebastián, Dr. Juan Carlos Izagirre and EAS President 2012-2014 Kjell Maroni greeted participants to the event. On their way to the drinks reception, delegates were given a demonstration of the traditional Basque stone lifting *Harri jasotzea* with one lift of 250 Kg and a one-handed lift of 200 Kg! A heavy way to start the week!

The following morning, Adolfo Uriate of AZTI Tecnalia presided over the opening ceremony, where welcoming speeches were delivered by D. Andrés Hermida – Secretario general de Pesca del Ministerio de Agricultura, Alimentación y Medio Ambiente, D. Bittor Oroz – Viceconsejero de Agricultura, Pesca y Política Alimentaria and Kjell Maroni.

AE2014 started with the traditional Basque dance, Aurresku, to welcome dignitaries and delegates to Donostia – San Sebastián and to the Basque country.

While the first plenary was being set up, EAS made two special awards – Honorary Life Membership to Michael New, OBE and the EAS Distinguished Service Award to Dr. Yves Harache.

The AE2014 Steering Committee wanted to start the event with something different.

The Basque Country and Donostia-San Sebastián are a well-known international reference in the gastronomy sector. To relate to the overall conference theme, the idea of “adding value” to our products was therefore put into perspective through a show cooking event to remind all of us why we are working in the aquaculture sector.

Mikel Gallo, a renowned chef from Donostia-San Sebastián www.restaurantenineu.com prepared three dishes, while the suppliers of the ingredients and industry specialists commented on market, sustainability and sensorial and gastronomic values of the dishes.

Neli-Manuela commented on the status and potential of the algae sector, Arnault Chaperon talked about caviar and sturgeon, and Javier Ojeda commented on the turbot sector.

This is what Mikel prepared – and also how he did it!

Smoked mussel, algae consommé and cream of Idiazabal cheese and bourbon

Algae are extensively used in haute cuisine, due to their variety, textures, colour and flavour and they are gradually being introduced into other fields, such as domestic cuisine, as they are extremely healthy and highly nutritious. In the world of gastronomy, they are used for different dishes: salads, clear soups, creams, dressings. They are crunchy and gelling agents to create textures... They are particularly useful in the vegetarian world as they add a marine flavour in the form of a vegetable.

In addition to algae, this dish also includes another aquaculture product - mussels.

The mussels are cooked for 8 minutes and then smoked slightly on a grill. During this time, a consommé is prepared based on a vegetable bouillon dressed with flakes of dried tuna, nori seaweed and sea lettuce. A cream of cheese and bourbon is prepared using Idiazabal cheese, from the Basque country, bourbon and egg yolks.

Organic caviar, roasted egg at a low temperature and Iberian ham juice

In gastronomy, we have traditionally associated luxury with certain products that have a lot to do with aquaculture. Caviar is undoubtedly one of them, along with lobster, clams, oysters, king prawns, etc. In this dish, we use caviar with high added value: organically produced.

On one hand, we have the egg which is cooked in a water bath. This is a device that keeps the temperature stable whilst moving the water with a fan. The eggs are cooked at 63.5 ºC for 35 minutes. In this way, the egg coagulates in layers from the outside to the inside, obtaining an interesting texture.

An Iberian ham juice is prepared using only quality ham and water. The Iberian ham is cut and placed in water that is heated to 50 ºC. The pan is then removed from the heat, covered and left to infuse for an hour. After this time, the ham is removed and the water remains.

The base is a bed of mashed potato, on which the egg is placed, the ham juice is served and is rounded off with the caviar eggs.

Turbot confit with green curry

Different textures can be found in turbot: the upper part is juicier that the inside and depending on how it is cooked, the skin can be crunchy. Furthermore, on the lateral fins between the bones, we can find small tear-shaped pieces with a totally different texture: sweet and very juicy.

The turbot is glazed in extra virgin olive oil for 8 minutes at around 65 ºC. Once it has been glazed in a non-stick frying pan, the turbot is marked on both sides to obtain the crunchy texture on the skin. It is seasoned and put on one side.

A green curry is then prepared by roasting onions and crushing them with almonds and a series of aromatic herbs: lovage or marjoram, chervil, dill, tarragon, chives, peppermint and lemon balm. It is an extremely fresh and aromatic cream. It is dished up: A spoonful of this cream is used and the turbot is placed on the cream and is rounded off with some red shiso leaves.

On the second day, the plenary session focussed on the future of fish protein and adding value to our products. It was split into two presentations…

Michael T. Morrissey, Director of the Oregon State University Food Innovation Center presented "The Future of Fish Protein: Beyond Sustainability." The world population has been growing at an unprecedented rate and it is estimated that by the year 2050 the total population will be between 9-10 billion people. There have been numerous articles about the grand challenge of increasing the production of food protein to meet increasing population demands. It is estimated that this increment will require a doubling of the world food production especially in high quality animal protein. One of the reasons for the escalation in protein demand is the rapidly growing middle class sector in developing countries such as India and China. While much of the debate has focused on the energy costs, green-house gas emissions and environmental damage of animal protein production versus plant protein production, there has been little discussion of the role of fish protein production in this debate. This paper will review the current situation in fish protein availability for human consumption and its future role in meeting growing demand. In most cases fish protein production, provides environmentally sound and sustainable systems, especially when compared to land-based animal protein production sectors, such as livestock. Opportunities exist for expanding fish production systems as part of the solution for meeting increased demands for protein foods over the next three decades.

His presentation was followed by a case study of the marketing of fish products, by **Carlos Luna**, Managing Director of Angulas Aguinaga. His company sees great potential based on the launch of fish products that meet the demands of a new type of consumer – people who do not have much time to go shopping or cook, but who are increasingly aware of the importance of fish in their diet. New products are therefore required, which are easy to use, pre-cooked, fresh-cut, in individual portions, with a use-by date, sustainable, in environmentally-friendly packs, etc. That is, a range of "convenience" products that meets new needs. Although surimi-based products are its main market today, in the last five years it has included more products using prawns, salmon, octopus, mussels, etc. while promoting quality and innovation.

On the last day, the plenary sought to place aquaculture within our latest knowledge on climate change. Professor **Anil Markandya**, Executive Director, the Basque Climate Change Research Centre and one of the core team that drafted the IPCC 4th Assessment that was awarded the Nobel Peace Prize in 2007 presented the opportunities and challenges of climate change scenarios on primary food production, with a focus on European aquaculture.

Production activity of aquatic species (aquaculture) depends on factors such as water temperature and currents, energy consumption, carbon footprint, regulating prices and ultimately the competitiveness of each sector and country. His presentation contextualized these issues within internationally accepted climate change scenarios.

Parallel session summaries

The session reports are in the order that they appeared in the programme, except for the nutrition sessions that have been grouped.

Nutrition: Outputs of the EU ARRAINA Project

Chairs: Sachi Kaushik, INRA, France and Douglas Tocher, Stirling, UK.

This session provided an update on the outcomes of an ongoing EU – FP7 project ARRAINA[1], which started in January 2012 for a five-year period. Having come midway through the project, the session was an occasion to present the results to the general audience of EAS. There were 24 oral presentations and 19 posters. The first presentation by the co-ordinator dealt with the overall objectives and the descriptions of different work packages of the project. He pointed out that over the past years European research has demonstrated that it is possible to reduce FM and FO levels singly or in combination in the feeds for fish. However, several questions remained to be addressed such as whether what is obtained with juvenile fish up to marketable size can be extended to the whole life cycle; whether such dietary interventions can have effects during specific physiological stages such as very early life stages or broodstock; whether supply of nutrients based on available data on nutrient requirements are valid for all stages of fish fed diets low in FM and FO; whether fish can be tailored to accept such low marine diets.

The ARRAINA project addresses these issues using the top five farmed fish in Europe: Atlantic salmon, rainbow trout, common carp, European seabass and gilthead seabream. The presentations were made by different research groups and dealt with the different areas of research undertaken within the consortium. It was nice to see the presentations were made by PhD students as well as by senior scientists.

Some of the ARRAINA consortium members present at AE 2014

[1] http://www.arraina.eu/

A series of presentations dealt with evaluating and fine tuning data on micronutrient requirements of fish fed low fish meal low fish oil (low FM/FO) feeds. In the following we try to summarise some of the major points rather than going through all presentations.

- Dealing with micro-nutrient recommendations for Atlantic salmon when fed diets based on plant ingredients, study by Hemre et al. (NIFES, Norway in coop with BioMar) showed for instance that when plant-based diets are fed to Atlantic salmon, current recommendations of the NRC (2011) should be increased by about 50% for nutrients such as pantothenic acid, pyridoxine and niacin.
- Another presentation by Taylor et al. (Univ of Stirling in coop with NIFES, LNS and BioMar) showed that a reduction in dietary FM/FO level will require at least a two fold increase in the vitamin plus mineral premix (compared to the NRC recommended levels) in diploids and even much higher levels for triploid salmon.
- In gilthead seabream fed diets high in plant proteins and vegetable oils, the effects on bone morphology were studied by Dominguez et al. (Univ. Las Palmas, Gran Canaria in coop with NIFES and BioMar) who found that mineral mixture supplied at the NRC recommended level was sufficient to ensure proper bone development.
- A study by Carmona Antonananzas et al. (Univ of Stirling in coop with BioMar, LNS) showed that the intestine of young Atlantic salmon (<10g) is immature, not capable of *de novo* synthesis of phospholipids and that phosphoglycerides have to be supplied in the diet for normal growth and development.
- In the rainbow trout, the study by Belghit et al. (INRA) showed that dietary methionine level affects several factors involved in muscle protein turnover explaining the reduced somatic growth seen in fish fed feeds deficient in methionine.

Data from long-term studies with different species of fish fed low FM/FO feeds were also presented.

- In rainbow trout fed over the full life cycle with low FM/FO feeds, data on growth, reproductive performance and gamete quality were presented by Lazzarotto et al. (INRA).
- In the European seabass, Torrecillas et al. (Univ Las Palmas in coop with BioMar, INRA) showed that a level of substitution up to only 5% of FM and 3 to 6% of FO did not affect final growth, survival and disease resistance.
- The study by Cotou et al. (HCMR, Greece in coop with BioMar) showed the possible effects of dietary FM/FO levels on antioxidant defence systems.
- In the gilthead seabream, the study presented by Benedito-Palos et al. (CSIC, Spain in coop with BioMar, INRA) showed that growth performance and quality were not reduced in fish fed extremely low FM and FO feeds.
- In the common carp, a study by Ardo et al. (HAKI, Hungary) fingerlings fed vegetable oil based diets showed no reduction in growth performance, or innate immune response or disease resistance compared to feeding with FO.

In the area of developing novel nutrient vectors, data from a study with seabream larvae by Ghrab et al. (Univ Las Palmas, in coop with NIFES, Sparos and Univ. Insubria, Italy) on the effects of dietary Fe, Mn, Se or Zn supplied in different forms (organic, inorganic, nanometals or encapsulated) were presented. The study by Engrola et al. (Univ of Algarve, Portugal and Sparos) showed that

sonophoresis can be an extremely useful tool to modulate the composition of egg reserves, with promising results as regards free amino acids.

Four presentations dealt with the application and validation of the concept of “nutritional programming” early in life or through broodstock nutrition to modify the metabolic potential and possibly the acquisition of a changed physiological phenotype. This was shown in rainbow trout fed varying levels of proteins and carbohydrates or fed an “all-veg” feed during early life (Panserat et al. & Geurden et al. INRA), in gilthead seabream through changing the dietary fatty acid supply to broodstock fish (Montero et al. Univ. Las Palmas & BioMar) or through early nutritional stimuli in larvae (Rochas et al. CCIMAR, Portugal in coop with Sparos and INRA).

In seabream larvae fed on different types of microdiets having different physical properties, the consequences in terms of feed intake, feeding rhythms and digestive function were presented by Yufera et al. (CSIC, Univ Las Palmas and Sparos). Looking at the digestive tract of seabass, the study by CSIC provided original data on biomarkers of gene expression across the gastro-intestinal tract. These tools were also used to analyse the consequences of low FM/FO feeds by Estensoro et al. (CSIC, with BioMar and INRA). Two other presentations dealt with the analyses of transfer of undesirables from feed to fish with specific data from Atlantic salmon and gilthead bream (CSIC and NIFES). The possible interactions between contaminants and dietary vitamin A were also presented by Berntssen et al. (NIFES in coop with BioMar).

The sessions were well attended by scientists as well as private sector representatives and the discussions were positive and focused.

The Kursaal at Donostia – San San Sebastián. Home to AE2014

Nutrition: Alternative feed ingredients

Chairs: Marisol Izquierdo - Universidad de Las Palmas de Gran Canaria, Spain, Tiago Aires – Aquasoja, Portugal, Aires Oliva Teles - University of Porto, Portugal and Shuichi Satoh - Tokyo University of Marince Science and Technology, Japan.

Sponsored by Aquasoja and Tereos Syral

Four half day sessions spread over two days dealt with the potential and evaluation of different feed ingredients used as alternatives to fish meal and or fish oil. The sessions were chaired by different co-chairs and the presentations were made by young as well as senior scientists with the active participation of academia as well as industry representatives.

There were in all twenty eight oral presentations (plus two cancellations). Studies presented dealt with a number of freshwater and marine species: Atlantic salmon, rainbow trout, European sea bass, gilthead seabream, Senegalese sole, turbot, yellowtail, tuna, Asian sea bass, Arctic charr, Nile tilapia, silver catfish and white shrimp.

A wide range of ingredients were tested as alternatives to fish meal or fish oil. They ranged from plant protein sources such as soyprotein concentrate, wheat gluten, soybean or sunflower meals (in European sea bass, Costas et al.) and vital or hydrolysed wheat gluten (in rainbow trout, Apper et al.), non-starch polysaccharides (in Tilapia, Haidar et al.) to terrestrial or aquatic animal – derived protein sources such as squid meal (in tuna, Biswas et al), sardine waste protein hydrolysate (in silver catfish, Fabergat et al.), mussel meal (in Arctic charr, Vidakovic et al.) , poultry meal (in Atlantic salmon and rainbow trout, Masoval et al.) and insect meal (in gilthead seabream juveniles, Sardinha et al.). A study with yellowtail dealt with the development of non-fish meal feed based on a mixture of plant and animal protein sources (Satoh et al).

As regards fish oil replacement, an original study dealt with the potential of a novel EPA (eicosapentaenoic acid) rich plant oil derived from transgenic plant, *Camelina sativa*, in Atlantic salmon (Tocher et al).

Several studies focused on the potential beneficial effects of novel ingredients or additives such as solid state fermentation products (in rainbow trout, Bowyer et al.), of phytase (in shrimp, Gaxiola et al.) and of several probiotics (in salmon, Jaramillo-Torres et al.; in trout, Casado et al.; in sole, Batista et al.), besides glucanes or alginic acid (in turbot, Fuchs et al.), fructo- or xylo- oligosaccharides (in seabass, Gurreiro et al.), of potassium diformate (in Asian seabass, Luckstadt et al.) and of taurine or hydroxyproline (in European seabass, Peres et al.). The effect of inclusion of seaweeds in the feeds on the antioxidant capacity in rainbow trout was reported (Araujo et al.).

Besides growth and husbandry parameters, several criteria were used in the different studies to assess the effects of such ingredients or additives. As regards feed intake regulation, a study dealt with appetite regulating neuropeptides (in Senegalese sole, Bonacic et al.). At the intestinal level, parameters of gut health, changes in gut microbiota (in gilthead seabream, Martinez-Llorens et al.), immune response were used to assess the effects of dietary changes. In terms of metabolic changes, carbohydrate and lipid metabolism were dealt with (in European seabass, Castro et al.) with glucose tolerance tests (in Senegalese sole, Conde-Sieira et al.) and fatty acid profiles (Valente et al.) and

bioconversion capacities (Tocher et al.). Specific studies dealt with the use of vitro cell culture models (Rubio-Mejia et al.) and metabolomics (Cheng et al.) to analyse the effects of dietary fats and fatty acids. The effects of replacement of fishmeal and fish oil with either a blend of plant protein sources or a mixture of non-ruminant processed animal proteins (PAPs) and poultry fat in gilthead seabream were analysed especially with regard to environmental N and P loads (Ramalho et al.).

The sessions were focused with original scientific data presented covering a large area, providing new methodologies as well as practical data on the use of alternative ingredients for replacing fish meal and fish oil in the feeds of more than a dozen different species.

Nutrition: Requirements

Chairs: Jaume Pérez Sánchez (IATS-CSIC, Spain) and Vasilis Karalazos (BioMar R&D, Greece)

Sponsored by Biomar

This two day session focused on nutritional requirements, presenting research advances and providing new insights into aquaculture nutrition. Briefly, a total of twenty two oral presentations were presented on macro- and micro-nutrients requirements as well as bioenergetics, digestive enzymes and nutritional physiology. They covered a wide range of aquaculture species, namely salmonids, marine species (European sea bass, gilthead sea bream, turbot, cod, red grouper, ballan wrasse), carp, Nile tilapia, tambaqui and zebra cichlid, but also octopus, cuttlefish and bull frog. Lastly, different life stages were investigated from larvae to juveniles and growers.

Several presentations focused on amino acids requirements. Dietary arginine was shown to affect growth in juvenile salmon and to have a functional role in both juveniles and adults. Also, arginine supplementation improved the utilization of highly lipid diets for carp. Dietary methionine concentration and delivery strategies were shown to affect the mRNA transcript levels of genes involved in methionine metabolism in salmon juveniles. Moreover, L-Methionine and DL-Methionine bioavailability differed, but they seemed to be utilized equally well by salmon. Lower and upper thresholds of dietary sulphur amino acids levels were suggested for juvenile turbot. Moreover, at similar dietary EAA/Lys ratios, reduction of protein concentration did not affect the utilization efficiencies of protein or EAA in salmon. Lastly, trials in triploid Atlantic salmon demonstrated that dietary histidine can be increased to prevent the further development of cataracts while growth and FCR should be taken into account when estimating requirements.

Lipids and fatty acids requirements were also in focus in this session. Lipogenesis in rainbow trout was shown to be mainly regulated by dietary protein intake through the activation of TORC1 signaling pathway. European sea bass was shown to utilize efficiently a wide range of dietary saturated/mono-unsaturated fatty acids ratios even at very low EPA and DHA levels. Also, sea bass growth was largely not affected by dietary ARA. However, higher levels increased the immune response to infection. Lastly, it was demonstrated that EPA, DHA and ARA are essential FA at least during early life stages of cephalopods.

Other contributions investigated nutritional and physiological responses in early life stages. Feed restriction during first feeding of trout fry was demonstrated to have long-lasting effects on energy partitioning in later life. Cod larvae fed copepod nauplii had higher growth than cod larvae fed rotifers, while somatic growth rate associated with the contribution of hypertrophy and hyperplasia were changeable corresponding to standard length of cod larvae. Commercial diets were tested on farmed ballan wrasse during weaning and on-growing stage, revealing differences in survival, growth performance and intestinal structure. The existence of a clear diurnal pattern in tryptic enzyme activity was shown in gilthead sea bream larvae, which is likely to be a reaction to feed ingestion. A study on zebra cichlid showed that digestive enzymes are detectable at 0 dph and then gradually increase their activities from 3-7 dph and suggested this period for life food replacement by artificial diets. In octopus, water temperature affected the accumulation and consumption of inner yolk for embryos and paralarvae. Lastly, a study on Nile tilapia breeders suggested that vitamin C supplementation of at least 600 mg/kg increased progressive sperm motility.

Finally, in regards to macronutrients requirements, the dietary inclusion of up to 46% carbohydrates at either 4 or 8% lipid did not affect the productive performance of juvenile tambaqui. Another study suggested that dietary protein level of 42% and lipid level of 12 % was recommended for juvenile red grouper (*Epinephelus morio*). Lastly, the importance of lipid inclusion in the diets of bullfrog (*Lithobates catesbeianus*) was demonstrated indicating also that too high of levels may also have negative effects on growth. The plasma indicators of lipid peroxidation (TBARS) and main plasma antioxidant component (thiols) showed that the redox status of gilthead sea bream is affected by dietary lipid levels and water temperature.

Advances in disease and welfare

Chairs: Patrick Smith, Tethys, UK, Tore Kristiansen and Ørjan Karsen, IMR, Norway.

The Advances in Diseases and Welfare sessions of Aquaculture Europe 2014 comprised of three sessions including one dedicated to Welfare and the outputs of the EU COPEWELL Project (*see following summary*). The number of oral presentations made totalled 35 and there was a poster session comprising 54 poster presentations.

In addition, there was an EAS/EATIP Workshop on the Performance of the Sea Bass and Sea Bream Sector, part of which focussed on the Potential Impact of Fish Health/ Fish Diseases and the Availability of Veterinary Treatments.

The overall quality of the presentations covering Fish Health and Welfare at the EAS Conferences continues to improve and it has become a significant, and relevant, component of the Aquatic Animal Health ‘calendar’. Papers included reports of new and emerging diseases, diseases of new species, the effect of environmental parameters on fish diseases, nutritional diseases, functional foods, disease mapping, epidemiology, vaccine development against specific diseases and immunomodulation/ immunostimulation.

All of the papers made a significant contribution to our knowledge and the presentations were clear, concise and with sufficient time allowed for discussion. The level of audience participation reflected the high quality and content of the presentations. There was a great improvement in the number of

'no-shows' with only one in the sessions I chaired and, once again, this improved the 'flow' and attendance at the sessions.

The poster session also reflected the quality of the oral sessions and it is quite remarkable how the quality of the posters has improved over recent years in terms of content, clarity and readability. Once again, the posters showed a great variety of subject matter with a high level of 'new' content.

All –in- all, a valuable addition to the 'knowledge-pool' of the sector and an excellent contribution to a very successful Conference.

Summary of the Friday morning session, chaired by Ørjan Karsen, IMR, Norway:

The final session on Friday morning comprised 7 presentations.

The first investigated the effect of transporting juvenile cobia at 15, 24 and 33 g L^{-1} on stress response and mortality. Blood analysis showed reduced pH and elevated pCO2, and increased mortality at the highest densities, and the authors concluded that a transport for up to 8 hours at a density of 24 g L^{-1} was safe.

The use of gnotobiotic animals, where new bacterial communities in the gastrointestinal tract may be established, can be used to study host-microbe interactions. Gnotobiotic Nile tilapia were established by egg disinfection and sterile culture medium. Larvae were then challenged with *Edwardsiella ictaluri*. In contrast to previous studies, this study did not found that the larvae were more susceptible to infections. However, they showed that the gnotobiotic system may be a useful tool to study host-microbe interactions and evaluating new methods of disease control in for aquaculture production.

The parr-smolt transformation is challenging for Atlantic salmon, and the authors showed worsened gut integrity two weeks after sea transfer. The test feed reduced this, and reduced mortality in an IPNV challenging test, and therefore showed that optimized feeds may be used to better prepare the fish for the transfer to sea.

Cephalopods are now included in the new European Directive on animal protection of animals used for scientific purposes (Directive 2010/63/EU). The COST action CephsInAction was established as an interdisciplinary network of experts aimed to promote sharing of tools, training, dissemination, and to increase scientific knowledge to improve methods and procedures required for the care of cephalopods in different contexts.

Atlantic salmon is mainly bred for improved growth and disease resistance. However, other traits may also be favoured, as those that shows less stress response grow faster than those with high responders. Selection for rapid growth may therefore also select for low stress responsiveness. However, oxygen consumption data were presented that did not indicate that domesticated smoltifying salmon had stronger 1st day response, response decay rate or level of response after 13 days than a population originating from wild parents and hybrids of these two populations.

Farming of fish often involves practices that are stressful to the fish. In African catfish night feeding promoted growth, tested densities did not affect stress hormones, basal metabolism or aggression. However, added stress as air exposure increased aggression in the low density group, while adding

shelter to the high density group increased aggression and basal stress hormones. The results show that care should be taken in using objects as shelter/enrichment for African catfish.

A lecture was given presenting benefits using LED lighting systems, as both photoperiod, intensity and wavelength is easily manipulated. This enhances the possibility to adapt light regimes to the different farmed species.

Blood samples are often used to assess the health status of fish. It was shown that several of the commonly used enzymes linked to acute and chronic patho-physiologic changes as aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase and alkaline phosphatase may be affected by fish age and size. This study presented data that enhance the knowledge of the reference intervals for these enzymes for Rainbow trout.

Welfare: Outputs of the EU COPEWELL Project

Chair: Tore Kristiansen, IMR, Norway, Marie-Lure Begout, Ifremer, France and Michalis Pavlidis, University of Crete, Greece.

The session comprised 12 talks that addressed results from the EU FP7 Project: COPEWELL - A new integrative framework for the study of fish welfare based on the concepts of allostasis, appraisal and coping styles, where the target species are Atlantic salmon (Salmo salar), Gilthead sea bream (*Sparus aurata*), and sea bass (*Dicentrarchus labrax*). The project (2011-2015) consists of four work packages and the session had three presentations from each.

Individual fish within a population differ in production performance and how strongly they respond, behaviourally and physiologically, under stress conditions. The goal of **WP1 COPING STYLES** is to demonstrate the presence and consistency of individual variation in coping style in fish. The first presentation (Sebastien Ferarri) investigated comparative characteristics of coping styles in the three target species, while the second (Sonia Rey Planellas) and third (Marco Vindas) investigated the underlying mechanisms of individual variation using transcriptome analysis and neural characterisation of the brain. The presence of coping styles, characterized by e.g. high and low stress responders, high and low aggression, or proactive or reactive behaviour, is now well recognised in these species and their implications for aquaculture are broad. Various species dependent group sorting methods have been developed in the project.

Appraisal theories developed in cognitive psychology have been suggested to provide an operational framework to assess the animal's point of view. The large individual variation in stress responses in fish should not only depend on the situation to which the individual is exposed, but also on the cognitive evaluation that the individual makes of the situation, i.e. on the way the stressor is appraised. The main goal of **WP2 APPRAISAL** is to test the occurrence of cognitive appraisal in fish and how fish experience appetitive and aversive stimuli. In the first talk Magda Teles showed how cognitive appraisal drives neural and behavioural plasticity in zebrafish, and in the second Sandi Millot showed that conditioned place preference/avoidance test could be used to assess affective states in bass and bream. Al last Marco Cerqueira presented a study of how fish modulates the way they appraise their world by investigating how predictable and unpredictable events affect behaviour and physiology. This study showed that fish exposed to appetitive and aversive stimuli significantly

differed in their behavioural and physiological responses. This suggests that the fishes' response to stressors and positive events is modified by the way they cognitively interpret the situation.

A good understanding of stress physiology in sea bass is essential for a just evaluation of welfare and production. The main goal **WP3 ALLOSTASIS** is to demonstrate allostasis as fundamental regulatory process in fish. The first talk (Athanasis Samaras) investigated allostatic load and overload in seabass exposed to various intensity of crowding, the second (Angelico Madaro) investigated how long time unpredictable chronic stress and high allostatic load affected the regulation of the stress (HPI) axis in Atlantic salmon, both illustrated by stress hormones and gene expression in the brain and interrenals. The third talk (Jonatan Nilsson) investigated how predictable and unpredictable repeated stress of different intensity affected the stress responses, indicated by oxygen consumption and plasma cortisol. The three talks clearly showed predictive regulation of stress based in the both salmon and seabass, illustrating the concept of allostasis, constancy through change, where stress response is regulated based on experiences and expected demand. The studies also showed that during high allostatic load the cortisol response was down regulated also for novel stressors, but at too high stress level over long time the stress axis will be dysfunctional . The fishes' ability to perform allostasis and adjust their stress reactions to expected demands can be used to train the fish to respond more properly to the actual conditions and thereby improve their welfare and performance in aquaculture conditions.

The main goal of **WP4 ONTOGENY** is to study the ontogeny of neuronal function and neuroendocrine stress responses and to investigate the impact of early-life stress experiences on the ontogenesis: The first talk (Aleka Tsalafouta)investigated effects of early-life stress on performance and cortisol response in sea bass, and showed that exposure of larvae at early life stress resulted in reduced growth and more skeletal deformities. In addition, fish were more sensitive to common sampling practices as indicated by the elevated plasma cortisol levels at the juvenile phase. In the second talk (Hanne Johnsen) investigated effects of stress during embryogenesis in Atlantic salmon and showed results that indicated that stress exposure during early life stages may have the potential to induce long term effects on gene expression which is central to the functionality of HPI-axis. Further, embryonic stress may also alter responses in gene expression and endocrine changes to acute stress during later stages of development and may hold a potential for the production of a more robust and stress tolerant salmon in the future. In the third talk (Themis Tsarouchas) investigated how brain responses to acute stress are modified by early stress experiences by studying how adrenoreceptors and cell proliferation in the brain is affected by different levels of early-life stress exposure in sea bass. His results showed that chronic mild stress experience during early life can modulate acute stress responses in cell proliferation later in life and support the hypothesis that chronic mild stress during early postnatal life may be adaptive for future stressful environments

Advances in hatchery technologies

Chair: Alicia Estévez, IRTA, Spain.

The session included topics as diverse as the use of probiotics in live prey, enrichment of live prey with phospholipids, culture of new fish species (hake, seahorse, bluefin tuna, ballan wrasse) or the use of plant ingredients or low dietary lipid levels during larval culture or nursery.

Speakers were also from very different countries: Egypt, Germany, Hungary, Norway, Portugal, Spain, Sweden, Scotland, Turkey and the audience was also very different either in quantity or in participation.

Among the most attended presentations were the two presentations by C. Guevara-Fletcher about the best conditions for egg incubation and embryogenesis of hake *Merluccius merluccius*, the use of copepod *Acartia tonsa* on first feeding of Atlantic bluefin tuna and lobster by A. Hagemann, the use of low dietary lipid levels on post-larval growth of Senegalese sole by W. Pinto, the use of plant proteins for trout by S. Michl and the two presentations by I. Lein and A. Davie about the reproduction of ballan wrasse *Labrus bergylta*.

The session gave a good idea of the direction of research in larval production

- New species production (hake, tuna, ballan wrasse)
- Effects of new ingredients on juveniles (low lipids, plant proteins)
- Use of new live feed or new enrichment products (copepods, phospholipids, probiotics)
- Factors affecting larval survival (incubation temperature, predation, paternal care)

Interesting results were presented in the use of copepods for tuna and lobster feeding, as a way to increase survival and growth of the larvae, and avoid the use of other preys such as fish larvae in the case of bluefin tuna. *Acartia tonsa* is now commercially available and preserved eggs can be purchased, hatched in the facilities, and either the nauplii, copepodits and/or adults administered to the larvae.

A very big effort has been made for ballan wrasse culture in captivity to be used as a delousing agent for salmon. The results obtained in Norway and Scotland gave a clear view of the advances in the control of reproduction, collection of eggs, use of alcalase for degumming the eggs in a very effective way and incubation technology to obtain viable larvae and juveniles.

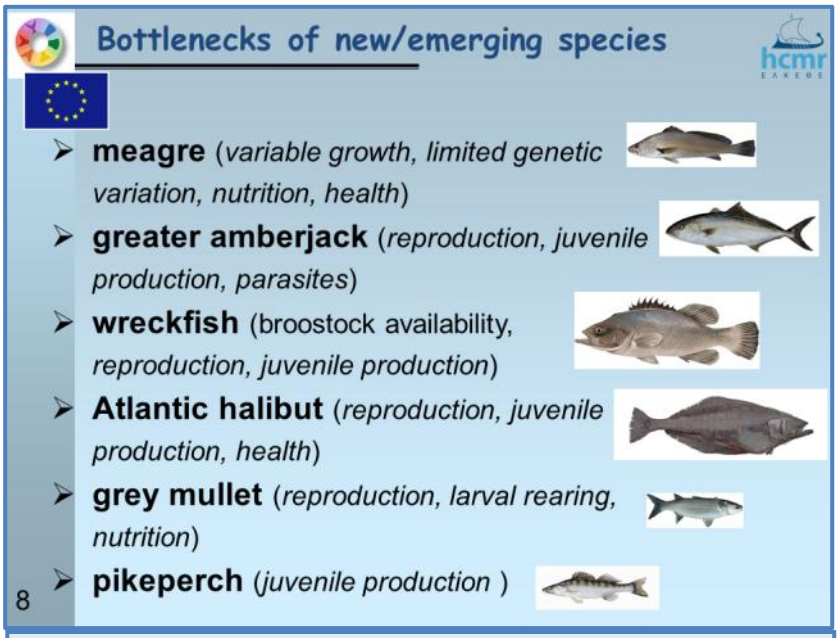
A procedure for DHA enrichment in the phospholipids of rotifers was also given by K. Li who recommends to enrich the rotifers with products that contain phospholipids (i.e. Multigain, Biomar) using long term enrichment procedures and low temperature. Under these conditions DHA levels can be stable for 24h at 10ºC.

Recommendation for the incubation of Artic charr were provided by H. Jeuthe, the eggs are very sensitive to low temperatures during the initial stages of embryogenesis, thus incubation of eggs needs an initial warmer period (6ºC), once the eggs reached the eyed stage fluctuating temperatures had no effect on survival or deformity rate. Similarly C. Guevara observed the best results in hake eggs incubation when a constant temperature of 12.7ºC was used whereas total mortality occurred when incubation was carried out at 22ºC, which can be considered out of the tolerant limit for this species.

Species diversification

Chair: José Benito Peleteiro, IEO, Spain and Rocio Robles, CTAqua, Spain.

A total of 17 oral presentations and 40 posters were presented at this session. Regarding aquaculture diversification and new candidate species, the presentation of the DIVERSIFY[2] project, funded by the 7th Framework Programme from the EU was the most significant contribution to this section. In this project, 6 new potential species were presented, and 38 partners participate in this 5 year project. During the session, special importance was given to new species with great aquaculture potential, such as the grey mullet (*Mugil cephalus*), wreckfish (*Polyprion americanus*), or the Atlantic hake (*Merluccius merluccius*), all presenting fast growth, interesting nutritional habits and great market value. Other species already cultured but with great optimization potential, such as recent advances on reproduction of sole (*Solea senegalensis*), or new feeding systems for *Sarda sarda* and advances on culture techniques of the blue fin tuna (*Thunnus thynnus*) were also presented.



Some of the bottlenecks identified for the species considered by the EU DIVERSIFY project.

Presentation on species with more local interest such as Shi drum (*Umbria cirrosa*), but with great aquaculture potential, or fresh water species such as *Lota lota*, or pike perch (*Sander lucioperca*) cultured in recirculation systems were also given.

Especially interesting were the presentations on stalked barnacles (*Pollicipes pollicipes*) or the sea cucumber (*Holoturia forskali*), spider crab (*Maja brachydactyla*), sea urchin (*Paracentrotus lividus*), or polychaete (*Hediste diversicolor*), as species with high potential interest, with several possible markets, which are important species for aquaculture diversification, both of producers and consumers.

New culture systems and techniques were also presented, regarding the use of geothermal waters for the culture of the European lobster, and the possibility of transporting *S. senegalensis* without water, as well pilot-scale experiments on multi trophic culture with fish, mollucs and algae.

The feedback and general evaluation of the section was positive; new lines of investigation were opened regarding culture techniques for species that present very high potential for aquaculture diversification, and are desired by small and large producers, as well as consumers in general.

[2] http://www.diversifyfish.eu/

Biology of aquatic species gametes – the AQUAGAMETE Cost Action

Chairs: Juan Asturiano - Universitat Politècnica de València, Spain, Ákos Horváth - Szent István University, Hungary, Paz Herráez - Universidad de León, Spain and Constantinos Mylonas – HCMR, Greece.

The Aquaculture Europe 2014 Conference dedicated a special session to AQUAGAMETE COST Action that was entitled "*Biology of Aquatic Species Gametes – AQUAGAMETE*". This special session lasted one full day, October 15th (chaired by Drs. Juan F. Asturiano and Ákos Horváth), and the morning of October 16th (chaired by Drs. Paz Herráez and Constantinos C. Mylonas) with a total of 24 speakers.

The first day's session was opened by the Chair of the Action with a resume of activities carried out during the first grant period (March 2013-May 2014) of the AQUAGAMETE COST Action www.aquagamete.webs.upv.es including meetings, workshops, training schools and short-term scientific missions.

The rest of presentations delivered during the session covered a range of topics englobed by this Action. The first 3 presentations were dedicated to proteomics and protein identification in the seminal plasma of different cultured fish species, evidencing the high number of specific techniques available. The next 4 presentations were dedicated to new and comparative methods for the cryopreservation of sperm of aquacultured species and zebrafish, including some standardization objectives, one of the major targets of the Action. Sperm motility and sperm quality evaluation were the subject of 6 further presentations, including studies in fish species and oysters. The last 3 presentations of the first day's session were dedicated to studies on germ cells during embryogenesis in tench, interspecific transplantation of spermatogonia and oogonia in sturgeons, and genotoxic damages in rainbow trout.

The second day started with 5 presentations highlighting aspects related to eggs (sampling, development, quality) and fertilization. The final 3 presentations addressed endocrine disruption in different fish species as well as to development of hormonal treatments to induce spawning induction in carp.

A total of 21 posters related to AQUAGAMETE were presented during the poster sessions, including miscellaneous studies with different subjects: endocrine disruption, hormonal treatments, sperm-testis, ovary-egg-fertilization, and sperm cryopreservation and vitrification.

A total of 19 speakers (15 early-stage researchers and 4 senior) were selected as eligible for reimbursement by AQUAGAMETE COST Action.

Beyond monoculture, including the EU IDREEM project

Chairs: Thierry Chopin - University of New Brunswick and CIMTAN, Canada and Kenny Black, SAMS and IDREEM, UK.

The IMTA session was called “Beyond Monoculture”, reminiscent of the EAS conference in Trondheim, Norway, in 2003, whose theme was also “Beyond Monoculture” (the IMTA acronym was created in 2004). This year’s session, co-chaired by **Thierry Chopin** (CIMTAN) and **Kenny Black** (IDREEM), was a full day long, with 16 oral presentations illustrating IMTA research in 11 countries. There were 4 other oral presentations on IMTA (from Portugal, Norway and France) in other sessions of the conference. If we add the 8 oral presentations in the session on aquaponics, which is also a form of IMTA (freshwater IMTA or FIMTA), this makes a total of 28 oral presentations on integrated systems, or 7.2% of the conference’s oral presentations, which is a sign of significant progress of the IMTA concept. There were also 13 poster presentations on IMTA and 2 on aquaponics.

The “Beyond Monoculture” session included 8 presentations by the European project IDREEM (Increasing Industrial Resource Efficiency in European Mariculture), with representatives in the UK, Ireland, Israel, the Netherlands, Portugal, Italy and Cyprus, and 8 presentations highlighted other IMTA projects from Canada, Norway, Denmark and Brazil. **The eight speakers from IDREEM provided an overview of all the activities being carried out by the consortium and the preliminary results achieved so far.**

Adam Hughes (Scottish Association for Marine Science, Scotland) provided an overview of the IDREEM project’s rationale, the importance of IMTA and its expectations, the current and future activities within the IDREEM consortium and its achievements so far. Growing at approximately 8% per annum for the last 30 years, the global aquaculture industry now supplies over 50% of fish and shellfish for human consumption. On the contrary, the European Union aquaculture industry grows only at approximately 1% per annum and Europe is the world’s largest market for fish and fishery products, importing 16B€ of seafood annually. In this context, IMTA offers an opportunity to reduce inputs, maximise productivity and minimise waste, converting waste products into secondary raw materials.

Daryl Gunning (Daithi O’ Murchu Marine Research Station, Ireland) presented the status of implementation of IMTA at the different pilot sites and showed the differences and results achieved so far at the Mediterranean and Northern sites.

Richard Corner (Longline Environment Ltd., UK) spoke on the importance of computer modelling to aquaculture and IMTA. Bioenergetics models are able to provide overall mass balance estimates; therefore, they can be used to some extent as a quantitative indicator of performance of monoculture species, to increase our understanding of their impacts within an IMTA system.

Dafna Israel (University of Haifa, Israel) presented the first results of her experimental trials with growing grey mullet as bioremediators at a seabream farm, Suf Fish Farm. A digestibility trial was conducted with particulate effluents of seabream, in order to quantify the extent to which grey mullets can utilize seabream waste. Results showed that freshly produced waste material does not possess any nutritional value for mullets; however, aged material, accumulated over time on the seafloor, thus becoming enriched in microbes and undergoing chemical alteration, can be available

to grey mullets. This indicates that mullets could be used as bioremediators in an IMTA system, provided that their cages are moored directly on the sediment where particulate organic matter can accumulate and be predigested by microbes.

Angelica Mendoza Beltran (Leiden University, the Netherlands), spoke on the status of the assessment of IMTA life cycle (LCA) and the quantification of its environmental effect. The qualitative description is finalized for most small and medium enterprises (SMEs) and the quantification of input and output flows is currently ongoing. Infrastructure, total feed use, fish production, energy/fuel consumption and other chemical and material uses have been reported for the foreground processes for most of the SMEs. The next step to be taken is the collection of appropriate feed and growth data.

Shirra Freeman (University of Haifa, Israel) gave an overview of the preliminary results of her assessment of the economic value of IMTA. The major reason for interest in promoting IMTA production systems is the double dividend potential of improved profitability and environmental performance. In addition to the improved profitability for fish farmers and investors, IMTA can bring other important economic benefits associated with improving environmental performance. A combination of financial analysis, market analysis, conjoint valuation methods and ecosystem service assessment is used to estimate the monetary value of these benefit flows.

Joao Ferreira (Universidade Nova de Lisboa, Portugal) spoke about the environmental effects of Atlantic salmon cage culture, modelling and mitigation with IMTA. In this regard, the IDREEM project has allowed the validation of production of various finfish species in monoculture, including salmon in Norway and Ireland; however, further work is needed to improve simulation.

Karen Alexander (Scottish Association for Marine Science, Scotland) spoke on the social criteria and public acceptance of IMTA, presenting the results of the international survey she conducted, the first of its kind in Europe. The survey showed that 65% of the people interviewed recognize that IMTA can improve the sustainability of aquaculture overall, despite uncertainties on the perception of the effect of IMTA on food quality and on preventing disease outbreak.

Three presentations covered some of the work carried out by the Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN) in Canada.

Thierry Chopin (University of New Brunswick, Canada) explained the breadth of the IMTA concept and its many variations. The ecosystem services provided by extractive aquaculture should be recognized and valued by fed aquaculture and society, and lead to the implementation of nutrient trading credits (NTCs), used as financial incentive tools. Nutrients are not necessarily wastes and recycling, encouraged on land and in agriculture, should also be at sea and in aquaculture. There is a renewed interest in the mariculture of seaweeds for their integrated cultivation, the ecosystem services they provide and novel uses. Business models will have to embrace the emerging Integrated Sequential BioRefineries (ISBR) concept. Extractive aquaculture will have to be developed in a more evenly distributed manner throughout the world. In the western world, IMTA systems are being developed by modifying fish aquaculture systems and adding, presently proportionally small, organic and inorganic extractive components to build FIS (Fish/Invertebrates/Seaweeds) IMTA systems. In Asia, large scale co-cultivation systems of seaweeds and invertebrates already exist, to which are added, presently proportionally small, fed fish components to build SIF IMTA systems. Are we

comparing apples and oranges when comparing the efficiency of these FIS and SIF IMTA systems, and should we work towards more integrative solutions?

A seaweed salad (of course) for the IDREEM networking lunch.

Shawn Robinson (Fisheries and Oceans Canada, Canada) underlined the need to pay more attention to a significant component of IMTA systems: deposit-feeding organisms. At finfish sites, the bulk of the organic waste is represented by larger particles that have relatively higher settling velocities, which tend to keep them in close proximity to their original source. The deposition rate of these particles and the assimilation capacity of the sea floor underneath the farming operations will determine whether there will be a significant impact to the benthos, positive or negative. Since most of the organic matter available to IMTA species occurs near field, this level has the highest return potential for inserting deposit-feeding organisms. The species currently being investigated are the green sea urchin (*Strongylocentrotus droebachiensis*), the northern sea cucumber (*Cucumaria frondosa*) and the sea scallop (*Placopecten magellanicus*). Experiments are underway to evaluate the growth rates and assimilative capacities of these extractive species at the experimental IMTA sites in the Bay of Fundy. Hatchery protocols are also being developed. Research is also conducted on the assimilative capacity of aerobic bacterial populations to convert organic carbon from the waste carbohydrates into carbon dioxide.

Duncan Knowler (Simon Fraser University, Canada) demonstrated that economic analysis is critical to understanding IMTA's potential impacts and how he, and his collaborators, are developing an integrated economic-ecological, or "bioeconomic", IMTA model. They address several management and policy-related questions pertaining to the performance of IMTA versus monoculture operations

and explore these possibilities using a social welfare maximizing framework. They use the model formulation to analyze several aspects: introducing a fixed site area for the operations, considering the current regulatory regime in Canada, and considering the cases for a nutrient tax and a nutrient credit.

Two presentations covered some of the work carried out by the EXPLOIT project in Norway.

Henrice Jansen (Institute of Marine Research, Norway) reported on the release and dispersal of dissolved and particulate wastes from a commercial Atlantic salmon farm and what the implications are for IMTA in Norway. High resolution mapping could not detect enhanced particle concentrations close to the farm. Slightly enhanced Turbidity : Chl a ratios at a fixed mooring station close to the farm identified the presence of organic wastes, however, their magnitude was interpreted as negligible. Results from the systematic water sampling program confirmed these patterns. Dissolved and particulate nutrient concentrations around the salmon farm were not enhanced compared to background values, except for ammonia concentrations close to the sea cages. The sediment trap study indicated that most of the particulate wastes quickly settled at the bottom. The lack of strongly enhanced dissolved inorganic nutrient concentrations challenges the need for limiting the integration seaweed-fish to only the farm scale. High benthic deposition and absence of enhanced particulate material in the pelagic zone indicates that biomitigation of particulate wastes should focus on the benthic component.

Maria Bergvik (Norwegian University of Science and Technology, Norway) reported that the Norwegian salmon production is expected to increase from 1.2 to 3 million tons, requiring the use of 3.6 million tons of feed per year by 2030. There are some concerns regarding negative environmental impacts associated with an increased nutrient load due to increased production, and IMTA is being considered for bioremediation purposes. Blue mussels (*Mytilus edulis*) and scallops (*Pecten maximus*) were deployed close to an Atlantic salmon farm to document potential assimilations of nutrients from the farm. Scallops were also fed salmon feed and salmon faeces in a laboratory experiment to verify a potential assimilation. The salmon feed and salmon faeces from the farm contained high amounts of the fatty acid 18:1n-9. The share of 18:1n-9 in the digestive gland of blue mussels was higher at the farm station compared to the reference stations at 20 m depth, but there were no differences at 5 m depth. Scallops at the farm station showed a higher fraction of 18:1n-9 in their digestive gland at 5 m depth compared to the reference stations, while no differences were found at 20 m depth. The results of this study indicated that blue mussels and scallops were able to assimilate salmon feed and/or faeces released from salmon farms.

Hugo Quental-Ferreira (Portuguese Institute for the Ocean and Atmosphere, Portugal) reported on a 3 year assessment of IMTA practices in earthen ponds, the main aquaculture production system in Portugal. Production costs of extensive and semi-intensive fish cultures are still too high to offer sustainable economic activity due to low productivity. A possible means for improving the output with higher profitability and risk reduction would be to develop IMTA in these ponds using oysters as suspension filter feeders and sea cucumbers as deposit feeders. The results, accumulated over 3 years, indicate that:

1. The sea cucumber, *Holothuria tubulosa*, is not a species to grow in earthen ponds.
2. The integration of seabream (*Sparus aurata*, *Diplodus sargus* and *Diplodus puntazzo*) and meagre (*Argyrosomus regius*) with oysters may be the optimal combination for IMTA in

earthen ponds. Fish were more robust, suggesting a better degree of nourishment, in these ponds.

3. Mesh bags floating at the surface are the most suitable grow-out structure for oysters in earthen ponds.
4. *Crassostrea gigas* grows faster than *C. angulata*.
5. Oyster growth was acceptable for commercial standards, but mortality rates need to decrease to increase the overall productivity.
6. The bacterial load in fish mucus is highly reduced by the presence of oysters.
7. IMTA ponds have higher benthic diversity, which helps in the remineralization processes and, subsequently, increases water quality.

The overall picture reveals a promising future for IMTA practices in Portugal and other countries with strong focuses on earthen pond aquaculture.

Paula Canal-Vergés (Technical University of Denmark, Denmark) spoke about the Seaweed Challenge in Europe, due in part to the lack of incentives to produce seaweeds: seaweeds are relatively new products and therefore not part of most European cultural heritages or culinary traditions. Nevertheless, seaweeds and seaweed aquaculture have many attractive attributes and European seaweed aquaculture has the potential to become an asset for the future of human nutrition. The introduction of seaweeds into the European diet will require changes in mentality and attitude and therefore a transfer of knowledge rather than straight forward public relation campaigns. In order to promote economically sustainable seaweed production, a multidisciplinary study incorporating all parts of the value chain was conducted: cost efficient production farms (*Saccharina latissima* and *Palmaria palmata*) adapted to local conditions in the Limfjorden, Denmark; documentation of the positive properties of seaweeds in a Danish context; development of new seaweed based products (*Saccharina* sushi plates, smoked *Palmaria*, seaweed bread, seaweed cheese, seaweed sausage and seaweed “schnapps”); and their introduction to both the general public and primary school children followed by evaluation surveys. The study found that, with the correct application, seaweeds may become an important product for human consumption in the near future and that seaweeds can be produced at costs compatible to similar products. In addition, the way in which new products are introduced and the information presented to the public regarding the environment, health and business could be key for the further development and introduction of seaweeds in the market.

Fernanda Seles David (São Paulo State University, Brazil) reported on the quantification of the phosphorus balance in multi-spatial and multi-trophic systems growing Nile tilapia (**Oreochromis niloticus**) and Amazon River prawn (*Macrobrachium amazonicum),* with the addition of different substrates and the use of hypereutrophic water. The most representative compartments of phosphorus inputs were allochthonous diet, followed by inlet water, fertilizer, stocked tilapia, rainwater and stocked prawns. In treatments without substrate and geotextile blanket, the input values were higher than the output. Sediment was the compartment with more accumulated phosphorus, followed by tilapia, freshwater prawn and periphyton. In bamboo treatment, the input values were higher than the output. The phosphorus contained in the feed was the component that contributed the most to the entry of this element in the system, followed by the inlet water. This can be associated with the large supply of allochthonous food and the high amount of nutrients present in the hypereutrophic water, combined with the large volume to replace seepage. The phosphorus

retained in the periphyton was low; however, it regenerated the phosphorus into a form available for reared species ingestion. The periphyton can, then, replace part of the allochthonous diet.

The abstracts of all the presentations can be read at
https://www.was.org/easOnline/SessionAbstracts.aspx?Code=AE2014&Session=4

It is interesting to realize how IMTA has gradually gained legitimacy at international conferences, which now regularly schedule full-fledged IMTA sessions with between 15-20 speakers from as many as 10-15 countries at a time. The room for the "Beyond Monoculture" session in San Sebastián was, in fact, too small and a sound system was brought into the hallway for the people standing outside. What an indication of increased popularity of the topic!

Land based aquaculture technologies

Chair: Raul Piedrahita, University of California, Davis, USA

The Land Based Aquaculture Technologies session was very well attended, with a total of 17 papers (in addition to 12 posters). The main areas covered in the session were off-flavor removal and recirculation systems, especially topics related to biofiltration and system design and operation. Some highlights are presented here.

Off-flavor continues to be an important problem which affects primarily recirculation system. Off-flavor compounds accumulate in lipids and the only reliable management method currently consists of purging, or holding the fish to be harvested in clean water. In one paper presented, the researchers described the effectiveness of ultrasound treatment of water containing off-flavor compounds. A major characteristic of the method is that its effectiveness is independent of organic matter content in the water. The treatment was effective but required significant contact time and further development of the technique is needed. In a second off-flavor paper, the researchers focused on identifying ways to increase the rate at which fish loose off-flavor compounds once placed in a purging system. They also were trying to understand the fate of off-flavor compounds once they are released into the water. Their work raised very interesting questions regarding the mechanisms by which off-flavor compounds are transformed as they are purged from fish.

A series of papers looked at biofiltration with interesting findings on the importance that reactor scale has on nitrification rates (scale has a significant impact on nitrification rate and is lower in laboratory-scale and pilot scale filters that in full scale filters) and on differences in nitrification rates between biofilters at different farms. In addition, the relationship between COD and ammonia removal in biofilters differed between farms. Clearly, although much is now known about biofiltration, there are many unknowns and future work in which microbial communities are studied as well as their microenvironments will continue to elucidate the behavior of biofilters and will help explain differences such as those noted in the papers presented at the session.

There were a couple of interesting papers considering fish welfare and performance as affected by tank size and in comparison to cages. The authors concluded that tank size has a significant impact on fish performance but also that fish handling is key and that the fish are more susceptible to handling stress at certain sizes, especially at the post-smolt stage. The findings presented suggest

that production-scale research is key but faces significant challenges due to costs and the need to ensure optimum system design and operation at full production scales.

The application of novel microbial identification techniques was described in two papers. In one case, they were applied to biofloc culture of Pacific shrimp and in the other to a study of colonization of fish larval gut and mucosa. Interestingly, researchers concluded that system water was more important in determining the larval gut and mucosa microbiota than diet. They also noted that recirculation systems had a more stable microbial community than other types of systems and that a way to manage the microbiota in fish larvae should be based on managing the water microbial community.

An interesting paper was presented on the feasibility of cod aquaculture in the Basque region. The researchers examined economic, environmental and technical feasibility as well as acceptability of the cultured product by consumers. Finding suggest that a high quality fish can be produced that would be well accepted in the marketplace, that systems are environmentally and technically feasible, but that there need to be improvements in production efficiencies to ensure economic viability as production costs were deemed to be too high, especially those associated with feed and energy.

Shellfish aquaculture

Chairs: Rene Robert, IFREMER, France and Dolors Furones, IRTA, Spain.

This year the shellfish session was rich in content but mainly concerned three groups of species from different countries: cupped and flat oysters (USA, Sweden, U.K., France, Spain, Portugal), mussels (Canada, Chile, New Zealand, U.K., Belgium, Spain, Egypt) and abalone (South Africa, Korea). Additional miscellaneous species included clams, shrimp, cockles, scallops and ascidians.

The session consisted of 24 oral communications and 19 posters with quite a different split for oral presentations both from the species and the thematic point of view. In addition, the quality of the communications and posters was globally high.

Different topics were covered by the posters and concerned diverse fields such as growth/reproduction/nutrition in the surroundings (5), improvement of rearing parameters under controlled conditions (5), legislation and pathology (3), micro-anatomical description (2), food safety and quality (2), molecular physiology (1) and ecotoxicology (1).

Six posters were informative and the most innovative concerned the “Evidence of vertical transmission of ostreid herpesvirus 1 microvar in the Portuguese oyster” which showed that this species should be as sensitive as *Crassostrea gigas* to OsHV-1 and this could become a limiting factor for the cultivation of the Portuguese oyster. Moreover, it might limit the grow-out of imported *C. angulata* spat in contaminated areas such as France or Ireland where this disease in *C. gigas* has spread severely since seven years ago.

Pathology/mollusc stress (5) and reproduction/larval development (5) were the two dominant topics for oral communications. Others were devoted to growth and quality of products (3), genetic and genotyping (3), shellfish and biodiversity (3), improvement of rearing practices (3) and nutrition (3).

The oral presentations focused mainly on mussels and oysters, where *C. gigas* was the most represented (7) and mainly focused on the Mediterranean Sea that covered larval recruitment in lagoons and its modelling, the impact of herpes virus in *C. gigas* cultivation, epidemiology and the key factors of management regarding herpes virus control, as well as remote sensing of wild socks, larval rearing conditions, and the quality comparison between *C. gigas* and *C. angulata*.

Mytilus edulis was also well represented and covered a wide geographical range. Site studies for criteria selection of culture areas, performance or impact on wild populations, and *Vibrio* pathogens in wild adults were all dealt with in a series of interesting communications. Presentations on *M. galloprovincialis* focused on ecophysiology, both in rafts and pilot off-shore systems. A contribution to genomics was also made and there was a presentation on *M. chilensis*. Two presentations on **Ruditapes philippinarum** dealing with genetic differentiation in European stocks generated an intense debate on methodology.

Five communications were especially enlightening:

- One pointed out the negative effects of bubbling for *Pecten maximus* larvae that contrasted with most of the other species reared in a hatchery, and concluded that rearing procedures have to be modified accordingly.
- The second communication concerned an outbreak in shrimp farming which could be limited by a change in zootechnical practices and target use of probiotics.
- A modelling tool to determine larval connectivity was applied in a third study and will be very useful for identifying the best locations for collecting spat from natural surroundings.
- In a closed spat system, including ponds for phytoplankton production, periods of high levels in TAN and high fluctuations in pH might result in reduced performance of the spat populations being produced. Thresholds of daily repetition of pH fluctuations in TAN elevated water should be included in the automatic water quality monitoring system in order to reduce the negative effects of water parameter fluctuations in land-based spat production.
- The status of the wild Pacific oyster (*C. gigas*) has recently changed from being invasive to being a resource, due to the mass summer mortalities of cultivated oysters. Traditional surveys using field GPS measurements and systematic sampling of the oyster biomass are time consuming and inconsistent. It is difficult to reach wild reefs established on intertidal rocky areas, particularly when they are surrounded by large mudflats. An alternative method for detecting spatial distribution of wild reefs automatically using visible and near infrared remote sensing was successfully tested. This work highlighted the interest of spatial and airborne remote sensing to understand the functioning of the coastal environment and the development of management strategies in shellfish ecosystems.

Worldwide mollusc cultivation is today highly limited by diseases. Such pathogenic events have recently affected mussels in France, which is unusual as this species has generally been considered as tolerant. Future research will have to focus on this developing aspect and, particularly, on the relationship between pathogenic bacteria or *Vibrio* occurrence and climate change.

EAS-SG Student workshop

Chair: Rob van de Ven, EAS_SG

The session was directed especially to students, but everyone could attend it. It included 4 presentations, and the main subject was less scientific but more related in helping students to contextualize their careers and have some real examples of it.

The first presentation was done by Rob van de Ven, President of EAS students group (EASSG), to introduce the session and explain its main objective. Also very important, was to detail EASSG activities during the year and what are the main objectives of this group. Student advantages in become EAS members were made clear and the ice was broken to encourage more interaction between people assisting for the following sessions.

Ramón Fontanillas, a researcher from the EAS_SG sponsor Skretting, kindly presented the second talk. He shared with the audience his pathway from his student season until his current position in Skretting, which triggered several questions from the public, especially students. He also talked about the functioning of such a big and important company in aquaculture as Skretting and gave some tips to students who want to find a job after their graduation. Some examples of what a company seeks when recruiting young students were given.

After a quick discussion break, the last two presentations were done. The responsible for the talks were Antonios Chalaris and Elena Wernicke, both travel grant winners to attend this conference. Both presentations were focused on challenges and opportunities in aquaculture in their representative country, United Kingdom, but focusing in the student's perspectives.

The session ended with a long discussion between the students present in the room and the presenters, which made us conclude it was successful and fulfil our objective of promoting network and help students clarify some of their doubts related to their careers.

Governance, policy and strategic planning

Chair: Javier Remiro, Spanish Aquaculture Observatory, OESA, Spain

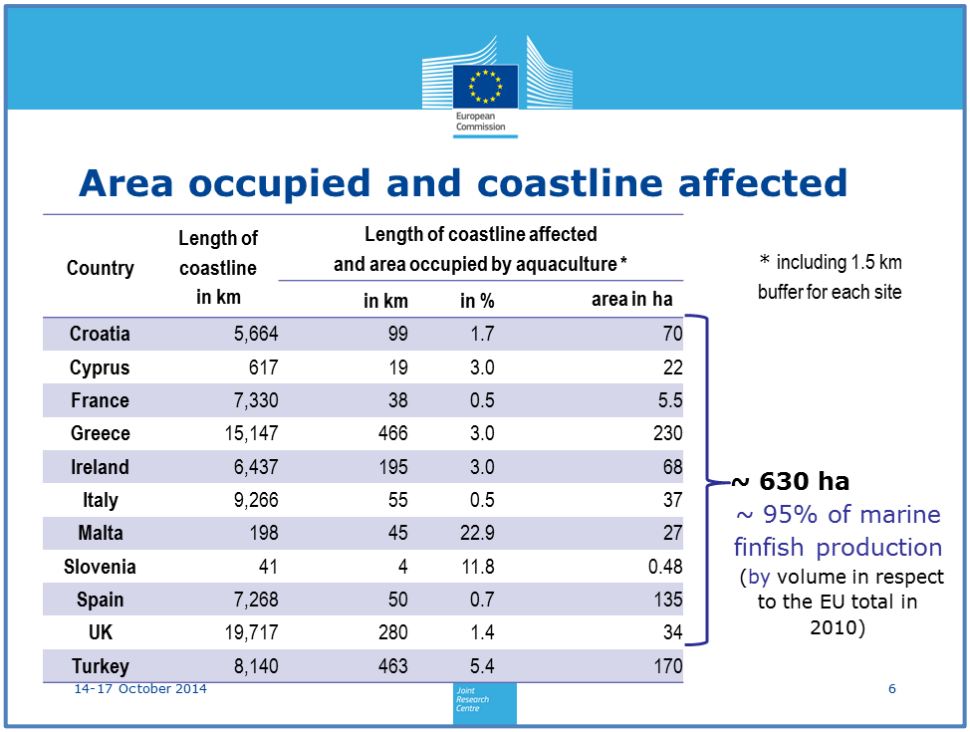
Good aquaculture governance and more specifically, the need to support this in a strategic planning for the growth and development of the sector have been positioned at the forefront of aquaculture worldwide and especially in recent years in Europe. Unfortunately, this boost has not been driven, at least in the first instance by the Member States, it has been the European Commission at the request of the production sector itself which after quite a few years of stating aquaculture as a strategic sector for the European Union, while supplying the European market with fish products, has forced states to develop a Multi Annual Strategic Plan to guide the development of the sector in the year 2020, linked to the European Maritime and Fisheries Fund (EMFF).

On this issue many of the speakers have dealt with sectorial planning highlighting the importance of governance and encouraging this important issue for future editions, not only of those strategic

plans, but also aspects of sector governance and policies that articulate the object of promoting its momentum and growth.

In this regard, the presentations made by the speakers from the US, Brazil, Hungary and the Basque Country have highlighted the significant growth estimates desired by the industry and governments, supported by FAO and World Bank stating the growth in world population, especially in the increasing of fish consumption. During this session aquaculture plans and strategies to implement by the representatives of the countries to undertake the development of the sector have been summarised.

Johan Hofher from the Joint Research Centre Institute for the Protection and Security of the Citizen presented a study **questioning the lack of space as a limiting factor for the development of aquaculture in EU coastal areas**.



This study examines the space occupation of marine finfish aquaculture in the EU, identifies geographical clusters and administrative areas where aquaculture development is particularly significant and provides evidence on the interactions between aquaculture and the touristic use of the coastline. The results indicate that existing marine aquaculture sites occupy very limited space in terms of surface and length of coastline (*see photo above*). The surface occupied by aquaculture cages amounts, for example, to around 230 hectares in Greece, and 34 ha in UK, which represent respectively 24% and 44% of EU marine finfish production in volume. Considering these small surfaces it is difficult to imagine that the expansion of marine aquaculture in the EU is constrained by a lack of space in absolute terms.

Diego Mendiola from AZTI-Tecnalia, Marine Research Division, presented the **Basque Aquaculture Plan**. The Basque country supports one of the largest European commercial fishing industries. In 2013, the global production from Basque capture fisheries reached 210.190,00 Tm. Currently, aquaculture fish products consumption in the region is exclusively dependent on importation volumes, which mainly comprises of the following species: salmon, mussels, sole, sea bass, sea bream, turbot, trout and shrimps. The Basque Aquaculture Plan offers accessibility to the companies and investors interested in developing aquaculture in the region. Its contents describe state of the art developments, regulatory considerations, market and RTD tendencies and strategies, SWOT analysis, technological planning (species, systems), local resources (stakeholders for investment,

research or education in aquaculture developments), ICZM studies based on specific proposals and so on. Each of the contents and recommendations of the Basque Regional Plan represents the outcomes of a fluid series of transparent meetings, interviews and consensus activities carried out between the main stakeholders from the region and the Public Administration. Furthermore, it includes a proposal of 22 strategic specific actions and 13 different tentative coastal and offshore locations for installing aquaculture production farms.

Michael Rust from the NOAA Office of Aquaculture presented the **United States National Strategic Plan for Federal Aquaculture Research**. The plan communicates Federal priorities for research, science, and technology development that encourages aquaculture in the U.S. with the goal of building an industry that increases seafood availability, jobs, economic opportunities, and recreational opportunities, while providing for the restoration and promotion of healthy aquatic ecosystems. In addition the plan will promote adoption and implementation of ideas, concepts, approaches, technologies, and capabilities to advance U.S. aquaculture production, and provide technological and environmental leadership in aquaculture. The plan addresses; research in both marine and freshwater aquaculture, for plants, shellfish and finfish, risks and benefits, and is organized along nine strategic research goals. Each of the strategic goals includes outcomes and milestones that identify specific agency and interagency research, science, and technology priorities over the midterm (5 years).

Rodrigo Roubach presented a **sustainable development of aquaculture in Brazil**, which is a technical cooperation project elaborated between the Government of the Federative Republic of Brazil, through the Ministry of Fisheries and Aquaculture and the United Nations Food and Agriculture Organization (FAO). The main objective of the Studies is to contribute to the sustainable development of aquaculture, promoting: strengthening the aquaculture production chain, with its diversity and planning towards to an increased production and social inclusion; and providing increased income and jobs offer for low-income populations and other relevant actors in the sector. Regarding the finfish mariculture system, the results showed technical feasibility for near and offshore systems producing cobia and for the mollusc's mariculture, the southeast region has excellent features and vocation to be a major scallop producer. However, if the national hygiene and sanitary control program is not put into practice, the supply chain will not move forward, even if with all the above efforts above. Therefore in order to attain a sustainable marine aquaculture development in Brazil there is the need to a continued technical assistance to producers, cooperatives and associations courses, deployment of a hygienic and sanitary control for shellfish, preparation of a marketing plan to develop the Brazilian scallop, and conduct regional studies to optimize the techniques of cultivation on the environment.

László Stündl from the University of Debrecen closed the session with the **Hungarian Multiannual Aquaculture Strategic Plan and its relation to the Europe 2020 Strategy**. Fish production in Hungary is mainly based on fishponds (with a total area about 37 thousand hectares but only 24 thousand are currently under regular operation). The large number of ponds and the availability of fresh water are the main base of the aquaculture development. Extensive pond aquaculture is considered to be one of the most sustainable fish production methods that contribute to the conservation and protection of biodiversity by providing valuable habitats to several species, especially birds. More than half of the ponds are Nature 2000 areas. Intensive fish farming has an important role in the Hungarian aquaculture as well, where flow-through and recirculation systems are used. One of the main goals

of the national strategy is to encourage farmers to create such economically and environmentally sustainable systems. The most important species is carp, but several other cyprinids are also produced on a regular basis. The main goal in Hungary is to increase fish consumption by at least 20% per capita per year by 2024; cover the demand mainly with freshwater fish products, and in the meanwhile maintain sustainability in the sector in all terms.

Marine biotechnology

Chairs: Ionan Marigomez, PIE-Basque Country University and Naiara Rodriguez, AZTI Tecnalia, Spain.

Marine biotechnology is a large and multidisciplinary field of research that consists on developing biotechnological applications derived from molecules extracted from living organisms or on applying biotechnological tools to understand living organisms. The talks and posters presented during this session included topics related to these two sides of marine biotechnology and included a variety of innovative omics techniques.

For example, works presented in one talk and a few posters studied factors involved in fish immune responses to virus and bacteria through genomic and transcriptomic characterization of candidate molecules, and other studies utilized metabolomics profiles to classify molluscs according to their quality and assist selective breeding programs.

Other presentations dealt with the effect on ploidy in morphology and physiology of fish gut, linking it to the digestive efficiency and therefore growth, and another work presented the use of gene therapy as an alternative to produce recombinant hormones, useful in important applications such as out-of-season breeding programs.

Finally, an overview of the developments of biotechnology linked to aquaculture carried out in Russia was presented

Salmon farming sustainability

Chairs: Lars Gansel, SINTEF, Norway and Bjorn Myrseth, Vitamar, Norway.

This session included a wide range of topics regarding the sustainability of Atlantic salmon aquaculture, including sustainable finfish farming on islands (*Patursson et al*.), salmon lice (*Finstad et al., LeClercq et al.*), fish farm wastes, IMTA and biomass from seaweed (*Ferreira et al., Handå et al., Skjermo et al.*), effects of the rearing environment, effects of handling and triploid salmon (*Calabrese et al., Espmark et al., Migaud et al.*), feed management (*Noble and Sæther*), interactions of farmed and wild salmon (*Sæther et al., Diserud et al., Hamoutene et al*.) and monitoring and modelling of fish in sea cages (*Lange et al., Føre et al*.).

The environment inside sea cages is in constant interaction with the surrounding environment. While the exchange between water inside and outside of net cages assures god conditions for fish, it also enables spreading of unwanted material into and from sea cages. A circulation around the Faroe Islands transports water around the Islands, and therefore pathogens may be easily spread in between farms. After severe outbreaks of viral infections the Faroe Islands revised their farming

management, and today salmon farming is done using **all-in all-out strategies within separate farming zones**. Good knowledge of currents and waves around the Islands helps to determine what conditions farms may encounter. Experiences from the Faroe Islands may be used to optimize farming management in other parts of the world.

Also parasites are a thread to finfish aquaculture. Salmon lice are a serious challenge in the mariculture of Atlantic salmon. They occur naturally on wild and farmed salmonids so that salmon farms may act as pools for the parasite. Larvae produced in open net cages can infect passing wild salmon and this interaction can be problematic in areas with intensive salmon aquaculture. **A review on issues related to salmon lice and their effect on sea trout was presented**. Existing knowledge was summarized and knowledge gaps were identified.

A number of different measures are being used and developed to battle and prohibit sea lice infestations in salmon aquaculture. A part of an **Integrated Sea Lice Management (ISLM)** is the use of cleaner fish. Even though the delousing performance of cleaner fish in sea cages may be lower than in controlled tank trials, the latter provide a valuable tool to investigate the effect of selected factors on the delousing efficiency. In such trials, the delousing rate was found to be directly proportional to the mean sea lice count per salmon, Performance indicators are proposed that describe the delousing efficiency of a cleaner fish stock, which now should be applied to commercial settings to optimize the use of farmed wrasse to control sea lice in salmon aquaculture.

Waste products originating from fish farms may have negative implications for the surrounding environment, but they may also be a resource for **Integrated Multi-Trophic Aquaculture (IMTA)**. Determining the nutrient output from fish farms is not an easy task. One way to estimate the output from net cages is to use existing models for fish growth and the associated mass balance between feed and excretions. The Aquaculture Resource Management model (FARM) that translates processes in individual fish to the farm scale, taking biotic and abiotic factors into account. The model predicts effects of salmon culture on the surrounding environment and may aid in the evolution of IMTA.

The potential for IMTA in Norway was investigated using sugar kelp and blue mussel as model organisms for the extraction of dissolved and particulate nutrients in proximity to sea cages. The growth of sugar kelp seems to be accelerated in close proximity to fish cages, but already 200 m from a fish farm no improved growth was found in comparison to kelp at a control station. Experiments with blue mussel suggest that bio-mitigation of particulate fish farm wastes should focus on the benthic system in Norway.

Seaweeds are fast growing primary producers that can be mass cultivated in the sea, also without the influence of other aquaculture. Seaweed convert sunlight, CO^2 and nutrients present in the sea into biomass, thus being a renewable and sustainable biomass for which there is growing demand. Seaweed biomass can be used for the production of a wide range of products, but the seaweed cultivating industry in Norway is in an early stage and cultivation costs are relatively high. This is due to sub-optimal technical solutions and use of manpower. The development of bio-refineries producing several different products can enhance the sustainability and profitability of seaweed farming.

Three main priority areas are proposed to facilitate the development of a bio-economy based on products from seaweed:

1) Biomass production technology - for cost effective and predictable cultivation of biomass of predictable quality.
2) Bio-refinery processes - processing methods for preservation and complete utilization of the biomass into valuable products.
3) Market and product development - both to meet the demands from the market and to encourage the market to demand for bio-based products from cultivated seaweeds.

Variations of the rearing environment, operations during production, but also the choice of fish can strongly affect **welfare, growth and survival**. Tests on the effect of CO^2 levels on post smolt growth, physiology and stress responsiveness revealed that the specific growth rate in semi enclosed cages is reduced at relatively high CO^2 concentrations of 30 mg/l to 35 mg/l in the water. The tests indicate a linear relationship between pCO^2 in the water and regulatory responses in the blood of the fish. Furthermore, CO^2 was found to be a chronic stressor in post smolt Atlantic salmon and high CO^2 concentrations in the water may lower the stress response to additional stressors.

Atlantic salmon experience repeated crowding and pumping during the **smolt production** and handling of salmon in this phase may influence the performance of the fish after transfer to sea cages. Pumping and crowding significantly stresses salmon, which can be reduced by slight sedation of the fish. Crowding and pumping may lead to delayed smoltification, and it can lead to loss of scales. However, some handling of fish during the freshwater phase may adapt them to handling during the transport to sea cages, potentially leading to lowered mortality of fish in the early sea water stage. An ongoing experiment will tell, if the use of sedative during handling in freshwater can have positive effects on survival rate and growth of Atlantic salmon in the sea.

Triploid salmon are an alternative to diploid salmon mostly farmed today. The main potential advantages of triploids are faster growth, at least in parts of the production period and the inability of escapees to interbreed with wild populations. In previous tests triploid salmon were susceptible to spine deformities and cataracts. A series of experiments have shown that conventional diploid diets may be inadequate for the nutritional requirements of triploids. Higher histidine inclusion into the diet during periods with rapid growth can arrest the development of cataracts. Spinal deformities in triploids can be strongly reduced by changing the composition of feeds, especially by supplementing phosphorous content.

Feed is a major cost factor for finfish aquaculture. Optimization of the **feed management** can help the aquaculture industry to grow in an environmentally, ethically and economically sustainable manor. Feed management strategies can be diverse and may include 1) pursuing a maximal growth strategy, 2) feeding efficiently to reduce Feed Conversion Ratios (FCRs) and avoid feed waste, or 3) optimising feed distribution to avoid underfeeding and produce a fish of a uniform size, or a combination of these factors. Different management strategies and their effect on the overall farm performance were reviewed. While good feed management is beneficial for the efficiency and sustainability of fish farms, missing the mark in feeding can potentially cause high costs.

Wild and farmed salmon can interact both directly and indirectly. Examples are the transfer of pathogens or interactions of wild fish with aquaculture escapees.

Marine fish farms attract wild fish. Fish farms may change migration patterns. Wild fish may ingest particles originating from fish cages and a changed diet can change their physiology and reproduction. Possibilities for the **sustainable coexistence of fisheries and fish farming** were discussed.

Salmon that escaped from aquaculture cages may spawn together with wild salmon. Genetic introgression of farm to wild populations is of great concern. Recently, a method was developed to **quantify the unidirectional gene flow from farmed to wild Atlantic salmon**, and this method is expected to be an important tool for the classification of wild populations with respect to genetic integrity and viability. The model can, amongst others, help to investigate the influence of population and environmental characteristics on genetic introgression.

Farmed and wild salmon may experience very different environmental conditions during early life stages and therefore, escaped farmed salmon may show reduced fitness in comparison to wild fish. Also F1 hybrids between wild and farmed salmon may show different tolerance to local environmental conditions in comparison to wild individuals. It was previously shown that wild salmon from Nova Scotia inhabiting acidified rivers had higher survival than farmed salmon from a strain originating from non-acidified waters. Recent tests in Newfoundland showed that low pH conditions more strongly affected pure farm salmon than hybrids or wild salmon. In contrast to a previous study, no differences were found between salmon cross-types during temperature challenges. Based on pH and temperature challenges it seems that F1 hybrids of wild and farmed salmon used in the present tests in Newfoundland do not experience higher mortalities than wild strains when subjected to low pH and low temperatures.

Acoustic tags can be used to transmit in vivo sensor data in real time from individual fish inside fish cages. Atlantic salmon fish cages contain a large biomass and fish are often at high densities. Even though large biomass can make acoustic transmission in net cages challenging, acoustic tags could be used to monitor the movement and distribution of fish inside cages. The technology is also suited to be used on fish farm structures, for example to monitor the movement of mooring systems around cages.

A numerical individual based model (IBM) was developed of the performance of salmon reared in production units of different sizes. The model was validated with data from laboratory experiments at different scales (0.9 m^3, 3 m^3 and 190 m^3) and with results from full scale field trials. The model describes growth, behaviour and feed intake of individual fish, considering movement patterns, feed distribution and spreading and variations in the rearing environment. The model was able to predict fish growth in the experiments and it was able to capture the main mechanisms of fish performance.

Knowledge management, transfer and extension networks

Chair: John Bostock, Stirling, UK.

The Aquaculture Europe conference is itself an excellent example of knowledge transfer (and knowledge exchange) so this session provided an opportunity to reflect more widely on some of the issues concerning the value of knowledge and how transfer can be enhanced. There was a mix of presentations ranging from the thematic to specific case studies. The overall context was guided by

the inclusion of knowledge management in the European Aquaculture Technology and Innovation Platform Strategic Research and Innovation Agenda (Thematic Area 6).

The session started with a presentation by Marieke Reuver on the Aqua-tnet project – the EU Lifelong Learning Thematic Network for Aquaculture, Fisheries and Aquatic Resources Management. She highlighted the range of issues with which the members have engaged, from research into specific and general skill requirements, through national and EU qualification frameworks to innovative teaching methods and open educational resources. The network has particularly tracked EU policies in post-secondary education and worked on translation to the aquaculture and fisheries industries. In the second presentation, John Bostock, also from the Aqua-tnet project, explored the concepts of knowledge management and learning organisations in the context of the European aquaculture sector. The need for greater focus on "knowledge capital" and how it is being built and utilized was discussed. A third presentation linked with the Aqua-tnet project came from Magdolna Müllerné Trenovszki who presented a case study on interdisciplinary knowledge transfer involving fisheries and aquaculture in Hungary.

Attention then turned to the EU funded AQUAEXCEL project which is primarily a knowledge generator through wide ranging collaborative research utilizing a network of leading fish research infrastructures. The project coordinator, Marc Vandeputte introduced the range of activities and particularly highlighted the importance given to dissemination and exploitation of results which is achieved through a range of channels including the organization of short courses, use of scientific journals and conferences and dissemination through newsletters, web site and other publications. Petr Cisar then gave a specific example of knowledge sharing through the project using a database platform for building experimental protocols and recording results. The theme of documenting and communicating knowledge outputs from research was further discussed in Cliona Ní Cheallacháin's presentation which provided case studies on how Aqua TT are able to add value to European funded research through specifically targeted knowledge transfer activities.

The final three presentations in the session looked at more direct knowledge management and transfer in the production sector. Stanley Serfling shared experiences from the USA and Asia of training and extension strategies for encouraging good aquaculture practices in the use of chemotherapeutic agents and for control of product quality. Marleen Dehasque and Benjamin Jennes presented a new software platform "FindIt" which uses data mining technologies to help producers extract more information and understanding from their existing farm production data and which can also provide benchmarking services when producers opt in to anonymous data sharing. In the final presentation Tony Vaught shared his experience as a producer turned consultant advising on farm design and operation. One of the frustrations of that role could perhaps be summed up in the old saying "you can lead a horse to water but you can't make it drink."

Overall this was a very diverse session underlining the ubiquity of knowledge management and transfer as critical elements in all aspects of aquaculture research and practice. However, as a specific focus area for policy and strategic management, it deserves further research to better understand different contexts and needs and the most effective actions that can be taken by a broader range of stakeholders.

Organic aquaculture

Chair: Elena Mente – University of Thessaly, Greece.

Organic aquaculture is based on the principles of environmental sustainability, product quality, safety and animal welfare. According to EU (2007, 2009), organic aquaculture production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of consumers who value products produced using natural substances and processes.

However, there are issues to be addressed, which require more understanding such as the lack of organic juveniles. In this respect, there are concerns with regards the fulfilment of the EC requirement which stipulate that by the end of 2013 at least half of the juveniles need to come from organic sources and after two years from this date all juveniles should be from organic sources.

Furthermore, the availability of organic feed ingredients needed to produce organic aquafeeds and the improvement of the organic feed formulation in line with the requirements of organic aquaculture legal framework needs further investigation.

There is limited experience and no literature available in organic marine fish hatchery production. Results have shown that the conversion to organic hatchery production offer different challenges in each culture stage. This also needs further information. The use of new methodologies and protocols for organic fish hatchery production needs testing and thorough evaluation.

The potential expansion of organic aquaculture in Europe and globally, would require detailed and specific standards to be set regarding animals' well-being.

In summary, organic aquaculture should incorporate the research results and update the criteria and standards to provide high quality eco-label products. Further research is ongoing to enhance knowledge on how to improve the EU organic aquaculture regulation and the economic development of the European organic aquaculture sector.

Genomic research and applications

Chair: Patrick Prunet, INRA, France.

This session of the EAS 2014 meeting was devoted to various aspects of genomic research in fish and shellfish species. Indeed, there was large variety of presentations covering different aspects of animal biology. As a way to propose a structured session, the presentations were organized along 3 main topics, i.e.' genomic and genetic', 'genomic and reproduction' and 'genomic and metabolism'.

This led to the presentation of 22 original research works of high scientific quality and interest. Among these presentations, we have noticed for example the functional regulation of the enzyme of mitochondrial respiratory chain in various tissues of sea bream exposed to fasting. This study, presented by J. Calduch-Giner, provides an interesting functional view on energy-generating processes and their regulation by caloric restriction and confirmed the major role of adipose tissue

and liver but also the importance of mitochondria functions for providing a refine metabolic phenotype of fish.

In the search for molecular markers of stress using genomic approach, Christian De Santis et al. presented their more recent data related to nutritional stress and use of soybean meal in salmon whereas another presentation was devoted to the effects of thermal stress on liver metabolism in sea bream using transcriptomic and proteomic analysis. These approaches allowed highlighted the benefits of using diet of enhanced nutritional quality to mitigate the negative effects of winter thermal stress.

The session also illustrated the development of genomic approaches in invertebrates: Thus, B. Pardo presented a comprehensive picture of the genes involved in the immune response of European flat oyster (*O. edulis*) exposed to Bonamia. Another group, P. Norouzitallab et al., also investigated in the parthenogenetic *Artemia* model the effects of thermal stress on phenotypic and epigenetic changes in three subsequent generations. This study provided strong evidence for epigenetic inheritance along three generations caused by original heat shocks and also suggested that these phenomena could be associated with modification of histones.

The use of genomic approaches to study reproduction was also presented. For example, Ana Gomez presentation demonstrated that measurement of plasma 11-keto-testosterone can be an efficient non-lethal markers for detection of early puberty in sea bass. Another group, H. Migaud et al., presented interesting data on the kiss system in seabream which allowed them to suggest involvement of that system during early development, maybe in relation to reproductive physiology and also its involvement in the sex reversal process of that fish species. Dr. D. Penman et al. presented use of Next Generation Sequencing- based technique (RAD-seq) for identification of new sex-determining regions of the genome involved in Nile tilapia sex reversal. Using the same NGS technology, the same group also presented interesting data on a sea bass SNP map based on meiotic gynogenetic families. Such genetic linkage maps allowed the authors to localize the centromere of each chromosome in sea bass.

By-products management and sustainability assessment

Chairs: Jogier Toppe, FAO and Erling Larsen, DTU Aqua, Denmark.

The session on By-products Managements and Sustainability Assessment comprised eight talks and 15 posters covering issues such as new methods for quality control of by-products intended for human consumption, methods for managing and utilizing growing starfish populations, utilization of aquaculture wastewater, tools for assessing and evaluating the sustainability of fish farming, intensive fish farming using agro-ecology and ecosystem services, environmental impact of fish farming in the Amazon river basin, and small scale poly-culture of shrimp in Bangladesh and its impact on sustainability and nutrition security. A dynamic group of around 40 people actively attended the session.

NMR technology can be used to characterize a number of fish metabolites as a result of microbiological and enzymatic degradation, indicating the freshness in fish products. The technology was shown to be a good analytic tool for following quality changes in some salmon rest raw materials

intended for human consumption. The methodology will be used for further research on how different treatments affect the quality of the rest raw material of fish.

Wastewater from pikeperch culture has been used as a substrate for Microalgal Bacterial (MaB) flocs, treating the wastewater. MaB-flocs have successfully been used in feed for Pacific white shrimp. Future research should focus on nitrogen removal of MaB-flocs, and study increased levels of MaB-flocs in shrimp diets.

Fierce starfish predation has seriously impacted the mussel industry in the Limfjorden, Denmark, completely depleting mussel beds in some cases. A new innovative starfish purse seine has allowed selective fishing of starfish, allowing mussels to thrive again. Starfish has been processed to flour containing 70% protein, a potential substitute for fishmeal. Future research should include trials on including starfish meal in feed, and developing cost efficient system for removing debris (sand and stones) from the raw material.

Life cycle assessment (LCA) was used to study the carbon footprint through the whole value chain of salmon farming. Results showed that the main contributors to the carbon footprint were related to the feed and transport. The LCA can provide comprehensive information on the environmental impact of the salmon industry, and will be an important tool in moving towards a more environmentally sustainable production.

The concept of ecologically intensive aquaculture, offers options to re-design aquaculture systems using biophysical and social mechanisms. New production systems have been proposed, focusing on nutrient recycling from an economic and environmental point of view, changing the perception of the role of aquaculture in the studied areas.

The environmental impact of farming Amazon (freshwater) prawn as monoculture and polyculture with Tilapia was compared. Polyculture systems showed a significant lower environmental impact and higher production.

Family driven small scale polyculture of shrimp is an important activity among the poorest in Bangladesh. Polyculture is most common among non-shrimp producers providing food fish for local and domestic markets. Out of 54 farmed species, only 2-3 species are destined for export. Fish destined for the local market plays an important role for food security, and the diversification of species is important for the local and sustainable aquaculture.

Aquaponics

Chair: Dieter Anseeuw, Inagro, Belgium.

A first informal meeting of aquaponics researchers was held at AQUA2012 in Prague resulting in the formation of the Aquaponics Network Europe (see linkedin group). The current aquaponics session at AE2014 was the first parallel session devoted to this theme organized during an Aquaculture Europe conference. The aquaponics session attracted much attention.

The first presentations demonstrated different aquaponics pilot projects from the Nordic countries, including Norway (Siv Lene Gangenes-Skar, Bioforsk), Denmark (Paul Rye Kledal, Institute of Global

Food and Farming) and Iceland (Ragnheidur Thorarinsdottir, University of Iceland). Bioforsk is looking into coldwater aquaponics growing local brown trout (*Salmo trutta*) and vegetables which may be a good approach for regions with a cold climate, like the Nordic countries. In Iceland, the potential of geothermy and local Hekla pumice as substrate in the hydroponic beds is explored to grow nile tilapia (*Oreochromis niloticus*) and leafy greens in a small-scale (600 L) system. Paul Kledal pointed out that, for large-scale commercial setups, aquaponics should focus on combining the best of aqua- and horticultural technologies. Systems in which plant support media, such as gravel or expanded clay, also functions as biofilter media are neither efficient, nor sufficiently productive for large scale commercial producers. A decoupled aquaponics setup, with a recirculating loop in the aquaculture unit and a separate recirculating loop in the horticulture unit, may offer the flexibility and safety of production without any compromises as required by commercial growers. In order to open up for organic certification of aquaponics in EU, Kledal's test plant makes use of potted plants in conventional ebb and flow hydroponic tables.

If freshwater aquaponics (research) is currently underdeveloped in EU, then marine aquaponics (maraponics) is to be labelled as premature. Gavin Burnell (University College Cork, Ireland) presented a maraponics setup combining seaweeds (*Ulva* spp.), marsh samphire (*Salicornia europaea*), mussels (*Mytilus edulis*), sea-cucumbers (*Holothuria forskali*), and steelhead trout (*Oncorhynchus mykiss*) to model onshore integrated multitrophic aquaculture (IMTA). Three maraponic units have been constructed and undergone operational testing. Growth rates and water quality parameters are currently being monitored and recorded.

The presentation by Charlie Schultz (Lethbridge College, Alberta, Canada) offered a look across EU's borders on how aquaponics in Canada initiated in 1994 as an industry driven initiative and has evolved now over 5 generations each time adapting the system to better perform in the cold climate of Alberta. The current system has become a zero-discharge decoupled aquaponics design incorporating an aerobic bioreactor coupled with a micro-screen drum filter to completely mineralize solid waste within the system. To increase the rate of mineralization, aeration was replaced with oxygenation through the use of oxygen concentrators. The system pH is not managed or manipulated, allowing the pH to stabilize at 6.0-6.5. Under these conditions, no nutrient supplementation is required and toxicity of ammonia is of little concern. In winter, plant production is halted for energy saving purposes, the greenhouse is completely cleaned and only the fish production is continued. Interestingly, in Canada aquaponics and fish farming can be certified organic.

Standing room only at the AE2014 aquaponics session.

Tom Beyers (Proefcentrum voor Groententeelt, Kruishoutem, Belgium) presented an eye-opening overview of the apparent benefits commonly claimed by aquaponics versus the actual benefits that aquaponics may offer in the high-productive (75 kg tomatoes / m²) hydroponic greenhouse setups of the lowlands (Belgium, Netherlands). The integration of aquaculture with hydroponics is often seen to contribute to nutrient recycling and reduction of fertilizer costs in the greenhouse production. However, RAS water can only supply about 25% of the N, P, K needed by the plants. If growers do not want to compromise on the efficiency and quality of the plant production, artificial fertilizers have to be added to the nutrient solution. As such, the hydroponic nutrient solution cannot be recirculated to the fish, reinforcing the necessity for a decoupled aquaponics approach in commercial setups. Artificial fertilizers make up only 2% of the total production costs in hydroponics. Therefore, the usage of RAS water to save on fertilizer costs does not really make an issue. On the contrary, because RAS water will contain sodium (originating from the fish feed) which plants do hardly take up and thus will accumulate in the nutrient solution upon recirculation, causing osmotic problems. Second, the physical integration of fish basins in the greenhouse proves to have more costs (humidity control, stressed fish, …) than benefits. This is especially so since greenhouse producers in the lowlands commonly own a proper cogeneration/combined heath-power unit producing warmth and electricity for their greenhouse and for selling over-capacity. From this cogeneration unit, also CO^2 is recycled to boost plant production.

Tom Beyers pointed out that the real benefits of integrating aquaculture with hydroponics can be found in (i) the multiple use of freshwater: rain water collected from the greenhouses can first be used in the aquaculture unit and then re-used in the hydroponic unit; (ii) recycling of wastewater from the aquaculture in hydroponics; (iii) recycling of excess heath from the co-generation unit into the aquaculture unit; (iv) strategic clustering of industries to reduce waste streams; (v) contribution to sustainable food production, after all aquaponics is a sexy concept.

Based on the simulations for the Danish reference climate year, Paul Rye Kledal has modelled some symbiotic effects from CO^2 and heat contribution to quantify their physical environmental impact and economic savings on the variable costs. Savings amounted to approximately 6.500 Euro per year for a 1.000 m² fish-lettuce aquaponic production, under the assumption that fossil fuels are being banned from the production cycle (e.g. which is not the case in conventional greenhouse production in Belgium/Netherlands where the implementation of co-generation units in the business strategies creates a completely different story whereby the physical integration of fish basins in the greenhouses turns out to be a cost rather than a benefit).

Benz Kotzen (University of Greenwich, London, UK) was the final speaker of the session and presented the COST Action FA1305 "The EU Aquaponics Hub". In the EU aquaponics is undeveloped and largely non-competitive. Research and practice are fragmented, but both researchers and practitioners consider it has great potential. Aquaponics in the EU needs research and development for the EU to become competitive in the field of sustainable food production. The EU Aquaponics Hub aims to the development of aquaponics in the EU by leading the research agenda through the creation of a networking hub of expert research and industry scientists, engineers, economists, aquaculturists and horticulturalists, and contributing to the training of young aquaponic scientists.

Progress in Eel research

Chairs: Jonna Tomkiewicz, DTU Aqua, Denmark and Elin Kjörsvik, NTNU, Norway.

This session focused on recent advances in breeding of European eel (*Anguilla anguilla*) in aquaculture. It comprised seven presentations and five posters that addressed a variety of relevant topics. One cancelled presentation was eloquently summarized by one co-author. The majority of the contributions, but not all, related to the EU FP7 project PRO-EEL "Reproduction of European eel: Towards a Self-sustained Aquaculture". One poster was awarded the AE2014 Best Student Award.

Although European eel is a well-known species in aquaculture, captive breeding and hatchery technology for commercial purposes has not yet been established. Until recently, European eel was characterized by reproductive failure in captivity. These difficulties in captive breeding relate partly to complex hormonal mechanisms, controlling eel reproduction, and partly to imperfect larval culture technology, hampering healthy development and ongrowing. However, experimental research in recent years applying hormonally induced maturation has resulted in a production of viable eggs and larvae in European eel and promising results for future development of hatchery technology.

Presentations and posters included: factors influencing male reproductive performance, e.g. spermatogenesis and sperm motility; enhancing female broodstock suitability and culture conditions; assisted reproduction technology; egg and embryonic quality; advances in offspring production and culture technology; and lastly larval characteristics, in particular muscle development under different temperature regimes.

Dietary conditioning and reproductive physiology of female broodstock has received much attention over time in order to optimize offspring quantity and quality. In this session, novel insights on dietary effects and probiotic influences on the performance of male eels in terms of sperm density and

motility were presented. The results including analyses of fatty acid dynamics and hormonal regulation (steroids and specific gene expression) during spermatogenesis factors, demonstrated dietary and probiotic influences on sperm quality and quantity. This points to a need for dietary conditioning and reproductive physiology of male as well as female eel broodstock.

Female broodstock condition and quality was addressed through an interesting study allowing extraction of sub-lethal pollutants from wild-caught European eel female broodstock, which might be needed for reproductive experiments in certain parts of the species' distribution. Furthermore, methodologies related to induction of maturation and rearing conditions of female eel broodstock were addressed. Thus, hormonal treatment schemes adopted from the Japanese eel (*A. japonica*) are gradually being tested and improved. Studies presented regulatory effects of temperature on maturation success, molecular studies of final oocyte maturation and egg quality, as well as maternal mRNA expression during embryogenesis. These studies provided new insights into offspring quality, which is a critical point, particularly in assisted reproduction.

Lastly, the final result of the PRO-EEL project on production, survival and development of European eel offspring was presented. In this project, results of basic science and application development have improved assisted reproduction technology and enabled mass production of viable eggs and larvae, allowing experimental work on larval culture technology. Rearing conditions, e.g. temperature, light, and microbial control in rearing systems, have been explored, providing first larval rearing protocols and novel analyses of larval development, such as digestive system and muscle development. Latest progress includes quantification of survival during the embryonic and yolksac larvae leading to the feeding stage. These results show that in order to establish first feeding, not only the identification of suited feed for ongrowing, but also enhanced survival during the yolksac stage need to be addressed in future studies.

Together, the presented recent progress in eel breeding supports eel as a future "new species" in aquaculture hatchery technology. Such technology would promote future sustainable aquaculture of European eel, presently relying on captively-bred glass eels, and would also promote the rebuilding of the highly profitable market for eel aquaculture and suppliers.

Commercialisation and economics of aquaculture products

Chairs: Frank Asche - University of Stavanger, Norway, José Polanco- University of Cantabria, Spain and Begoña Perez - AZTI Tecnalia, Spain.

The economics session was well attended, with a total of 13 papers (in addition to 6 posters). The session covered a number of issues from input suppliers through the supply chain to the market.

The contribution of input suppliers from an economic perspective is a relatively new field. One paper addressed productivity growth in smolt production, showing how productivity growth in this sector contributed to lower cost and improved competitiveness for salmon producers. Another paper showed how copepods increased productivity in live feed and fingerling production.

Several papers addressed different issues for salmon, such as the economic effect of escapees and the potential for large scale offshore facilities, demand growth and consumer preferences, as well as one showing how the shift between generations increased the potential for price volatility.

The starting paper of the session took a more general perspective on price volatility, showing that it varied substantially between species, and product forms, and that price volatility for farmed species where substantially lower than for wild. Another paper discussed the lack of production growth in European aquaculture with the focus on production systems, showing how larger scale and better but more capital intensive production technology increased competitiveness, while traditional small scale dams lagged behind.

Three papers investigated different issues for sea bream focusing on the market. The papers covered market integration, consumer preferences and a comparison of sea breams nutritional value with salmon and meagre. The final paper of the session discussed value added of the new aquaculture species meagre.

The session focused mainly on economics and marketing, and had no papers on commercialization and specific product innovations. As aquaculture economics is a well established field, this can continue to be built on, and the call this time was unfortunately not very good in that respect. Marketing is a weaker field, but fits reasonably well into the economics session. Commercialisation is not really an academic discipline, and accordingly it is not very surprising that it did not attract papers. If this is an important topic for EAS, other venues for promoting it should be found.

Offshore mariculture

Chairs: Arne Fredheim, SINTEF, Norway and Diego Mendiola, AZTI Tecnalia, Spain.

Session reported by Lars Gansel, SINTEF.

This session included five presentations on topics including the use of traditional net cages for open ocean aquaculture (*Patursson et al.*), investigating and understanding the flow through and around fish farms (*Rasmussen et al., Gansel et al*.), multi-use platforms (*Papandroulakis et al*.) and genetic identification of seabass (*Brown et al*.).

Salmon farming is an important industry for the Faroe Islands. Because of limited available space in sheltered sea areas of the Faroe Islands, future expansion of fish farming using new sites will most probably be in highly exposed or open ocean sites. Measurements of currents and waves in a likely area for future farm sites were conducted and a numerical model was used to investigate the performance of traditional net cages in sea conditions in this area. The model results suggest that it is more wave steepness than only wave height that caused large forces on and submergence of the cage. Based on the model results, a cage, mooring and net design was proposed that would withstand sea states similar to those measured. These results show that it might be possible to farm salmon in open ocean sites in cages with the proposed design. Preparations for a prototype test are ongoing.

Understanding the flow through and around salmon farms is crucial information for fish farmers. Understanding the water exchange across nets and transport processes involved in the interaction of fish cages with their environment can help to optimize fish farms design, management and operations. The visualization of the flow field past cages and farms is a powerful tool that can help to understand the flow dynamics through and around marine fish farms. Current measurements were performed in the wake of fish cages at the “Gulin” farm on the Faroer Islands using Acoustic Doppler

Current Profilers (ADCPs) that were mounted to a boat. Measurements of the ambient flow were conducted using bottom mounted ADCPs. Appropriate data processing allowed the visualization of the flow field downstream from the fish farm in a three dimensional volume and the velocity reduction downstream from single cages. This method may be used in other locations and it may help to understand fish farm flow dynamics.

To understand how the flow speed influences the flow through and the behaviour of net cages and the behaviour of fish, it is necessary to systematically vary the flow speed while keeping all other environmental conditions stable. Both laboratory and field tests have been used for such investigations in the past and much has been learned. However, laboratory tests suffer from size restriction, which also prohibits appropriate use of fish, while field tests usually do not allow good control over environmental conditions. It was shown that pushing and pulling large scale fish cages is a method combining the strengths of laboratory and field experiments, while keeping disadvantages at a minimum. The method is found to be an adequate tool to build future understanding of the flow through commercially stocked fish cages, when used in areas with weak ambient current and a lack of waves. Many fjord areas fulfil these requirements. The method allows investigations of the behaviour of (deformation, volume reduction) and forces on fish cages or fish behaviour at different flow speeds. The present tests revealed a knowledge gap in our understanding of the flow past fish cages that needs further investigations.

Fish farming today often uses gravity net cages, but other models have been discussed. The size of intensive western fish farms steadily increased in the past and future growth is expected. The TROPOS project develops a modular floating platform adapted to deep waters that will be able to integrate a wide range of industrial sectors. The platform will provide both energy through the exploitation of ocean renewable energy and food through aquaculture. It will also serve as a maritime hub for transport, the leisure sector and for oceanic observation activities. Designs of the platform were proposed and analyses were performed of the sustainability of such a platform. It was shown that combined use for energy and aquaculture food production will be economically sustainable.

Marine aquaculture in Cyprus has focused almost exclusively on sea bass and seabream. As for other species farmed in net cages, escapes occur, but the effects of escapees on wild populations are unknown. A genetic study was conducted to compare wild and farmed fish and to identify escapees. Results from the study show the presence of fish in the wild that originate from fish farms. Sizes of fish of farm-origin caught in the wild were within the size range found within sea cages. Some individuals caught in the wild had a mixed genotype, which could be evidence of interbreeding of wild fish and escapees. Wild-type genotypes have been found in the broodstock of one farm, suggesting a local origin of broodfish. Broodstocks have otherwise largely been replaced with fish from other countries. This may strongly affect wild populations, if significant numbers of escapees interbreed with wild fish.

Climate change and environmental management

Chair: Angel Borja, AZTI Tecnalia, Spain.

This summary has been made after the abstracts submitted to the session and the notes taken during the presentations.

Aquaculture spots are currently located in coastal and marine areas where many human activities coexist and many ecological, socioeconomic and institutional processes interact, including climate change. Many countries across the continents are committed to growth of an aquaculture industry in the coastal zone to meet rising market demand and achieve higher food security. Aquaculture development, however, must be sustainable both economically and environmentally.

In this session some investigations have been presented showing the degradation after some years of activity. For example, after more than 20 years of activity of an abalone farm in Korea, the sediment achieved a reduced situation, with a bad chemical situation, increasing concentration of metals and impacts on benthic communities. It seems that these processes finally affected the production, with a decrease in recent years. In another study in the same country it was demonstrated that weaken tidal current by the dense and massive abalone aquaculture facility should seem the main cause of degradation of environmental condition of the study area due to reduction of exchange of seawater and materials.

The same results are obtained by a study on tuna farms activity in Malta, which produces a significant increase in sediment organic carbon and organic nitrogen, and a non-significant increase in the abundance of Capitellidae in the vicinity of the cages. The changes in attributes of the benthic assemblages and sediment resulted from accumulation of uneaten feed-fish on the seabed.

The application of the Trophic Index (TRIX) to Iranian coasts demonstrates that low values are related to oligotrophic waters corresponding to high water quality that coast. In turn, bilateral, collaborative projects have addressed specific aspects of the interactions between Harmful Algae Blooms HABs) and suspension-feeding, bivalve molluscs. Bivalves can respond at essentially all functional levels, from behavioural and physiological to immunological and pathological, to different HABs have suggested that a more comprehensive approach to investigating interactions between specific bivalve-HAB pairs is essential to understand how HAB expansion will influence shellfish industries worldwide.

One of the presentations undertook a review of over 400 recent journal articles and reports from the primary and grey literature, to assess the state of knowledge of marine cage culture environmental interactions. The analysis provides an in depth study of impacts to water quality, sediment chemistry, benthic communities, marine life, and sensitive habitats. Owing to progress in siting and management practices, the authors find that environmentally sustainable marine cage culture is possible in the coastal ocean. Many management tools such as siting guidelines, best management practices, fallowing, integrated multi-trophic aquaculture, and aquaculture modelling simulations are now available to assist managers with coastal planning for aquaculture.

As an example, a study presented a ranking of the most suitable sites for aquaculture activities in Algeria, based on model-derived indicators. This step can usefully contribute to the implementation of the ecosystem approach for the management of aquaculture.

In this management, safety for consumers should be taken into account. Hence, one of the studies presented the results after a survey conducted in 5 European countries, to near 3000 people. From the study, it can be seen that a higher agreement with the possible causes of pollution is associated with a higher egocentric, altruistic and biospheric concern about marine environmental problems. Furthermore, people who are not neutral toward the causes of pollution have a significantly stronger belief that an individual can have an influence on marine environmental problems by behaving accordingly.

Among the environmental factors climate change is of paramount importance. Hence, a study over a period of 28 years, give new valuable insight to the effects of increasing water temperatures on the egg viability in an Arctic charr hatchery. The study provides quantitative evaluations on the consequences of the ongoing climate change, and reinforces the need for foresight in the planning of future aquaculture development and management; for example, moving the broodstock to a locality with more favourable temperature conditions, which resulted in greatly improved egg viability.

From another study, it can be concluded that changing climate will influence the potential for aquaculture, and the conditions for sustainable and ethically acceptable aquaculture. It seems that a dynamic approach to management will be needed, as a given locality will change its suitability to given species over time.

In the context of the previous problems, a system modelling approach fore aquaculture, proposed in another study, enables (1) to better understand the dynamics of aquaculture socio-ecosystems through accurate representations of the interactions between their components and (2) to explore management actions driving these systems towards sustainable trajectories.

Integrity, safety and authenticity of food products

Chairs: António Marques, IPMA, Portugal, and Marinella Farré, IDAEA-CSIC, Spain.

This session included 6 oral presentations and 11 posters. Unfortunately, two oral presentations were not finally made, and the organizer did not receive any indication for the reason. Nonetheless, all presentations were clear, appealing and with valuable information. All oral presentations were clear and kept the time allocated, allowing questions and interesting discussion with the audience. The oral presentations addressed chemical contaminants in farmed seafood and water (3 presentations), and traceability of farmed fish (1 presentation). It was a mix of presenting ongoing projects and results from finished projects. All presentations dealt with farmed fish, including seabass and Atlantic salmon.

The session opened with the presentation of the output of the ongoing FP7 project Sea-on-a-chip that deals with the development of a miniaturized, autonomous, remote and flexible immuno-sensor platform based on micro/nano-electrodes and a microfluidic system combined with electrochemical detection for real time analysis of eight representative compounds (including antibiotics, pesticides and toxins) simultaneously. The system is built to work with one-month autonomy and measuring in real time at least once per hour. The results of the optimization of different immunoassays against the antibiotic sulfamides and the antifouling Irgarol were presented. The new platform is extremely

useful and promising as will enable an early detection of contamination in aquaculture exploitations and coastal areas, in support of sea industry, environmental and human health protection.

One presentation dealt with the effect of warming in methylmercury accumulation, speciation and elimination by farmed seabass juveniles fed with contaminated feed. This presentation was done in the framework of a wider research topic being addressed by the authors that aims to assess how climate change will affect marine organisms in contaminated environments. The results indicate that in warming conditions this marine predator fish will accumulate higher levels of methylmercury, fully justifying the need for further research in this field in order to anticipate and develop mitigation tools.

One presentation dealt with the assessment of the levels of the important organic pollutant (pyrethroid) used as insecticide in farmed salmon available in the Spanish market. It was highlighted that this group of compounds accumulate in salmon samples regardless of production location. Additionally, it was found that smoked salmon always registered higher levels of this group of compounds compared to marinated salmon in samples from the same origin and species. Nonetheless, it was clearly stressed that the intake of all pyrethroids are well below the daily recommendations issued by food safety authorities.

The last presentation successfully tested the use of stable isotope analysis to assess the persistence of maternally-derived marine isotopic signatures in wild fish eggs compared to farmed eggs, and to identify wild from farmed fish and escapees. Marked differences were detected between wild and farmed salmon, but these differences were progressively depleted with the onset of exogenous feeding in the wild. Nonetheless, this simple tool can be useful for distinguishing hatchery-fed from naturally occurring fish in the wild.

The poster presentations partly covered the same topics as the oral session. In addition there were other three aspects covered, such as microbiological quality of farmed fish and shellfish, quality assessment of farmed fish and shellfish, and the use of natural coatings to improve the shelf life of farmed fish.

The topics under discussion in this session were extremely pertinent, actual, interesting and with high relevance for the aquaculture sector, fully justifying its inclusion in future Aquaculture Europe conferences.

Laboratory fish models for aquaculture applications

Chair: Miguel Angel Pardo, AZTI Tecnalia, Spain.

The session comprised four talks that addressed topics related to how fish laboratory models can help to aquaculture research. All presentations were focused on the application of zebrafish (*Danio rerio*) animal model.

During the last years, this small bony fish have been extensively used as an alternative model in different research fields such as immunology, toxicology, reproduction, etc… First session revealed germ-free zebrafish as a promising vertebrate model to study the host immune response under a number of microbial infections as well as the interactions between the host and the natural gut

microbiota. The results revealed new insights into the *Vibrio anguillarum* pathogenesis and the probiotic protective ability of *Lactobacillus* strains under an opportunistic infection.

Second session showed a promising device able to measure quantitatively in a precise, non-invasive way the level of stress of fish in experimental as well as rearing conditions by measuring their level of activity through the detection and the elaboration of EMG and / or other bio-electrical signals by means of an array of electrodes placed directly in the water tank. Third session revealed the importance of the process of ribosomal molecule stockpiling in oocytes, and point out the need to characterise the process when studying fish sexual determination/differentiation, gametogenesis and fecundity. Such research would be relevant in the fields of developmental biology, ecotoxicology linked to endocrine disruption, fisheries (fish stock dynamics) and aquaculture.

Finally, the last presentation focused on the importance of zebrafish model as alternative toxicology assays like cardiovascular, acute and chronic etc… A new toxicological test system, (Toxirack system) was also hosted in this session presented. In addition, poster session enforced the use of zebrafish as the model of choice in aquaculture.

EAS EATiP Day: Performance of the Sea Bass and Sea Bream Sector

Resulting from an initiative of two of the pioneers of European aquaculture, Bjorn Myrseth and Gustavo Larrazábal, this special one-day event addressed the production performance of the sea bass and sea bream sector by providing a forum for discussion of important technical challenges and potential responses.

The Mediterranean fish farming sector is very aware that there has been little to no improvement in its technical performance during the last 12-15 years and that this issue has become increasingly decisive for its development. In fact, the Mediterranean aquaculture producers believe this to be the most imperative challenge to be resolved, exceeding all other issues and topics raised by third parties and interest groups. Technical viability, including its biological aspects, is intrinsically linked to economic and marketing performance and, hence, to the growth and sustainability of the sector. At the 2014 Annual Meeting of the FEAP, it was agreed that for the successful and sustainable development of Mediterranean aquaculture, this issue must be addressed urgently and solutions must be found.

The event was chaired by Kjell Maroni on behalf of EAS and by Courtney Hough on behalf of EATiP.

It opened with an introduction of the issues by Gustavo Larrazábal followed by an analysis of the performance of the sector compared to salmon by Bjorn Myrseth.

Three panel discussions then followed – on breeding and genetics, on feeds and on health issues. A final session addressed issues of performance benchmarking and farm scale research priorities, moderated by Javier Ojeda. The event was wrapped up by Gustavo Larrazábal.

Special thanks to our panellists:

Genetics and breeding: Antonio Coli, Selonda, Carlos Mazorra, Tinamenor, Marc Vandeputte, INRA, Anna Sonesson, NOFIMA and Leonidas Papaharisis, Nireus.

Feeds, nutrition and ingredient substitution: Niels Alsted, Biomar, Ramon Fontanillas, Skretting, Marco Gilmozzi, Cosa, Alessandro Moretti, Inve, Sachi Kaushik, INRA and Torbjørn Åsgård, NOFIMA.

Fish health, diseases, parasites, availability of veterinary treatments: Patrick Smith, Tethys, Francesc Padros, SDPP-UAB, Panos Christofilogiannis, AQUARK, Claudia Maira, Pharmaq and Øystein Patursson, Fiskaaling

Production performance benchmarking and farm scale research/priorities: Javier Ojeada, APROMAR.

A special report has been prepared for this event and is available from the EAS and EATiP web sites www.easonline.org and www.eatip.eu

AQUAEXCEL industry workshop: Research infrastructures – adding value to the European aquaculture industry

Chairs: Marieke Reuver, AquaTT, Ireland and Marc Vandeputte, INRA, France.

The EC-funded AQUAEXCEL (Aquaculture infrastructures for excellence in European fish research) project hosted a successful workshop entitled "Research Infrastructures: adding value to European aquaculture industry" on Friday 17 October 2014 at the Aquaculture Europe 2014 conference in San Sebastian, Spain. AQUAEXCEL is an EC FP7-funded project working to integrate key aquaculture research infrastructures across Europe in order to promote their coordinated use and development. The project's focus is on further improving the efficiency of aquaculture production and supporting European research activities in this area.

The workshop focused on presenting the achievements and results of the AQUAEXCEL project as they have strong potential to positively contribute to the enhancement of aquaculture in Europe, and are demonstrably beneficial to the European aquaculture industry. During the event, researchers from AQUAEXCEL's joint research and Transnational Access (TNA) components presented their findings to an audience primarily drawn from industry. The AQUAEXCEL TNA programme enabled research groups to utilise the facilities of participating aquaculture Research Infrastructures to undertake experimental trials on a selection of commercially important fish aquaculture species and system types.

The event was organised by the project's Dissemination and Knowledge Management partner, AquaTT. The workshop was jointly presented by the project's coordinator, Marc Vandeputte (Institut National de la Recherche Agronomique (INRA)), and Marieke Reuver (AquaTT).

Marieke Reuver said: "The specific focus of this AQUAEXCEL workshop was on project results of value to the aquaculture industry and SMEs, and how they can exploit these outputs for commercial benefit. At all stages in the AQUAEXCEL project we have consistently generated results which are of high value to the aquaculture industry in Europe. This workshop provided an opportunity for us to showcase this progress. It also provided a forum for researchers and industry representatives to discuss mutual interests as well as future opportunities for collaboration."

More than 140 people attended the event, which featured dynamic and engaging discussions broadly focusing on the interconnectedness of research and industry, and the opportunities for both to collaborate and play a part in Europe's quest to produce high quality seafood with reduced environmental impact. Marc Vandeputte, AQUAEXCEL Project Coordinator, said: "The success of this workshop demonstrates the keen interest on both sides to strengthen ties between top class research and industry."

Results of value to the aquaculture industry that were presented and discussed during the workshop included descriptions of new aquaculture research tools and methodologies developed through the project, such as: new tools to easily evaluate chronic stress in farmed fish; guidelines on sizing research structures to ensure that results are applicable to industrial scales; and prototype electronic infrastructures (e-infrastructures) which enable interchange of data and remote operation of aquaculture research facilities over the internet.

Research carried out under the AQUAEXCEL TNA programme was also highlighted in a series of three minute presentations by TNA participants. The findings presented were then discussed with a panel of industry experts and the audience. Topics that sparked debate included research relating to fish feed studies examining the substitution of fish oil with alternative ingredients such as hazelnut oil.

For more information about the AQUAEXCEL project, please visit: www.aquaexcel.eu

Andries Kamstra (Institute for Marine Resources and Ecosystem Studies (IMARES), the Netherlands) presenting his research during the AQUAEXCEL workshop at AE2014.

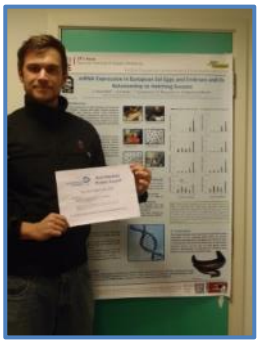
Special thanks go to our session chairs (not all of them feature here, as not all had sent their photos to EAS) for all of their hard work, not only in making difficult choices to select the oral presentations from the huge amount of abstracts received, but also for managing often long sessions during the event, finding time to judge the posters in their session and not least producing these summary reports after the event. It is very much appreciated.

Our thanks also go to all the student helpers that prepared the conference bags, checked badges, supported the session chairs and helped our delegates in so many different ways.

AE2014 Poster 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 AE2014 Programme co-chairs Diego Mendiola and Herve Migaud, to select the overall winners.

AE2014 Best Student Poster



The AE2014 Best Student Poster was awarded to **Christoffer Rozenfeld**, Ian A. E. Tomkiewicz, David Mazurais, & José Zambonino, for their poster entitled "MATERNAL mRNA EXPRESSION IN EUROPEAN EEL EGGS AND EMBRYOS AND ITS RELATIONSHIP TO OFFSPRING DEVELOPMENTAL COMPETENCE."

Christoffer received €250 in cash and a one-year free membership of EAS.

See the poster here

AE2014 Best Poster

The AE2014 Best Poster was awarded to **Lill-Heidi Johansen**, Aleksei Krasnov, Torunn Taksdal & Ingrid Moan, for their poster entitled "INFECTIOUS PANCREATIC NECROSIS VIRUS (IPNV) AS RISK FACTOR IN THE DEVELOPMENT OF HEART AND SKELETAL MUSCLE INFLAMMATION (HSMI) IN ATLANTIC SALMON *Salmo salar* L".

Lill-Heidi received €250 in cash and a one-year free membership of EAS.

See the poster here

EAS Student Group Ibrahim Okumus Award

The EAS-SG Ibrahim Okumus Award honours the life of Professor Ibrahim Okumus (1960-2008) of the Faculty of Fisheries in Rize University, Turkey, and awarded by the EAS Student Group in respect to his achievements for next generation researchers.

The EAS_SG is sponsored by Skretting and the 2014 award of €300 in cash was supported by Pharmaq.

It was awarded to **Ana Ramalho**, Rita Colen, Vera Rodrigues, Maria Teresa Dinis and Jorge Dias for their poster entitled "FISH BONE MEAL AS A DIETARY PHOSPHORUS SOURCE FOR JUVENILE GILTHEAD SEABREAM (Sparus aurata)".

See the poster here

Lindsay Laird Award

AquaTT and AQUALEX Multimedia Consortium (AMC) are pleased to announce that the winner of the 2014 Lindsay Laird Award for the best innovative aquaculture student poster at the 2014 Aquaculture Europe Conference (AE2014) is Marina Machado from Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), Universidade do Porto, Portugal, with her poster entitled "Dietary Methionine Supplementation but not Tryptophan Improve Cell Mediated Immunity of European Seabass *Dicentrarchus labrax*".

The aim of Marina's study was to investigate the effects of dietary supplementation of the amino acids methionine (MET) and tryptophan (TRP) on the European sea bass cellular and humoral (immune system) status, in order to develop functional feeds for this species. She receives an iPad mini, sponsored by AquaTT, and a book prize from Wiley-Blackwell.

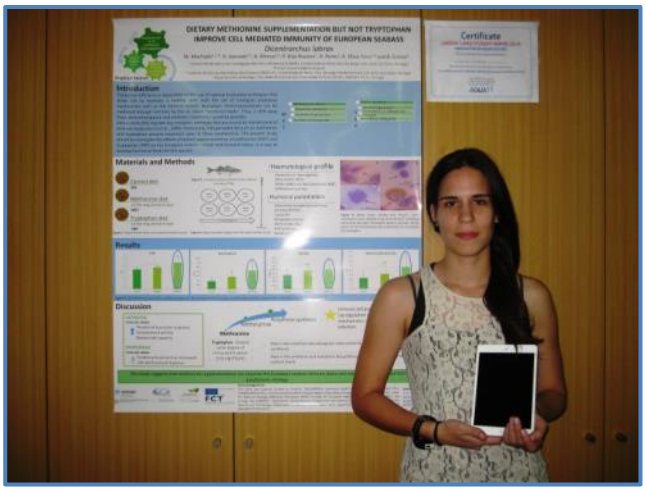


Photo Caption: Marina Machado, from Centro Interdisciplinar de Investigação Marinha e Ambiental (CIIMAR), Universidade do Porto, Portugal, winner of the 2014 Lindsay Laird Award.

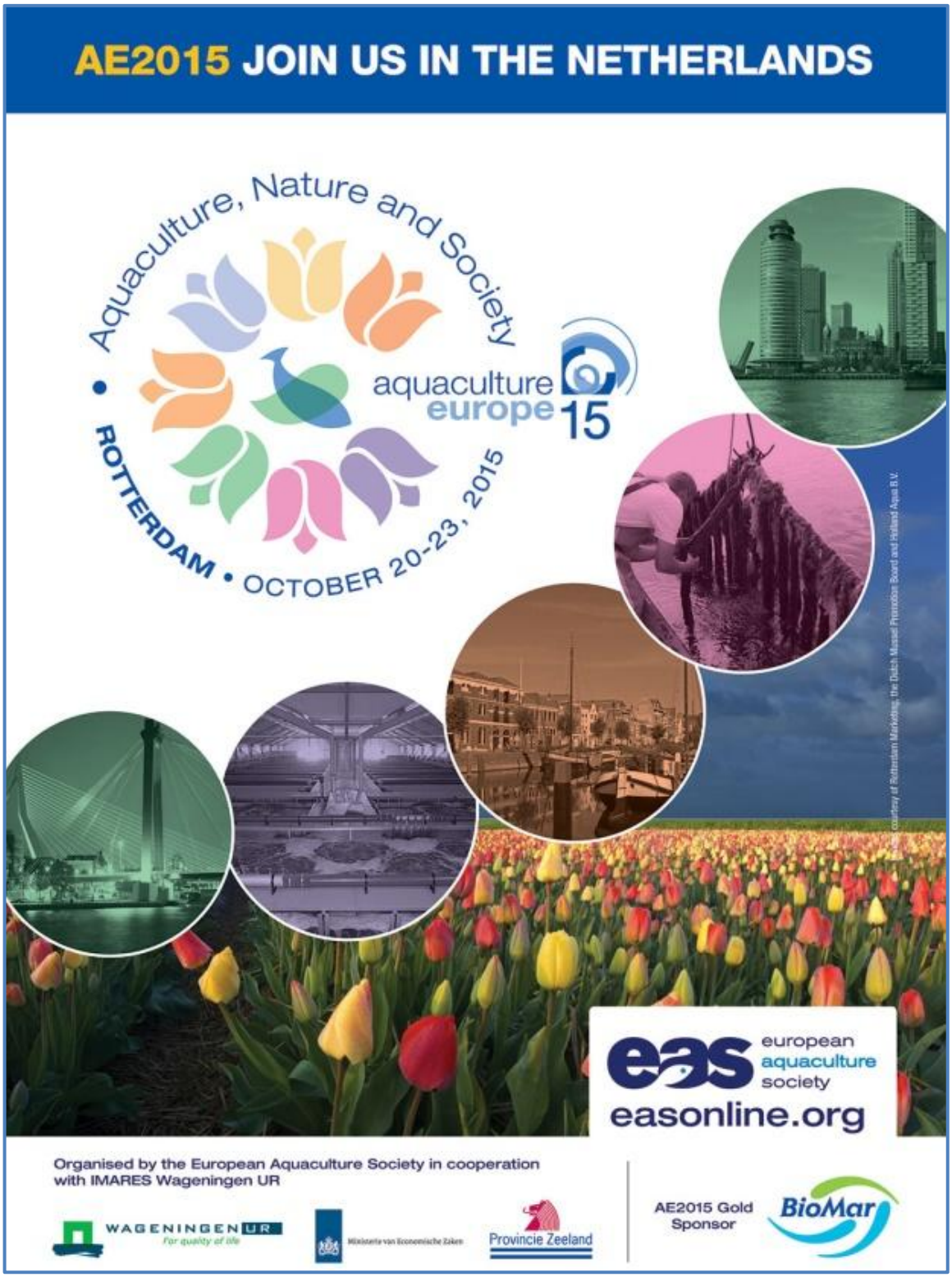
In 2008, AquaTT and AMC established an award in honour of Lindsay Laird, Senior Teaching Fellow in the Zoology Department at the University of Aberdeen, for the most innovative poster (in English) submitted by a student at the Aquaculture Europe Conference.

During this year's competition, more than 100 student posters were evaluated by a team of three judges: Kjell Maroni (Director R&D aquaculture, Norwegian Seafood Research Fund & President of the European Aquaculture Society (EAS) Board, 2012-2014), Dr Elena Mente (Associate Professor, University of Thessaly (Greece) and Board member of the EAS), and Marieke Reuver (Programme Manager, AquaTT and Director of AMC). The award was presented to Marina in absentia by Kjell Maroni during the wrap-up session of the AE2014 conference.

To learn more about Lindsay Laird, this award and past winners, please visit: www.aquatt.ie or www.aqualex.org

See the poster here

Welcome to Aquaculture Europe 2015!



More at www.easonline.org