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VOL. 40 (2) SEPTEMBER 2015

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Advances in pikeperch research

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EAS is a non-profit society that aims at promoting contacts among all involved in aquaculture. EAS was founded in 1976. Aquaculture Europe is the members' magazine of EAS.

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On the cover: Lumpfish. *Photo courtesy of Pablo Gordillo Chueca. See story on page 32*

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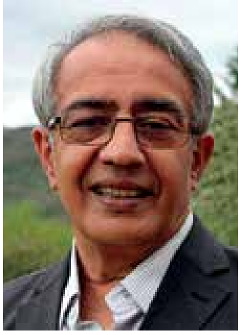

Dear EAS member(s),

On behalf of the members of the board of EAS, I am pleased to invite all of you to the forthcoming Aquaculture Europe 2015 in Rotterdam. Thanks to the steering committee, the local organisers and our programme co-chairs, AE2015 is diverse and engaging. Dealing with "Aquaculture, Nature and Society", the highlight will be on the role and contribution of aquaculture to the management of natural resources and its societal importance for the provision of healthy and nutritious food.

As is customary, we will also have the General Assembly of EAS on October 21st. I welcome all of you to take part actively for your society. The full agenda and the procuration forms, for those who cannot be with us physically, will be sent out by our secretariat on 22nd September 2015, well ahead of AE2015.

I am also pleased to announce that the board has fixed the venues and major themes of future meetings of EAS for the next four years to come. In September 2016, we will meet in Edinburgh, Scotland for Aquaculture Europe 2016. Aquaculture Europe 2017 will be held in Dubrovnik, Croatia.

AQUA 2018 will be an event jointly organized by EAS and the World Aquaculture Society (WAS) and will be held in Montpellier, France from August 26 to 29, 2018. This event will include the WAS annual International Conference and Exposition as well as the EAS Aquaculture Europe 2018 meeting.

We have two candidates for the event in 2019 and the decision on this location will be made during the EAS board meeting in Rotterdam.

EAS is also supporting a number of other aquaculture events in Europe and nearby. We thus were involved in the 7th International conference on "Water and Fish", held in Belgrade, Serbia in June. We also lent support to Aquaculture 2015 organised by Elsevier in Montpellier, France, in August.

We do hope to keep up with the successful trajectory set by the previous board and I thank you all for your support and contributions to our events.

Awaiting to see you all in Rotterdam.

Sachi

FOOD *for* THOUGHT

Recent developments and future perspectives of using marine microalgae in fish farming

Images courtesy of Alltech Inc and Nofima AS

BY: KATERINA KOUSOULAKI

The rapid growth of aquaculture brings challenges and entails risks. The role of research is to generate knowledge in order to maintain the quality and ethical standards, which will render this growth economically, socially and environmentally sustainable. Aquaculture stakeholders ought to be innovative in order to keep up with the pace of this tremendous growth of the sector at the same time, as they are obliged to establish fundamental knowledge in order to predict the consequences of innovation in all levels.

European union aquaculture production in 2010 had a values of € 3.1 billion for 1.26 million tons of production, corresponding to about 2% of the global aquaculture production. EU aquaculture production has stagnated in the last decade, while other areas – in particular Asia – have seen a very fast growth of the sector. Some of the main challenges of the sector are restricted markets and low aquaculture product prices, at increasing challenges created by the scarcity and increasing prices of available and appropriate ingredients for aquafeeds.

As a response to the challenge, the European Commission launched in 2009 a new initiative "Building a sustainable future for aquaculture; A new impetus for the Strategy for the Sustainable Development of European Aquaculture"[1] aiming to address the obstacles to growth faced by the stagnated aquaculture industry[2]. The new strategy aims at making EU aquaculture more competitive, ensuring sustainable growth and improving the sector's image and governance, including the key elements of the Bangkok Declaration[3]. Likewise, the stakeholders in the EU FP6 FEUFAR initiative identified two top research priorities for European aquaculture. Those were: 1) the development of healthy seafood with high flesh quality in terms of fat and n-3 long chain polyunsaturated fatty acid (n-3LC-PUFA) level for consumers, and 2) to decrease the environmental impact of aquaculture, i.e. the pressure on fish wild stocks, through utilization of new raw material food sources such as non-exploited marine invertebrates, algae and terrestrial vegetables for fish feed[4].

Among the recent changes of the modern commercial fish feeds, include variable lipid fatty acid composition, depending on the dietary levels of fish oil and the type of plant oil sources used (e.g. soya oil, rapeseed oil, linseed

[1] European Commission (2009) Building a sustainable future for aquaculture. A new impetus for the Strategy for the Sustainable Development of European Aquaculture. COM (2009) 162 final, 12 pp. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2009:0162:FIN:EN:PDF

[2] FAO (2010) FAO Fisheries and Aquaculture Department, Fishery Information, Data and Statistics Unit. FishStat Plus version 2.32. Universal software for fishery statistics time series. Global data sets 1950-2008. Rome. www.fao.org/fishery/statistics/software/fishstat/en.

[3] NACA/FAO (2000) Aquaculture development beyond 2000: the Bangkok Declaration and Strategy. Conference on Aquaculture in the Third Millennium, 20–25 February 2000, Bangkok, Thailand. Bangkok, NACA and Rome, FAO. 27 pp.

[4] FEUFAR (2008) Research needs for addressing key challenges in fisheries and aquaculture. Report 6. Topics for Research. Available at www.feufar.eu/default.asp?ZNT=S0T1O0P159

continued from page 5

oil, palm oil a.o.). Decreasing levels of total marine LC-PUFA as well as other changes in the composition of the dietary fatty acids affect the physiological processes of the fish, such as nutrient digestibility, lipogenesis, lipid deposition, storage and transport by lipoproteins, and fatty acid uptake and metabolism in tissues. It also affects the final product composition and nutritional quality for the consumer in terms of intake levels of n-3LC-PUFA. The main readily available food source of n-3LC-PUFA is fish and seafood and as over 70% of the world's fish species are either fully exploited or depleted[5], the development of new sources of n-3LC-PUFA is one of the major challenges in aquaculture.

Photo 1: Atlantic salmon.

Approaches

Salmon farming is one of the most prosperous aquaculture sectors and despite the drop in the fish oil levels in aquafeeds, farmed Atlantic salmon is still today an excellent source of n-3LC-PUFA to consumers. In order to maintain today's standards and allow for further growth of the industry significant volumes of novel n-3LC-PUFA rich ingredients need to be developed.

Photo 2: Atlantic salmon fillet.

One of the most inspiring and potentially sustainable way forward is microalgae biomass production. Microalgae, are a very diverse group of microorganism, and as the primary producers of n-3LC-PUFAs they are recognized as among the most prominent future sustainable sources of n-3LC-PUFA rich oils for aquaculture. Researchers at Nofima are engaged in long-term studies of Atlantic salmon's physiological condition and responses related to their need in essential fatty acids, and their immune responses and metabolic capacity when challenged with feeds with variable nutritional quality. Exploring the potential and consequences of feeding Atlantic salmon with microalgae is one of the priority areas of the Nutrition and Feed Technology research department at Nofima, featuring currently a long-term strategic research alliance between Nofima and Alltech Inc and 2 large Norwegian government funded research projects.

Photo 3: Alltech heterotrophic microalgae production facilities at Kentucky, USA

Alltech is one of the largest producers of heterotrophic microalgae (PHOTO 3) eager to explore the potential and limits of their products. During the past 3 years, we have investigated the technical and biological potential in salmon production of a Thraustochytrid microalgae species belonging to the genus *Schizochytrium*. *Schizochytrium* sp. (PHOTO 4) dry biomass typically contains high lipid levels (55-75% in dry matter), up to 49% of which is docosahexaenoic acid (DHA), whereas it contains also significant levels of n-6 decapentaenoic acid and saturated fatty acids, and is nearly devoid of ecosapentaenoic acid (EPA) (Figure 1).

Photo 4: Live *Schizochytrium* sp cells under the microscope.

[5] FAO (2009) World Review of Fisheries and Aquaculture. Rome. 148 pp.

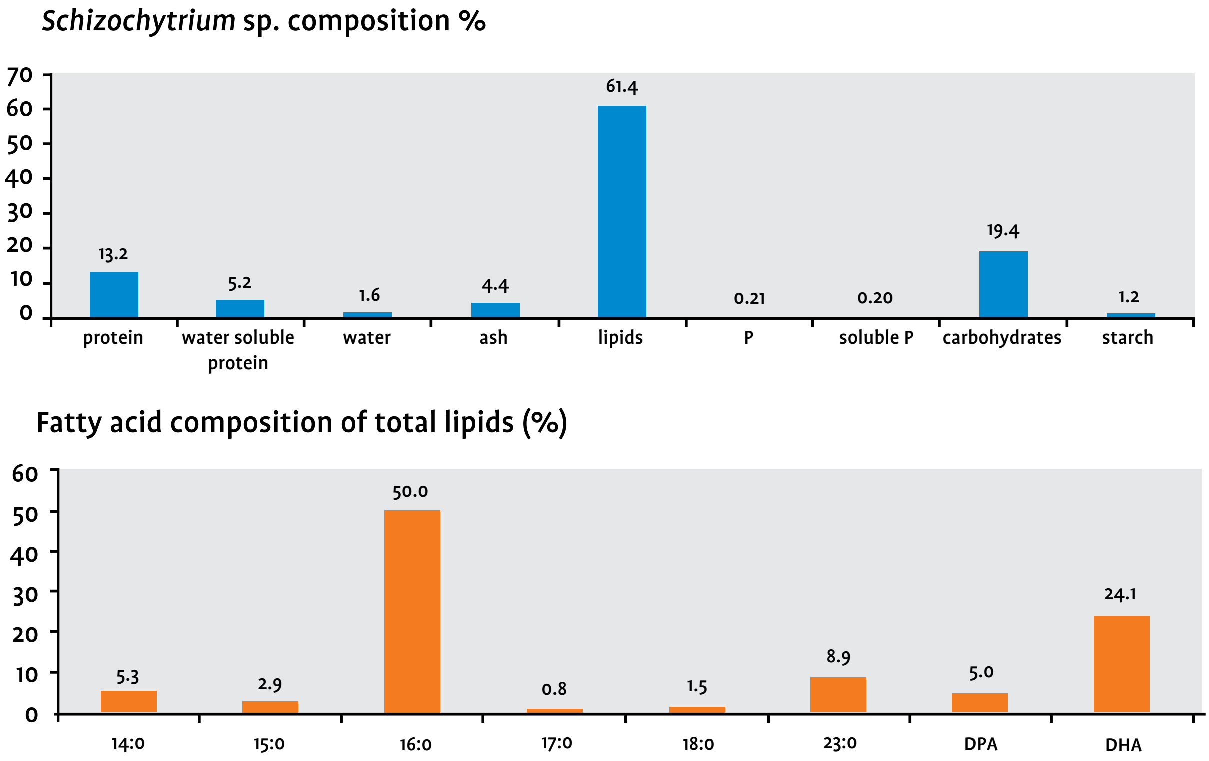

Figure 1: Chemical composition of *Schizochytrium* sp.

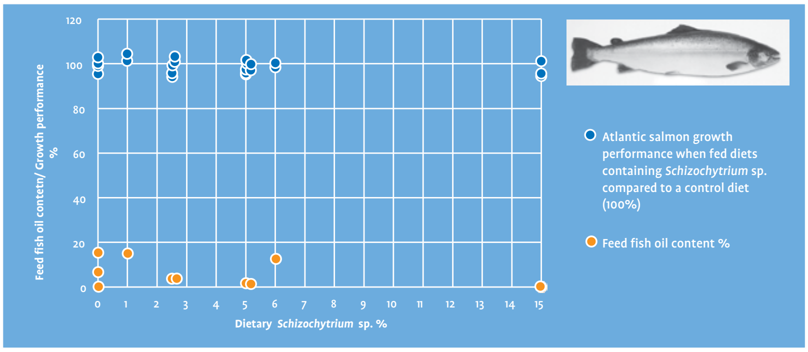

Figure 2: Comparative Atlantic samlon performance in diets where fish oil is substituted by *Schizochytrium* sp.

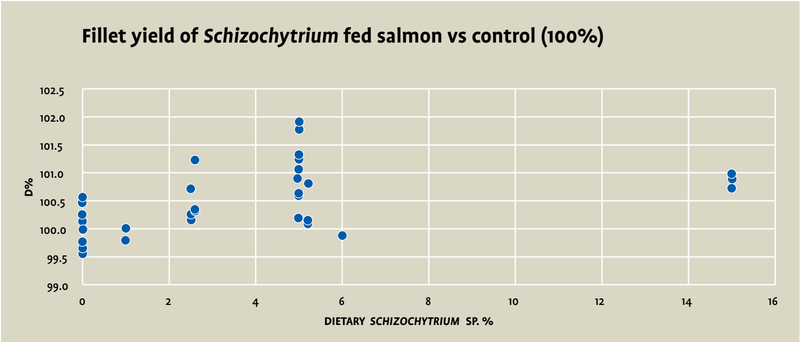

Figure 3: Fillet yield (D%: dress out performance) of salmon fed diets containing *Schizochytrium* sp.

Effects on fish growth

In our studies, we have tested different dietary *Schizochytrium* sp. levels substituting fish oil in feed for salmon grown from fresh water (18g start fish body weight), through smoltification, in smolt and post smolt fish (up to 1.2 kg final fish body weight). Our results demonstrated high performance of all feed given diets that contained between 1% and 15% *Schizochytrium* sp. *Schizochytrium* sp. was proven to be highly palatable for Atlantic salmon as well as highly digestible, especially in terms of total protein and unsaturated fatty acids.

Interesting findings or our studies were also the positive effects of dietary *Schizochytrium* sp. on salmon liver lipid levels and fillet yield, by stimulating muscle growth (up to 2 % unit higher dress out percentage –D%– compared to the control fish) rather than visceral fat deposition (Figure 3). Thus dietary *Schizochytrium* sp., unlike what is commonly seen with alternative land plant protein and oil ingredients leads to higher carcass yields, thus increasing the relative amount of fillets that are the best-

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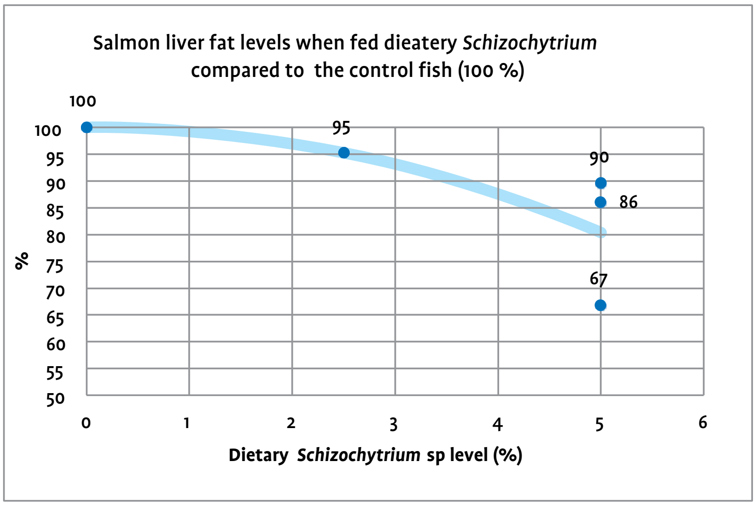

Figure 4: Reduction of Atlantic salmon liver fat levels at increasing dietary levels of *Schizochytrium* sp.

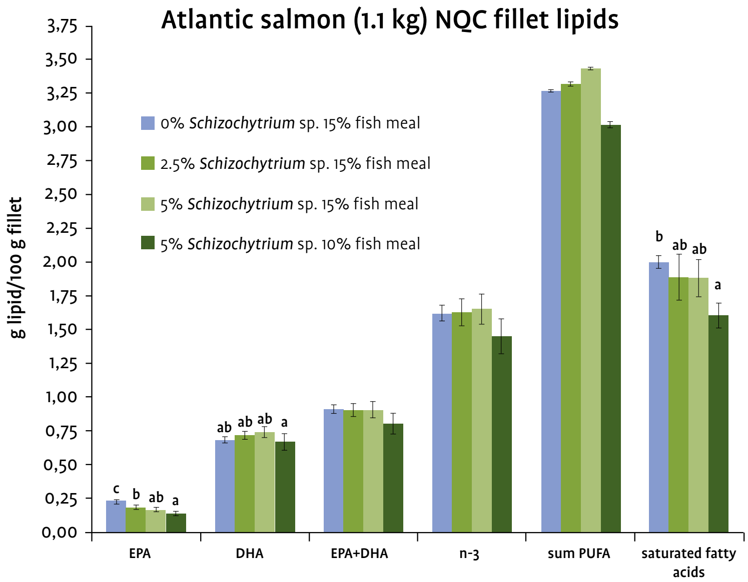

Figure 5: Atlantic salmon Norwegian Quality Cut (NQC) fillet fatty acids composition.

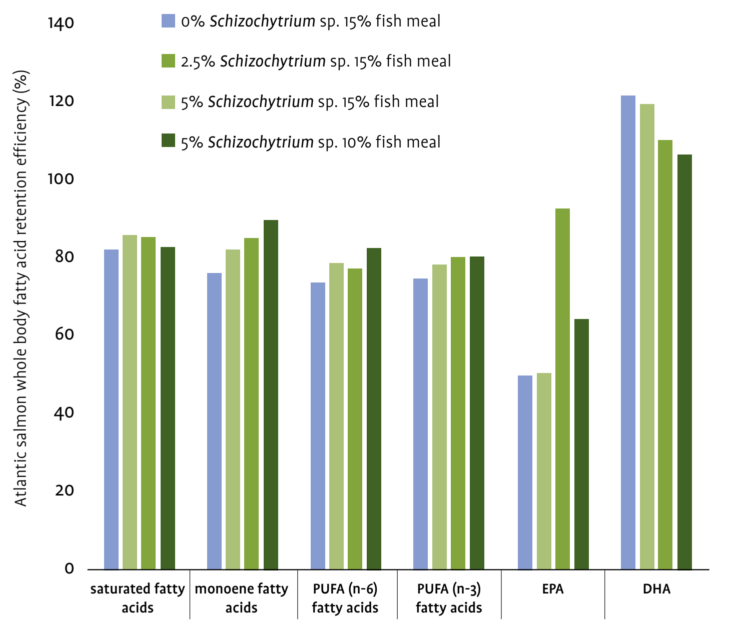

Figure 6: Mass balance of fatty acids in Atlantic salmon fed *Schizochytrium* sp rich diets

paid parts of the fish. What we believe is the reason laying behind these specific *Schizochytrium* sp. effects are the functional properties of the saturated fatty acids of this microalgae ingredient. Atlantic salmon has limited capacity of to efficiently digest saturated fatty acids at low temperatures and increasing dietary levels but at the same time it has been shown before that saturated fatty acids induce lipoprotein secretion facilitating the transport of lipids away from the liver and into the muslce, as well as due to increased b-oxidation to increase the amounts of digestible energy. In our follow up studies, though we balanced our diets for total saturated fatty acids, we observed the same results in terms of higher D% and lower liver lipids in fish fed the *Schizochytrium* sp. fed salmon.

Product quality

Though liver fat was decreased in the salmon fed diets containing *Schizochytrium* sp. (Figure 4), the fat content in the whole body, and the fatty acid composition of the salmon fillets was not affected (Figure 5). Moreover we found that, *Schizochytrium* sp. supplementation at balanced total dietary saturated fatty acids and n-3/n-6 fatty acid levels, resulted in more efficient retention of most fatty acids (Figure 6) in particular that of EPA as well as the sum of EPA+DHA, possibly due to reduced ß-oxidation of EPA and increased desaturation and elongation of shorter-chain fatty acids provided by the dietary plant oils or even by retroconversion of the algal DHA to EPA. It appears thus, that, using *Scizochytrium* sp. as n-3LC-PUFA source at todays and future relatively low levels of dietary n-3LC-PUFA can be an efficient way to deliver n-3 LC-PUFA to consumers.

Another important feature of Atlantic salmon product quality is the technical quality of the fillets, typically measured by the occurrence of gaping, the liquid holding capacity and texture of the flesh. The technical quality of the salmon fillets is challenged by the increasing amounts of unsaturated fatty acids typically present in rapeseed oil and the decreasing level of saturated lipids, typically present in fish oil. In this regard,

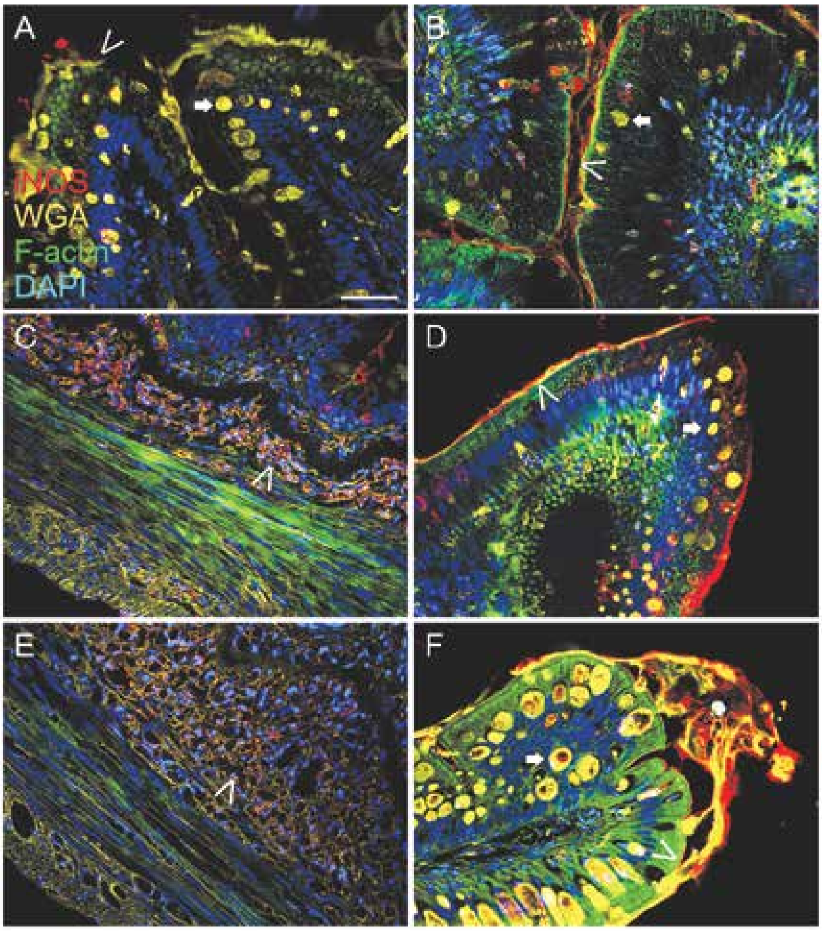

PHOTO 5: (*Kousoulaki et al., 2015*) Fluorescence staining and immunofluorescence analysis of salmon intestines fed different levels of *Schizochytrium* sp. A) Normal intestinal morphology in a control fish. WGA stained goblet cells and modest levels of iNOS activity (arrow head). B) Inclusion of 1% *Schizochytrium* sp. increase iNOS activity moderately (arrow head). Also there appear to be somewhat more goblet cells (arrow). C) In fish fed 5% *Schizochytrium* sp., up regulation of iNOS was evident at the base of the itntestine (arrow head). In control fish, no iNOS was detected in this part of the intestine (not shown). D) increased iNOS activity (arrow head)and more goblet cells (arrow) were evident in the villi from fish fed 5% algae. E) Inclusion of 15% *Schizochytrium* sp. showed similar iNOS activity as in C at the base of the villi (arrow head). F) In the villi a considerable increase in mucus, goblet cell number (arrow) and iNOS activity (arrow head) was evident when 15% *Schizochytrium* sp.was included in the diet.

the high level of the *Schizochytrium* sp. saturated lipids is optimal, giving us consistently good fillet quality results irrespectively of dietary rapeseed levels.

Effects on fish health

Our experiences so far have shown no negative effect of using *Schizochytrium* sp. in diets for salmon up to 15% dietary inclusion levels. Zero fish mortalities, normal hematocrit, plasma cholesterol and glucose levels and minor global trancriptomic effects are among our finding that support the fact that *Schizochytrium* sp. is safe to use in Atlantic salmon nutrition. Moreover, at high levels of *Schizochytrium* sp. in the diet we observed a significant immune response in the intestinal tissue of salmon, including increased iNOS, f-actin and goblet cell size, with no signs of abnormal morphology or inflammation (PHOTO 5). Microalgae, as other unicellular organisms, may contain bioactive cell wall compounds (e.g. ß-glucans), and other bioactive components (e.g. nucleotides) which may stimulate gut health. This finding is interesting regarding our understanding on whether the alterations in the immunological response of the fish intestinal tissues by dietary *Schizochytrium* sp. relates to nutrient absorption modulation or resistance to antinutrients and pathogens. Most of the data summarized in this article can be found in 2 peer reviewed papers of our group[67].

Potential development and Future works

Our current and future works, funded by the Research Council of Norway, FHF (Norwegian Fisheries and Aquaculture Research Fund) and Alltech Inc include closing the production cycle of Atlantic salmon, from fresh water parr to slaughter size fish in the cages, fed either fish oil or *Schizochytrium* sp. as the only supplemental n-3LC-PUFA oil source. This study will allow us to verify the results of our previous studies and will give us insights on salmon lipid metabolism in almost complete absences of dietary EPA. We will moreover study thoroughly several aspects of fish immunity and health in collaboration with our partners from Bergen (Quantidoc) and Ås (NMBU). Quantidoc will describe salmon's welfare condition using the Quality Index obtained by their methodology quantifying the mucosal tissue parameters as mucus cell size and mucus cell density. All the trial fish are pit-tag allowing us to follow individual fish performance and health condition. Repetitive samplings and transport from tank to the cage facilities of Nofima will subject the experimental fish to farming-related stress conditions so that we will be able to establish potential microalgae effects on the robustness of farmed Atlantic salmon fed a promising novel n-3LC-PUFA oil source in the diet.

continued on page 10

[6] Kousoulaki, K., T. Mørkøre, I. Nengas, R. K. Berge and J. Sweetman. Microalgae and organic minerals affect lipid retention efficiency and fillet quality in Atlantic salmon (*Salmo salar* L.). Aquaculture (in press).

[7] Kousoulaki, K., Østbye, T-K.K., Krasnov, A., Torgersen, J.S., Mørkøre, T. and Sweetman, J., 2015. Microalgae feed for future omega-3 rich farmed fish: Fish Metabolism, Health and Fillet nutritional quality. Journal of Nutritional Science 4, e24, page 1-13.

continued from page 9

Last, our present and future works focus, not only on the physiological effects of dietary microalgae, but also on technical and economic issues regarding the rheological properties of the microalgae ingredients during downstream processing and extrusion (PHOTO 6).

Though clearly environmentally advantageous, the progress and viability of using microalgae in aquaculture will be largely influenced by production economics. Fermentation technology, used to produce the *Schizochytrium* sp. (PHOTOS 6-8) biomass is easily up-scalable in all parts of the world, with high automation degree, that does not exclude high labour cost developed countries, providing realistic prospects of near future large scale application of heterotrophically produced n-3LC-PUFA rich microalgae in aquaculture. Still, more cost efficient downstream processing technologies need to be developed and the near future prospects indicate that microalgae production will be targeting the supply of the limiting n-3 LC PUFA and possibly also bioactives, rather than that of proteins, though of high quality, as other available and far more economic efficient marine and plant-based high-protein raw materials are available.

PHOTO 6: Heterotrophically produced *Schizochytrium* sp.

PHOTO 8: Alltech's large scale heterotrophic microalgae production facility at Kentucky, USA.

PHOTO 7: Extrusion trials with *Schizochytrium* sp.

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Phospholipids increase lipid retention and levels in the animals.

Lecithin may be produced from egg yolk, but more commonly used in aquafeed are soya and rape seed lecithin. It is well known that the phospholipids (PL) present in lecithin act as an emulsifier of lipids in the animal stomach and gut, but especially the nutritional benefits of lecithin is why fish nutritionists like to include it in fish and shrimp diets. Lecithin is widely used in feed for larval and juvenile stages of various species of fish and crustaceans, because those developing fish have a limited ability to the novo phospholipid synthesis. This article will highlight some of the other reasons and benefits to include lecithin in aquafeed for all life stages.

Phospholipids

Phosphatidylcholine (PC) is the most abundant PL in fish tissues and is among many others an important catabolic energy source for egg and larval embryogenesis and important for intestinal lipid absorption. In literature many examples may be found of the benefits of PL on survival, growth, resistance to stress tests, prevention of malformations, essential lipid composition of the fish. Seemingly phosphatidylcholine (PC) is more effective for growth improvement while phosphatidylinositol (PI) and phosphatidylethanolamine (PE) are more important for survival and preventing deformities in the developing fish and are a structural component of practically all cell membranes.

Pellet quality

PL may improve the performance of the diet by improving the water stability of food particles, or by their action as antioxidant or feed attractant. An interesting example of a practical application of lecithin was already published by Castell in 1997. They hypothesise that dietary supplementation of soybean lecithin prevents molt death in lobsters, by reducing the leaching of water soluble nutrients, in particular manganese and B vitamins. Various forms and concentrations of dietary choline were not as effective as PC in reducing molt death syndrome in juvenile lobsters. Soy lecithin may increase the

Lecithin induces a higher activity of enzymes.

physical water stability of aquafeed pellets and thereby reduce the loss of water soluble nutrients.

Lipid transport and retention

PL are required in shrimp feed for the efficient transport of dietary fatty acids and lipids from the gut epithelium into the haemolymph, and the mobility of lipids between the various tissues and organs. PL also reduce the accumulation of lipid droplets in the intestine, due to its essential role in the transportation of Triacylglycerol (TAG) from the intestinal mucosa via the haemolymph into the serum of shrimp as chylomicron and other lipoprotein. Diets with additional PL have higher levels of plasma lipoproteins and epithelial enzymes. The inclusion of PL in the diet affects lipid deposition, resulting in increased lipid retention and levels in the animal.

Nobacithin Aqua

Noba Vital Lipids developed a liquid lecithin blend, named Nobacithin Aqua R100. Native liquid lecithin has a very high viscosity and is therefore not so easy to handle in a feed plant. In Nobacithin Aqua R100, oil and fatty acids have been added to lecithin which makes its application much easier. This Nobacithin Aqua R100 is based upon rape lecithin. It is a NON-GMO blend. Beside this rape base blend, there are also mixtures of Nobacithin Aqua based upon soybean lecithin.

What makes Nobacithin Aqua R100 stand out from other lecithin products? There are many dry lecithin products on the market, those are mainly used for the juvenile and larvae stages. A liquid product is often cheaper than a dry product. With the usage of Nobacithin Aqua you have the possibility to increase the inclusion levels of lecithin, and that is interesting because of the nutritional mechanisms and benefits described in this article. Because of the stickiness of lecithin, blended with fish oil it may be applied

Benefits of lecithin (phospholipids):

- Higher survival and growth
- Better resistance to stress
- Prevention of malformations
- Improve water stability of food particles
- Reduce leaching of water soluble nutrients
- Antioxidant
- Reduce accumulation of lipid droplets
- Higher levels of plasma lipoproteins
- Higher levels of epithelial enzymes
- Increase lipid retention
- Better essential lipid composition of the fish.

as coating for the pellets contributing to a better pellet quality. Nobacithin Aqua is suitable for larvae, juvenile, and grower diets for many species of fish and crustaceans.

Noba

Noba Vital Lipids is a leading Dutch manufacturer and supplier of high energy fat products for the animal feed and aquafeed industries, servicing greater Europe. Our strengths are rooted in more than 60 years of experience alongside our high standards of quality, which are fulfilled at every step of the production process. Noba is deeply committed to ensuring meticulous care and product safety during raw material selection and processing, as well as in the final product. The result is the unbeatable quality found in each and every Noba product.

Noba partners with leading research universities and animal feed testing centres to conduct basic nutritional research and in-depth feed trials. We focus on nutrients, not just ingredients. Our proprietary technology allows us to deliver optimal nutritional value and consistency in every batch we produce. We deliver throughout Europe with maximum flexibility and reliability, even at short notice. At our premises in The Netherlands, Germany and Austria we have a tank storage capacity of over 100,000 tonnes. These capacities and the provision of a large fleet of modern tankers guarantee punctual and flexible delivery to our clients.

Phospholipids improve water stability of food particles.

Visit our booth at the exhibition during the Aquaculture Europe 2015 conference from 20-23 October in Rotterdam to see the product **Nobacithin Aqua R100.**

RECENT ADVANCES ON SENEGALESE SOLE WEANING

THE SOLEAWIN PROJECT

WILSON PINTO*[1], LUÍS E. C. CONCEIÇÃO[1] AND SOFIA ENGROLA[2]

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25 day-old sole post-larvae SE.

With the stagnation of aquaculture growth occurring in the last decades in several European countries (e.g. Portugal, Spain, France, United Kingdom and Italy), diversification of cultured species has been clearly identified by the main stakeholders within the EU as key factor to boost European fish farming. Among the most interesting and emerging candidate-species envisaged for aquaculture diversification in the Mediterranean area is Senegalese sole (*Solea senegalensis*), a white-fleshed flatfish species with a high market value (reaching values of 12-14 € kg^{-1} at farm gate) that started captivity adaptation in the 1970´s. Although targeted for commercial exploitation for some decades now, Senegalese sole farming has only recently taken off at a relevant industrial production. The reasons for such delay were mostly related to a high vulnerability to diseases as *pasteurellosis or flexibacteriosis*, difficulties in reproducing the G1 broodstock (fish that undergo a complete life-cycle under captivity conditions) and difficulties in the transition from live-feeds onto formulated diets (weaning).

Regarding weaning, results until 2010 still showed the production of low-quality juveniles with a poor growth performance, while low and variable survival rates (sometimes bellow 50 %) were also frequent (Engrola et al. 2007). In addition, a high incidence of skeletal deformities and, at a much lesser extent, pigmentation abnormalities and malformations related to caudal fin condition were also found (Engrola et al.

80 day-old sole early juvenile SE.

2009). However, recent advances in larval zootechnical conditions and microdiet nutritional composition and production technologies have allowed a significant progress in Senegalese sole weaning. For instance, it is now possible to attain an increased reproducibility on production of high quality juveniles at commercial facilities, with survival rates normally reaching values close to 100 % during this period. Among the differences in microdiet formulation that contributed for such success, the inclusion of protein hydrolysates have resulted in increased diet palatability and maturation of larval digestive tract.

It was within this context that SPAROS Lda, a Portuguese SME devoted to innovate in the development of new products and services for fish feeding and nutrition, challenged the Centre for Marine Sciences (CCMAR, Faro, Portugal) and

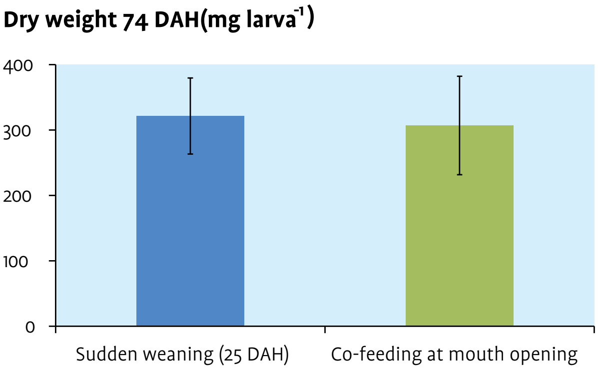

Fig. 1. Growth performance of S. *senegalensis* reared under different weaning regimes until 74 days after hatching. Results from SOLEAWIN project, n = 90. No significant differences were observed between treatments for fish dry weight. Significant differences were observed in fish survival, being around 50 % lower in the co-feeding treatment.

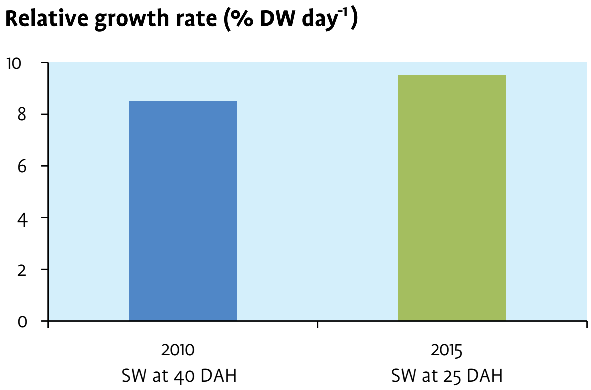

Fig. 2. Evolution of growth performance obtained during S. *senegalensis* weaning. Results from 2015 (SOLEAWIN project) show that is now possible to attain higher growth rates by sudden weaning (SW) larvae at 25 days after hatching (DAH) than in 2010, when larvae were sudden-weaned at 40 DAH (data from Engrola et al 2009, Aquaculture 288: 264-272)

SEA8-SAFIESTELA, a Senegalese sole hatchery based in Portugal (Póvoa do Varzim, Portugal), for a two-year research project named SOLEAWIN (Ref: 310305/FEP/71, funded by PROMAR – Portugal – with FEDER funds). The SOLEAWIN project targets the following objectives: 1) further validate a Senegalese sole weaning diet developed by SPAROS; 2) develop and optimise weaning tables for Senegalese sole larvae; and 3) ultimately, increase the growth potential of Senegalese sole larvae during weaning and enhance the farming of high quality sole juveniles. After project completion, achieving such goals will allow a further development of Senegalese sole farming under industrial settings.

One year and a half of SOLEAWIN project have confirmed that two different feeding strategies may be adopted to wean Senegalese sole: co-feeding with a low *Artemia* replacement and sudden weaning. The choice of the feeding strategy should be based on larval weight, since this parameter seems to be a better indicator of larval nutritional status than age (Engrola et al, 2007). In pelagic or small benthonic post-larvae (below 1 mg dry weight) a co-feeding strategy with a low *Artemia* replacement seems to enhance digestive maturation, leading at a later developmental stage to a higher efficiency on digestion and absorption of complex nutrients existing in microdiets (Engrola et al., 2009). This strategy may inclusively be adopted from mouth opening onwards, although survival values may decrease. However, a co-feeding regime with a high proportion of *Artemia* replacement at mouth opening may reduce sole growth performance and survival, with a lower protein digestibility and retention efficiency also occurring during metamorphosis

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(Engrola et al., 2010). In this case, it is interesting to notice that a considerable proportion (around 50 %) of the larvae tend to recover and compensate for the growth lost during the early developmental stages, achieving a weight similar to larvae weaned with a less risky strategy, such as sudden weaning at post-metamorphosis (Figure 1). These findings suggest that not only nutrition should be improved for small pelagic larvae, but also physical factors that contribute to a higher diet stability and residence time in water (floatability) are decisive for an adequate nutrient intake during the pelagic phase.

The sudden weaning is the more common and accepted strategy for the transition of live-feeds to inert microdiets in Senegalese sole. It is also the strategy that further progressed during the last decades, with the age of sudden weaning advancing over the years. From 60 days after hatching (DAH) in the 1990´s, to 40 DAH by 2010, and 25-30 DAH more recently (Figure 2), this strategy allows Senegalese sole post-larvae to achieve survivals close to 100 % and growth around 10 % per day when fed high quality microdiets. Yet, it is paramount to have sole in a very good nutritional condition prior to sudden weaning. For instance, recent sudden-weaning trials conducted with sole led the fish to reach mean wet weights of 1g in 70 DAH, while until 2010 this mean size would normally be reached at 90 DAH or older. These improvements in early life growth performance are likely reflected in

Weaned young sole juveniles.

juvenile quality parameters, such as higher growth potential and less susceptibility to pathogens during ongrowing, although these factors still remain to be demonstrated.

Future perspectives for Senegalese sole weaning protocols will surely target a complete replacement of live-feeds by inert microdiets at mouth opening. Although it remains uncertain if this goal will ever be achieved, it is seems clear that progresses in zootechnical conditions and microdiets for Senegalese sole will progressively allow reducing the importance of live-feeds during the early developmental stages of this species.

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THE KINGDOM OF SAUDI ARABIA NEED TO SUPPORT SMALL SCALE BUSINESS AQUACULTURE

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The Kingdom of Saudi Arabia considers its marine ecosystem as an important pillar of sustainable economic development for the country and for the welfare of its people (PERSGA, 2011). The Red Sea and Gulf of Aden has unique biodiversity, species endemism, significance for maritime culture, and its renewable resources (Gladstone et al., 1999).

In 2007, the agriculture sector accounted for 4.8 percent of the gross domestic product (GDP), and employed about 500,000 workers (USDA Foreign Agricultural Service, 2009). The Kingdom has achieved self-sufficiency in the production of wheat, eggs, milk, and dates, and among the important foods produced are fish, poultry, fruit and vegetables including tomatoes, potatoes, cucumbers, pumpkins, squash and watermelons. Despite the efforts that have been made to increase food production and to bring a decline in food imports, Saudi Arabia still continues to import most of its food products, around 60% from over 150 countries (Dina Al-Kandari, 2012). Unlike other shrimp producing countries where there is a directed development approach to benefit smallholders, in Saudi Arabia it had been purely a private sector initiative involving large companies. The private sector constitutes the water consuming public; agricultural and livestock operation and industrial enterprise. The tasks of each of these private sector components will be to maximize the efficient use of water delivered or produced on-site through modern user techniques; re-use of water with and without in-plant treatment; and in general to abide by the conservation regulations imposed and permits granted by the Government. Developing more sustainable forms of agricultural production that build on the agro-ecological knowledge

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Farmed European seabream basket for premium pricing.

Local fish market luring assortment.

of small-holder farmers has generally received only limited support from national and international institutions and policies (Pretty et al., 2010; Lang et al., 2009).

The demand for food within the Kingdom has increased rapidly in response to both population growth and rising incomes. Dietary changes are following the classical pattern of increased protein intake – rapid rise in the consumption of eggs, poultry, fresh vegetables and fruits ; modest growth in fresh meat, fresh fish, fruit drinks and milk ; static consumption of tinned products, vegetable oils and sugar ; decreases for rice and flour. The main objectives of the Kingdom's agriculture development are to establish and maintain a prudent level of self-sufficiency in food production, recognizing both producer and consumer interests ; to provide the opportunities for attaining the reasonable agricultural incomes and raise the welfare of rural

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Farmed Rabbit fish (*Siganus rivulatus*) and Sea cucumbers on a small scale in the Kingdom.

people so as to achieve a balance between the economic and social rewards attainable in rural and urban areas ; to improve the skill in the agricultural sector (including marine environment).

Despite the long history of agriculture and low cost agricultural finance in the Kingdom, only 2.4 % of all development credit found its way to the agricultural sector. It is very difficult for small businesses to raise finance for development projects. The institution of small business finance fund is pressingly wanting. 70% of seafood is imported in the Kingdom and so focus on local production for local people at the grass roots level is of paramount significance. FAO has being striving under the Ministry of Agriculture on the FAO project (UTFN/SAU/048/SAU - Strengthening and supporting further development of aquaculture in the Kingdom of Saudi Arabia) supporting the stakeholders to expand vocational training opportunities, more 'on-the job' training, progressive "rationalisation' of expat workers and reduction of Saudi unemployment. According to ADF, 2011, the enhancement of agricultural income for reduction of poverty is a major national target and embedded in '*National Strategy for Tackling Poverty*'. ADF asserts that poor fisheries policy linkages with other sectors e.g. tourism, oil & gas, urban development is clearly evident in the Kingdom. The '5th Committee' of Agricultural Development Fund allowed cross-sectoral planning for aquaculture development where ADF loans to aquaculture were capped at SAR 50 Million which are appropriate for small to medium sized aquaculture businesses but are relatively small for larger companies who have a larger requirements. Typical aquaculture require SAR 200-500 Million investment (ADF, 2011). Apart from the giant scale fully integrated companies, opportunities to develop rural aquaculture projects for remote villages has been clearly highlighted by ADF.

23,870 tonnes of total aquacultured production for the Kingdom was recorded in 2014 wherein the share of shrimp, fresh water fish and marine fish were 54.38%, 20.23 % and 25.38 % respectively. Aquaculture in the Kingdom must never be a gaining activity of a wealthy minority segment but balancing the resource users with economic intertidal fish culturists too. Tailor made projects could provide an economic package for fishers in coastal villages to adopt mini-scale shoreline fish culture or other alternative activities, principally as a means to reduce the use of destructive fishing gears. Gargoor traps and catch of threatened species (Giant Grouper, Najil Grouper) need to be stopped on a war-footing. Pomeroy et al., 2006 suggest a sort of synergism between fishing and aquaculture to household livelihoods indicating a clear need to address livelihoods at the broader level, examining the strategies employed by households to achieve defined outcomes. They underline that aquaculture can provide an alternative livelihood option for fishers, encouraging them to leave the fishery by providing a means to replace rather than supplement wild fisheries. Sheriff, 2008 claimed that the future of the sector, and its role as a means to reduce pressure on reef fisheries, is therefore likely to be sustained in the long term by keeping production in the hands of small-scale farmers. The ability of the poorest of the poor to engage in aquaculture or to derive a benefit from aquaculture activities must be called into question (Sheriff et al., 2008). Often excluded from direct involvement in aquaculture due to the high costs of investment, or lack of access to essential natural resources including land, water and seed fish, the poor may in fact not be accessing the benefits which aquaculture is theoretically capable of providing. Training of the suburban coastal villagers for small scale aquaculture need to be targeted more and more with appropriate licences being issued suiting the primitive farming structure of the coastal famished workers. Fostering the development of this form of aquaculture to the benefit of all social and island community groups is urgently sought for. Alternative livelihood option for coastal fishers engaged in destructive fishing practices is imperative. Live farmed fish trade fattening Groupers and Rabbit fish in pens is a sound and healthy proposition for the Kingdom.

Gill-netting targeted small rabbit fishes in shallow reef flats, and fish trapping targeted groupers, snappers and emperors on reef slops are a common activity at Farasan. Although the Farasan Islands have been inhabited for many hundreds of years, the population has always been relatively small, the villagers widely dispersed, and fishing effort low. The only form of traditional resource management involved the rotation of fishing effort amongst reefs to prevent over-fishing that was coordinated by the chief fisher of each village.

The sea between the Farasan Islands and the coast is currently Saudi Arabia's major fishing ground in the Red Sea, and continued growth is expected as demand for seafood increases (Gladstone, 2000). Developing a sustainable artisanal fishery will be a priority in the management of the proposed Farasan Islands MPA in order to maintain the economic livelihood of the Farasan Islanders, to diversify the national economic base and to maintain socio-cultural identity. Artisanal fishers expressed support for the concept of an MPA as a tool for sustaining fisheries, as long as there were limited restrictions on their own activities and stricter controls of the investor and industrial fisheries (Gladstone, 2002).

Umesh et al., 2010 have opined the strategy of empowering small-scale farmers through a cluster-based approach implying organized farmer groups as one of the key mechanisms for supporting farmer empowerment. Farmer societies do provide a good opportunity to link up with retailers following the existing controls that ensure that basic requirements of markets, including social and environmental responsibility and food safety, are in place. Farmer groups also improve information exchange and sharing among group members. Corporate giant-scale farmers do not perform an intellectual tithing process to share their know-how and available capacity building with their neighbours. When private firms lock up the breeding, larviculture and farming methodologies, then sustainable Arab food solutions are likely to be beyond the financial means of the farmers who need them the most (Erich Luening, 2014).

Sea cucumber resources in Saudi Arabia have long been exploited by an open access fishery with no management in place. The lack of information on the fishery makes it difficult to ascertain its characteristics, as well as determine sea cucumber stocks. Seven sea cucumber species are exploited mainly for the export market. Signs of stock reduction have become evident as fishers search for new fishing grounds and dive deeper and deeper to reach sea cucumber stocks (Hasan, 2008). Small-scale fisheries for tropical sea cucumbers have provided livelihoods for coastal communities in the Indo–Pacific for centuries (MacKnight, 1976 ; Conand, 1990). The Kingdom could steer forward supporting sea cucumbers below fish cages for copious nutritional feed supply from the fish cages. Training of small scale farmers for sea cucumber breeding shall pay back in the form of remineralisation of sea sediments, reef restoration and fish recruitment.

Aquaculture for the aquarium hobbyist trade, however, is a rapidly growing sector of the industry (Tlusty, 2002) and there is directed effort and increasing pressure within the ornamental trade to develop reliable and sustainable hatchery procedures for the captive breeding of many reef fish species. King Abdulaziz University scientists at the Faculty of Marine Science have screened the biodiversity of Clownfish and have sourced in wild broodstock for captive breeding in their aquaculture station at Obhur (Sambhu, *Pers. Commun.*). Graduate student training is a dynamic way forward for the future in the dissemination of rearing expertise to the Saudi nationals. Seahorse aquaculture is another promising area of impact for the Kingdom. The ornamental fish industry can have, under the proper developmental scenario, a positive impact on the global economy, particularly in less developed areas (Tlusty, 2002). While seahorse aquaculture is often promoted to alleviate the pressure on wild populations (Koldewey and Martin-Smith, 2010).

Distichlis nurseries at KAUST.

Right: Inland pond cage cultivation of seaweeds at MoA.

The Saudi buyers throng the fish stalls of city malls eyeing for Rabbit fish, Groupers, Emperors, Parrot fish, Snappers, Golden Trevally *et cetera*. Except for the first two fish species that are locally farmed, the rest are all supplied to the diner's plate by nature alone. More often than not, the local socio-economic implications of aquaculture development are taking a back seat to trade, ecological and technological motivations, especially in light of current efforts towards sustainable intensification of aquaculture production (Smith et al., 2010). To date, aquaculture development has been largely focused on technical and biological challenges (Costa-Pierce, 2010) and less on the socio-economic drivers underpinning peoples' behaviour. This view has been reflected in the ecosystem approach to aquaculture development, which promotes the integration of the social, economic and ecologic dimensions as the bases of sustainability (Costa-Pierce, 2010). A holistic analytical review on the market polarity, key driver identity and level of driving displays critically significant thoughts to ponder and act upon with redressal policies for the Kingdom. The farming supremacy of the recent bidecadal, Singaporean guest fish, Asian seabass by corporate giants that is still more and more bent upon overseas drivers of seafood value chains, reasons the underlying causes to an overtly deep oversaturation of the local markets and thereby belittling its value and stamping a downward pressure (on prices, splendour and demand) despite media-sensitized product innovations and value additions. Low end seafood service markets in Saudi Arabia flood with native fish species from UAE, Oman and Yemen. The advantage of spot market sales of own farm-sourced native fish (Rabbit fish/Groupers) also yields good profits when the market price is higher and native wild fish supply generic. Small scale family holdings of farmed native fresh fish on piece-meal basis does receive preferential prices (with an awaiting list of a diverse pool of indigenous fish buyers) than long-frozen status of premium fishes of elite consumers.

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Mangrove nursery industry in the Kingdom.

Pond farming of Asian seabass.

Right: Biofloc culture of Vannamei with zero water exchange.

Below: Spirulina Cultivation in the Kingdom.

It is most timely to accentuate that small farmers in the Kingdom ought to advance further, learning more about live reef fish farming and trading ; fattening of wild Rabbit fish juveniles to forage the periphyton and productive microfeeds in aquaculture drainage canals ; Sea cucumber breeding and farming ; Baobab tilapia farm design institution, fry production and rearing of Sabhaki Tilapia (*Oreochromis spilurus*) ; cultivation of air-breathing fishes (catfishes) employed in Closed Insulated Pallet Systems (CIPS, that require less water in fact) ; Use of 2-3 ppt aquaculture waste water for salt tolerant potato cultivation ; *Sesuvium* forage cultivation (for ornamental landscaping and/ or fodder for livestock) ; biofloc mode of fresh water prawn farming in greenhouses for water conservative and zero waste discharge aquaculture ; *Salicornia* forage farming in derelict (waste) lands with low saline aquaculture wastes for use as vegetable, seed oil and fodder for Camels ; Cultivation of low salt-tolerant commercial candidates - Olives, Argan trees, Ber trees as ornamentals and fruit / oil production ; mangrove nursery production and trading ; halophytic grass plantations (*Distichlis*, *Suaeda*, *Atriplex* for livestock feed requirements and marshland management.

Use of cultured seaweed biodegradable mulches for soil water retention and productivity efficiency in agriculture ; shoreline sea pen fish broodstock farming and trading (Grouper / Pompano / Amberjack / Sobaity / Rabbit fish) ; Biofloc mode of *Vannamei* farming at brackish water point-sources ; bioconversion of halophilic *Dunaliella* in salt marshland into Artemia biomass and cysts ; Decentralized biofactory units for shrimp nauplii production ; microalgae production (*Thalassiosira*, *Nannochloropsis* pastes), live rotifer production, other live feed mill biofactories – spawning and raising Brachyuran Zoea, Mysids, Polychaetes ; seaweed propagule supply (drainage canals) for IMTA farms from seed stock culturists ; Bivalve farming in drainage Canals for fresh feed trading; benthic diatom (*Cylindrotheca*, *Amphora*, *Amphiprora*) farmers in desert land with aeolian dust fertilisation ; ; Wild gravid marine finfish conditioning and trading ; extensive polyculture farming species at the low end of the food chain ; rehabilitation of abandoned shrimp ponds / salinas with cultivation of the coccolithophore, *Pleurochrysis carterae* (Haptophyta) ; *Chlorella* alga powders as poultry yolk pigmenters ; *Haematococcus* and *Spirulina* for algae pigments (Astaxanthin and Phycocyanin) industry ; farms fattening Lobsters ; pen holding of live trash fish for marine finfish hatchery broodstock feed utility ; breeding and farming of *Scylla serrata*.

Cultivation of seaweeds for carrageenan yield or phytogenic seaweed meal (*Macrocystis pyrifera*, *Ascophyllum nodosum*, *Kappaphycus alvarezii*, *Sargassum* sp., *Gracilaria heteroclada*, *Gracilaria cervicornis*, *Caulerpa sertularioides*, *Ulva clathrata*, *Enteromorpha* sps., *Hypnea cervicornis*, *Cryptonema crenulata* and *Chnoospora minima*) ; *Porphyridium cruentum* cell productivity for bio pigments ; ascidian / sponge culture ; pearl oyster farming ; halophilic *Dunaliella salina* on salt-sealed pans or raceways for sequestration or recycling of CO_2 from flue gases of desalination plants etc. The Kingdom of Saudi Arabia ratified the UN Framework Convention on Climate Change (UNFCCC) in December 1994. This convention aimed to stabilize the greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent significant potential changes to the global climate. Being a signatory to the UNFCCC, Saudi Arabia has agreed to develop a national inventory of greenhouse gas emissions and sinks as part of its National Communication. 'Solar aquaculture' of microalgae for pigments and algaemeal to replace fishmeal and their relative downstream processing forms a lucrative part of the sector (ADF, 2011).

Neoliberalizing Saudi coastal space for multiple users of the coastal zone for economic benefits viz., recreation, tourism, agriculture, marine forestry, fishing and aquaculture delivers income and employment. from this national capital resource, the development strictly compatible with sustainability regulations and not harming continued steady productivity of the coastal system. A recent report suggested that fish, along with poultry, are so-called 'necessity goods', with demand rising by nearly 5% per annum (Abdulaziz Al Shuaibi, 2011). With natural resources under careful stewardship and production increased through innovative aquaculture, it will certainly be possible to reverse the current dependence upon imported seafood and thus increase the food security of the Kingdom (ADF, 2011).

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International Symposium on Genetics in Aquaculture XII

SANTIAGO DE COMPOSTELA
2015

Conclusions from the Technology Transfer Round Table held within the framework of the International Symposium on Genetics in Aquaculture – ISGA XII

(Santiago de Compostela (Spain), June 24th 2015)

Scheduled within the framework of the International Symposium on Genetics in Aquaculture – ISGA XII (2015 Santiago de Compostela, Spain), a round table session on "Technology transfer" was held with the objective of providing an insight on how best to improve both technology uptake and market impact of genetic research applied to aquaculture, considering the available capacities and knowledge progress in this field.

The global aquaculture production in 2012 amounted to 90.4 million tonnes -live weight equivalent- (US$144.4 billion)[1], from which 66.6 million tonnes correspond to food fish (including finfishes, crustaceans, molluscs, amphibians, and other aquatic animals) and 23.8 million tonnes to aquatic algae. The main production areas are Asia, which has reached 54 percent of total production, and Europe, with 18 percent. According to FAO estimates world food fish aquaculture production rose by 5.8 percent to 70.5 million tonnes in 2013, from which China alone produced 43.5 million tonnes. Over recent years, world aquaculture production has undergone an uninterrupted growth trend; however, some major producers such as the United States, the European Union or Japan, among others, have experienced stagnation due to a combination of market, technical and administrative factors. Obtaining growth and development remains in a central position with regard to strategic planning for the aquaculture industry in these areas, and three key performance indicators need to be addressed in order to overcome this situation, namely growth performance, mortality and feed efficiency.

Within this context, genetic and genomic tools offer a huge potential for contributing to sustainable growth and to the improvement of industrial competitiveness.

The session, which was organised as an open debate with the symposium participants, was moderated by Mrs. Rosa Fernández (CETMAR). The panel was made up of Mr. Courtney Hough, general secretary of the Federation of European Aquaculture Producers (FEAP) and of the European Aquaculture Technology and Innovation Platform (EATIP); Mrs. Ana Riaza, director of R&D and Health at Stolt Sea Farm – Prodemar; Dr. Anna Kristina Sonesson, senior scientist at the Department of Breeding & Genetics of Nofima; and Mr. Pierrick Haffray, head of the Aquaculture Unit of the French Genetic Centre for Poultry and Aquaculture Breeding (SYSAAF).

Considering the audience profile and acknowledging that the round table's target was not a completely new issue under discussion for the aquaculture stakeholders, the starting point for the debate were the conclusions arisen from the EAS & EATIP workshop on the performance of the sea bass and sea bream sector in the Mediterranean. The latter was held within Aquaculture Europe 2014, on 16th October at San Sebastián (Spain)[2], and Mr. Courtney Hough outlined the outcomes briefly:

- relevance of improving knowledge on nutritional requirements of the different species, at different life stages, and feeds formulation as a key aspect for industrial improvement;
- the availability of high quality and genetically improved broodstock for increased survival and performance rates;
- spatial planning issues were also pointed out as critical;
- company size, collaboration strategies and funding/ investment capacity were also pointed out as relevant drivers for underpinning the sectors' uptake of new technologies.

There is a general acceptance that relevant research progress has been attained in the field of aquaculture

[1] Source: The State of World Fisheries and Aquaculture 2014. FAO.
[2] http://www.eatip.eu/shortcut.asp?FILE=1222

genetics and genomics during the last decades and that this can provide an important window of opportunity for the sector but what is restricting the uptake of results by the industry? Why is this aspect far from realising its potential impact?

Key points discussed

Technical issues

There has been some support for fundamental research in genomics for aquaculture during the last years. High density SNP chips and well annotated reference genomes are therefore now commercially available in Atlantic salmon and rainbow trout, but they are missing for the other important species reared in Europe (e.g. turbot, sea bass, sea bream, oysters,…). These genomic resources are essential both for improving accuracy of selection and understanding important biological processes.

One of the main kinds of traits with greater potential for improvement by applying genetic and genomic tools is disease resistance, as disease mortality constitutes a major threat for aquaculture industry. Preventive or therapeutic treatments can only be applied when the activity is carried out within controlled facilities, but they are useless in most molluscs rearing stages and in cages in the sea. Nutrition and feed performance is another critical target, since it has a direct influence in other key parameters related to health, growth, fertility, etc.

Through the application of selective breeding programmes, best growers, disease resistant or tolerant and, in general, individuals with certain characteristics of interest can be obtained, as some successful experiences demonstrate. In Norway, the selection programmes of Atlantic salmon started in 1970's. In Spain, Stolt Sea Farm – Prodemar started in early 90's a selective breeding programme for turbot, which the company is currently rearing the fifth generation, and they are now carrying out a similar strategy for the production of sole. In France in 1991, fish farming companies interested by genetic selection joined the SYSAAF poultry advising organisation to develop and share a collective advising service to initiate their own selection programs on rainbow trout (Aqualande, Les Fils de Charles Murgat, Pisciculture de Ménaouen, Salmona, …) and later on a similar approach has been implemented for turbot (France Turbot), sea bass (EMG), sea bream (FMD), sturgeon (Ecloserie de Guyenne), meagre (Les Poissons du Soleil) and now for oysters. These examples show that it is possible to keep this kind of strategies ongoing; however, as Mrs. Riaza and Mr. Haffray pointed out, they require the availability of highly qualified staff and technical advice to deal with and to keep carefully the selected stocks and constant and confident interaction with research organisations.

Moreover, progress in this field will need collaborative research investments with the industry owning stocks to develop and promote new breeding practices adapted to the biological specificities of aquaculture breeding.

Bearing in mind that improving production performance also needs to take into account economic and market issues, it is necessary to get further insight on how and how much the implementation of genetic and genomics can benefit companies. Bio-economic modelling and cost-benefit analysis should always be taken in by research projects on aquaculture genetics. There is a general perception that large investments in facilities are required to initiate breeding programs with several hundreds of tanks, but SYSAAF experience in using DNA-based parentage assignment since 1995 has demonstrated the possibility to limit such investments in adapting breeding programs to their investment capacities. Whatever the method of selection used, potential benefit is high if the industry is able to make genetic make-up expressed. This last aspect was considered as determinant by the panel and more interaction between breeding and feed companies was highlighted as a key condition to speed up integration of genetic innovation and to provide to the growers and processors the best combinations of seeds and feed and feeding practices.

A frequent topic that arises when the objective of putting knowledge into action is addressed refers to intellectual property rights (IPR). However, since animal strains cannot be protected by means of a patent with current regulations, it is likely to see concurrent use of the genetic progress created by breeding companies. Different strategies could be established to limit this risk but the most relevant protection strategy in this field is industrial secrecy and investment in R&D so as to be at the front of innovations.

Technology readiness level in aquaculture

It is widely agreed that moving to genomics is a key issue for the aquaculture industry, but the integration of genomic tools in a cost-effective way strongly depends on the Technology Readiness Level and, therefore, the time to market of such tools. Technology Readiness Levels (TRL)[3] are a type of measurement system used

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[3] https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html

to assess the maturity level of a particular technology, originally developed by NASA, which application is recently becoming widespread in Europe. The lower TRL value for a certain technology, the higher investment is required for getting it ready to market. Usually, agricultural crops and livestock farming are seen as reference sectors, while the aquaculture sector faces different issues, principally derived from the aquatic environments in which it is done. Plant breeding companies are currently investing around 10% of their annual revenue in R&D while, in an aquaculture company, this rate can be expected around 2,5%, in best cases, and includes other research than genetics.

The TRL of genomic tools applied to aquaculture should be considered on a case-by-case basis, since the capacity for technology uptake differs significantly between species due to market size and turnover and companies' particular characteristics (size, investment capacity, technology intensity, etc.). As seen in other economic activities, bigger companies are in a better position for knowledge uptake, so they might be able to adopt technologies and knowledge outputs at lower TRLs (from 4-5) and usually have better access to the financial and human resources necessary for a successful exploitation. Some of these have adopted the strategy of integrating all the components of the production cycle, so they have better control of the overall process. However, although there is consolidation going on in European fin-fish aquaculture companies and sub-sectors, there are still many SMEs operating in EU aquaculture. In many cases, SMEs need higher TRLs, normally 8 or 9 for being able to integrate new knowledge and technology, and they normally lack the capacity to integrate all production cycle stages. Therefore, there is a need of scaling up and adopting solutions that allow results to reach higher TRLs, which smaller companies are able to deal with. Intermediate organizations that would be able to uptake knowledge in an earlier stage, such as technology and research centres linked to clusters and industrial associations, are approaches that have proven to be successful in terrestrial agriculture and in some areas with certain species in aquaculture.

However, in general, in the case of rearing molluscs, or pond fishes as common carp, additional measures need to be undertaken for a more successful investment and adoption of genetics technologies by these productions. These subsectors are highly fragmented with mostly family based companies and most of the production, at least for molluscs, relies on natural recruitment, and common carp on out-breed domesticated and non-selected seeds. However, and after more than a decade of developing hatchery production, already 40% of the oyster Crassostrea gigas grown in France (the major producer) comes from selected seeds produced in hatcheries, but an intense effort is still needed to overcome the specific sociologic or economic barriers, other than technology maturity and investment needs, affecting these species.

Scope for collective planning and collaboration

Considering that production in different areas (not only geographically but also marine vs. fresh water) focus on diverse species and face different problems, and taking into account that funding is a major issue to initiate the implementation of new genetic and genomic tools, the decision on the geographical scope for addressing the identified challenges is of paramount importance for a successful result.

At EU level, technology platforms constitute a good channel both for boosting cooperation among different stakeholders and provide industry-led joint communication channels towards the European Commission. The Farm Animal Breeding & Reproduction Technology Platform (FABRE) and The European Aquaculture Technology and Innovation Platform (EATIP) have already set their visions and priorities after the EU AQUABREEDING concerted action "Towards enhanced and sustainable use of genetics and breeding in the European aquaculture industry"[4] (6th Framework Programme), in which they were partners. Collaborative research projects involving genetic improvement in aquaculture have been founded in the last 7th Framework Programme calls, such as FISHBOOST[5] and DIVERSIFY[6], and Horizon 2020, like ResisGal[7] (MSCA-ITN), and they provide significant steps but a new action plan needs to be developed. Advantage should be taken from the collaboration networks created within these projects' consortia that include breeding companies, following similar collaboration models to the ones adopted in the livestock or poultry farming sectors. Results arising from on-going and new R&D initiatives are expected to be available in the short term and within the next 5 to 10 years, if current challenges get sufficient support.

It is worthy to keep in mind that Horizon 2020 is open to third countries participation under certain conditions, so a cooperation strategy beyond European borders could be considered under this framework, and mutual learning between different areas of the planet can yield opportunities and help introduction to new markets.

[4] http://cordis.europa.eu/publication/rcn/11790_en.html
[5] http://www.fishboost.eu/
[6] http://www.diversifyfish.eu/
[7] http://cordis.europa.eu/project/rcn/195715_en.html

The European Maritime and Fisheries Fund (EMFF) is also expected to be source of funding opportunities for additional aquaculture research, but these will be conditioned by strategic multiannual plans set up by Member States.

It should also be mentioned that the European Investment Bank could be interested in funding the aquaculture sector, but complementary important private funding is required.

All the above means that there are clear chances for raising funds for aquaculture investment on R&D and Innovation but having a common European strategy is the base for being able to present the activity in a cohesive way in front of the regulatory and funding bodies. Acting at Member State level through national and regional technology platforms, associations, support structures and bodies, etc., would help to orient national policies and funding instruments; but also at European level, as the message to the Commission can be supported by the National Representatives in different European committees (European Parliament, funding programmes' committees, etc.).

General understanding of genetics, capacity building and other relevant enabling conditions

Improving the general understanding of genetics by society and governing bodies was pointed out, as a necessary condition in order to increase acceptance and create an enabling environment for the industrial uptake of genetics and genomics knowledge. The implementation of breeding programmes can contribute to improve production efficiency around 7-10% per generation, but it is essential to encompass such technical improvements with other legislative and administrative aspects that actually hinder further development of the available knowledge to prepare it ready for industrial exploitation. The more that aquaculture productivity increases, the higher will be the need for infrastructures for different purposes; obtaining licences and access to suitable space has been a big issue in many cases, especially with regard to specific needs on water quality, accessibility and/or communication infrastructures. For example, new areas may be required for certain stages of the production cycle such as the conditioning and maintenance of broodstock, so progress on the effective implementation of Marine Spatial Planning regulations - integrating

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all aquaculture activities - is a clear need for the sector, for planning and negotiating the activity futures with some more certainty. Another example of existing constraints, in addition to the ethical considerations it may have, has to do with limitations that do not legally allow to the fulfilment of controlled challenge of sibs by breeding companies to pathogens to identify more resistant families and associated genomic markers. This kind of challenge causes a mortality impact on a limited number of individuals in the breeding programs but shall also provide relevant knowledge and genetic progress for fighting against such disease that will save life of billions of siblings produced at commercial level. Adaption of regulation is then also needed to allow research works to be applied by the production sectors.

Raising collective awareness on the relevance and implications of the application of genetic tools to aquaculture practices, would also contribute to a better understanding and potentially increase acceptance of aquaculture activities, facilitating the necessary changes involving shared use of natural areas, in inland as well as coastal or marine facilities.

On the other hand, particular attention should be paid to new training needs arisen from the access to new genomic tools, in order to guarantee the availability of the aforementioned highly qualified staff that is required for a successful implementation of such tools.

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An Overview of Traditionally Processed Fish Products of North East India

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Tribal Women of Tripura

The North Eastern region of India is renowned for its magical beauty and bewildering diversity with vast natural resources and a cauldron of different people and cultures, lie deep in the lap of easternmost Himalayan hills in North-Eastern part of India, connected to rest of India by merely 20 km of wide land. The region comprises of States like Arunachal Pradesh, Nagaland, Manipur, Tripura, Mizoram, Meghalaya, Assam and Sikkim. The North-East India shares over 2,000 km of border with Bhutan, China, Myanmar and Bangladesh. Its total area is 2, 55,168 sq km with population of 40 million (as per 2010 census), of which the Brahmaputra valley in Assam alone houses almost half of its population. The North-East India is home to varied number of tribal groups (almost 166). The food and feeding habits are also varied with different tribes and they used to take food in different processed form. Fish is one of the common food items for the North eastern Indians and around 91 percent north eastern are fish eater. Traditional ethnic N.E. people of India used to take fish in different processed forms and as per the people demand these products are now popular and available in the markets of N.E. India.

Fish are products of high nutritional value that give several benefits to human health. They are important sources of calcium, phosphorus, vitamins A, B and D, besides being a high-protein food (Huss, 1988). Also, fish lipids are the main sources of highly unsaturated fatty acids (HUFA) in the human diet (Abrami *et al.*, 1992). On the other hand, fish is one of the most perishable items than any other foods and that's why preservation of fish is very much necessary. Preservation of fish is done by so many ways like smoking, drying, salting, fermentation, marinating etc. These preservation processes are followed with a principle to extend the shelf life of product by reducing the moisture content and retarding the microbial action. Different types of processed fish products which are popular and available in the markets of north-eastern states of India are in the form of fermented, smoked, dried and salted.

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Traditional recipie Shidal Chutney

Punti Shidal

Puthi Shidal

Phasa shidal

Ngari

Hentaak

Lona ilish

FERMENTED FISH PRODUCTS:

Fermented fish products are the most popular among other processed fish items in North eastern region due to some ethnic values among the people. Earlier these products were popular among the traditional people but now a day it became a common food recipe for the urban people also. Fermented fish products are popular due to their characteristic aroma, taste and some healthful effects. People believe that regular consumption of fermented fish products helps to keep away from some dangerous disease. Some fermented fish products which are popular and available in the markets of N.E. India are as follows:

Shidal: *Shidal* is the most popular fermented fish products which is mostly prepared from Puntius fish (*Puntius sophore*) and to lesser extent from Phasa fish (*Setipinna phasa*). They are popularly known as *Puthi shidal* (Fig. 1) and *Phasa shidal* (Fig. 2) respectively in their localities. *Shidal* is a pasty and solid product in which the shape of the fish remains almost intact. It has several local names called *shidal, seppa* and *hidal* in Assam, Tripura, Mizoram, Arunachal Pradesh and Nagaland. It is known as *Ngari* in Manipur (Fig. 3). It is commonly consumed in all the seven North-eastern states but most popular in the tribal and Bengali speaking communities of those states (Muzaddadi and Basu, 2012).

Phasa Shidal, a substitute of *punti shidal*, is presently very popular in Northeast India. This shidal is exclusively made from estuarine fish *Setipina phasa*; it is getting popular mainly due to its low price compared to *punti shidal*. At present phasa shidal is commercially prepared in Tripura and Manipur. In Manipur it is known as *Thum-thakpi*, *Thum nga, Ngari, Samudra ngari* etc. The shape of the fish remains almost unchanged but for a little disintegration near belly and caudal portions. The colour of best quality product is dull white that gradually becomes slightly brownish to deep brownish on continuous exposure to air. Dry phasa fish are procured by the local producers from Kolkata and Tamil Nadu.

For traditional *Shidal* preparation, the raw fresh fish species are washed and allowed to sundry for 4-5 days. They are placed in airtight earthen pots with the dry fish after water soaking for 2 to 3 minutes followed by drying in the shade, allowing draining out the excess water for overnight. The earthen pots are kept ready before filling with repeated smearing of oil and subsequent drying under sun. The earthen pots are saturated with oil to prevent the permeability of air. The filled earthen pot is then sealed air tight, with a cover paste made of waste of dried fish with water followed by a polythene sheet, finally with a layer of mud in the mouth portion of the pot, thus providing an anaerobic condition inside and stored at room temperature for 3-6 months for fermentation (Kakati and Goswami, 2013).

Tungtap: It is a fermented traditional fish paste popular among the Khasia tribes of Meghalaya (Thapa, 2002). The raw fishes of *Puntius* spp. locally known as *punthia* are eviscerated, sun-dried and processed with salt (10:1) along with local species (Bhuyan, 2010). Dry fish (*Danio* spp.) is also used sometime for *tungtap* preparation. The fermentation process is continued for 3-6 months at room temperatures. *Tungtap* is consumed as pickle and taste enhancer (Rapsang and Joshi, 2012).

Hentaak: It is an indigenous fermented fish paste product prepared by Meitei community of Manipur by using dry fish *Puntius* spp, *Amblypharyngodan mola*, *Esomus danricus* etc. along with vegetable like *Colocasia* spp (Fig. 4). The ingredients are ground, mixed, making small ball shape and wrapped with banana leaf and put inside the earthen pot which is covered by a lid and reinforced by a paste of raw cow dung and clay @ 1:1 and then kept for 6 months for fermentation and ready for human consumption (Singh *et al.*, 2010).

Lona Ilish: The name *lona ilish* means salted *ilish* (*Hilsa* spp). The product is sliced *hilsa* (hilsa chunks) about 1.0 to 1.5 cm in thickness, distinguishes from other fermented fish products by having a soft but firm texture, very pleasant flavour and aroma and an attractive fresh fish colour even after maturation (Fig. 5). It is kept immersed in saturated brine till consumption and when taken out it gives a uniform pink colour with glossy appearance (Majumdar, 2005).

Numsing: It is an ethnic fish product prepared by Mising tribes of Upper Assam region of India. It is prepared from flame dried and smoked small economic fish species like *puntius*, *mola*, *channa*, *tengra* etc (Fig. 6). Dried fishes are mixed with spices and then the mixture is ground in a traditional huller followed by stuffing in bamboo container with the mixture and sealing the container with the fern leaves, rice straws and the final layer with clay. Then it is fermented with intermittent heating and keeping it near a fire place for about thirty days. The final product *Numsing* can be stored in bamboo container or in glass bottle. It is consumed after steam cooking or after preparing some vegetable curry (Muzaddadi *et al*., 2013).

SMOKED FISH PRODUCTS:

Smoking is a curing method where fish or other food items are smoked by burning woods or any other combustible items. This method of preservation involves removal of moisture content by drying and reduction of microorganisms by the deposition of smoke constituents over the fish. The process imparts a characteristic golden brown colour and smoky odour to fish. Smoked fish products are mostly popular in Manipur state and to lesser extent in certain tribes of Nagaland and Mizoram states of N.E. India. Though there are several reports on smoke curing of fish in India and abroad, the smoking of fish in Manipur is unique in nature. The process may use unsalted fish or various salt additions giving salt concentration in the final products ranging from less 2% to over 20%. Various small fishes are smoked and available in the local markets of Manipur; eg. Rohu (*Labeo rohita*) (Fig. 8), Mrigal (*Cirrhinus mrigala*), Common carp (*Cyprinus carpio*), *A. mola, P. sophore* (Fig. 7), *C. fasciata, L. guntea, N. notopterus, C. striatus, M. armatus,* mixed species etc.

INDIGENOUS PROCESSING OF SMOKED FISH IN MANIPUR:

The traditional process adopted in Manipur is different from the smoking adopted world over. The fishes (salted/unsalted) after washing are spread over a wire mesh tray and then exposed to flame briefly to burn the skin. This is repeated by turning the fishes upside down till the characteristic golden brown colour develops. Fishes are smoked by exposing to smoke generated from burning wood or saw dust and paddy husk from a distance of 30 cm below for 2 to 3 hrs at 70 to 80°C. The smoked products are then spread on a bamboo mat and dried under sunlight so as to reduce moisture content before storing. In case of larger size fishes, these are split open along the vertebral column and then smoked. The end product is packed in split

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bamboo baskets and the baskets are generally hung from above the chimney in traditional household to keep them dried. The shelf life of such products ranged from 4 to 5 months at normal temperature.

DRIED FISH PRODUCTS:

The dried products prepared from fishes like *Puntius* sp, Tengra, Mola, small fresh water prawns etc. are commonly found in the markets of Tripura. Some of the commonly available dry fishes from the markets of Tripura are: *Awanya shutki* (*Pseudeutropius athernoides*), *Tengra shutki* (*Mystus vittatus, M. cavasius*), *Kaykya shutki* (*Xenentodon cancila*), *Chanda shutki* (*Peudambassis ranga)*, *Keski shutki* (*Corica soborna*), *Laytta shutki* (*Harpadon neherius*) (Fig. 10), *Icha shutki* (small prawns) (Fig. 9), *Chandana shutki* (*Hilsa toli*) (Fig. 11). The dried fishes are popular in Tripura, Mizoram, Manipur and Assam. Earlier it was mainly consumed by the tribal community people of these states but now a day dry fish is popular among the urban people also. It is mainly consumed as chutney or pickle and also used in vegetable curry as a taste enhancer but still people used to consume it directly after slight flaming.

In the traditional process of drying the fishes after harvesting are spread over a bamboo mat (locally called *macha*) and then kept for drying under sun light for 4-5 days (depending on species of fish and weather condition) till the products get dried and thereby reducing moisture content of the fish. Generally smaller fishes are dried in whole form i.e. without removing the entrails whereas bigger fishes are processed after removing the entrails and by opening the abdomen portion. Sun dried fishes are economically cheaper but quality of final product is inferior and shelf life is less compared to that of mechanically dried ones. Dried fishes are packed in gunny bags for storage. In retail markets these fishes are sold by storing in bamboo baskets which is unhygienic (Fig. 12).

SALTED FISH PRODUCTS:

Salting of fish is a curing method where fishes are salted and preserved for a long period at normal temperature. In North east India fishes are not directly consumed or marketed as salted fish product; it is dried after salting, smoked after salting or ferment after salting. Generally the fish which is dried after salting is Chandana fish (*Hilsa toli*) (Fig. 11), the fishes which are smoked after salting are *P. sophore, C. fasciata, C. striatus* etc. and the product which is ferment after salting is *Lona ilish* (*Hilsa* spp) (Fig. 5). Among the salted fish products Chandana fish and *Lona ilish* are popular in the state like Tripura, Assam, Arunachal Pradesh. Smoked salted fish products are popular in Manipur. The salt content in *Lona ilish* is around 15.75% (Majumdar and Basu, 2010) and in Chandana fish is around 12%.

CONCLUSION:

Processed fish products are very popular among the people of north eastern India. Traditional people used to take these processed fish products with some ethnic believes. Even though the food habits of people have changed over time, but those who have their roots in villages still take pleasure in consuming this traditional food items. Now some new technologies should be adopted in order to scale up these products. The traditional knowledge on preparation of such foods by different tribal communities of North-East India may be useful for future research in this area and also it may be useful for income generation especially for the unemployed educated youths in developing some small scale entrepreneurship. Among the processed fish products fermented fish products are having some health beneficial effects and scientific researches are going on to find out these healthful compounds from the fermented fish products.

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FISH 'JABS' COULD BOOST SCOTTISH SALMON INDUSTRY

The SAIC-funded jabs project will adapt vaccination techniques and technologies to the physiology of lumpfish. *Photo courtesy of Pablo Gordillo Chueca.*

A collaborative vaccination project, co-funded by the Scottish Aquaculture Innovation Centre, could enhance the efficacy and welfare of cleaner-fish and help to deliver growth in the salmon industry

Aqualife, a Stirlingshire business which vaccinates over 100 million fish a year, has received funding from the Scottish Aquaculture Innovation Centre for a research project to develop new fish vaccination techniques for species of lumpfish and wrasse.

The project could lead to significant production growth in the salmon industry in Scotland, the creation of new jobs, a more sustainable industry, and decreased use of medicines.

Demand in the salmon industry in Scotland for cleaner-fish species such as wrasse and lumpfish is high, due to recent research demonstrating their success in sea lice control. Providing sufficient cleaner-fish for the industry requires a major boost in production of robust cleaner-fish that can operate effectively throughout the salmon growth cycle.

The novel welfare-friendly techniques proposed by the project team could step up the survivability and robustness of lumpsucker and wrasse species, and help to upscale the effectiveness of cleaner-fish on farms. Project outcomes should include new protocols for vaccination methods for different lumpfish methods, and new vaccination devices for cleaner-fish.

This project is co-funded by the Scottish Aquaculture Innovation Centre (SAIC) and also involves major salmon producer Scottish Sea Farms and researchers at the University of Stirling's Institute of Aquaculture, the leading aquaculture research and teaching hub in the UK. Scottish Sea Farms will provide access to a range of its marine sites across Orkney, Shetland and the mainland for research to be carried out.

In keeping with SAIC's principle of open knowledge exchange, the results of the project will be made available to Scottish stakeholders.

The 18-month project rolls out in August, supported by a grant of £117,000 from the Scottish Aquaculture Innovation Centre (SAIC), launched in 2014 by the Scottish Government, to harness the strength of Scotland's research base and natural resources. SAIC's grant has been matched with £168,400 from the other partners involved, who are keen to work together to address aquaculture's key issues and opportunities.

SAIC is driving progress in the aquaculture sector in Scotland by instigating and accelerating innovative commercially-relevant solutions intended to lead to wealth creation, new jobs and economic growth. Top of its list of priorities is sea lice control, and the Aqualife project is part of a suite of activities being rolled out by SAIC to tackle the issue.

These include a grant earlier this year to a £4 million project to upscale the deployment of farmed wrasse, and invitations for project applications involving lumpfish or engineering-based solutions. A number of innovative project ideas are currently under consideration.

Heather Jones, CEO of the Scottish Aquaculture Innovation Centre, stated: "This cleaner-fish vaccination project exemplifies the way SAIC is galvanising researchers to collaborate with SMEs and multinationals on innovative projects that will benefit the industry and the Scottish and UK economy. It's estimated that each additional 10,000 tonnes of salmon that reaches the market creates an additional £96 million for the economy. This project that we're co-funding has hugely exciting potential to contribute to wealth creation."

Professor Jimmy Turnbull, Deputy Director of the Institute of Aquaculture, added: "This project will deliver valuable new insights into cleaner-fish physiologies and welfare, and define optimal vaccination protocols for cleaner-fish species. As well as helping the industry comply with the requirements of Quality Assurance schemes, our work will support the sector's commitment to welfare and sustainability."

One additional planned outcome of Aqualife's project is a new vaccination device based on a prototype the company has developed for salmon. The plan is to adapt the device for the anatomy and physiology of different lumpfish and wrasse species.

This, believes Ronnie Soutar, Managing Director of Aqualife, could pave the way for further adaptations of the device for use on other farmed non-salmonid species such as Mediterranean bass and bream, Asian catfish or North African tilapia.

Soutar explains: "We see a huge market opportunity in the development of vaccination devices and machine vaccination programmes. We want to be able to go to any farm or sector and say we can deliver a programme suitable for the physiology and welfare of the fish. This current cleaner-fish project, with the Scottish Aquaculture Innovation Centre, the University of Stirling and Scottish Sea Farms, represents a step towards that goal.

"By supporting innovative projects like this one, SAIC is delivering invaluable support for the sustainability and ambitions of companies in our sector, including the potential for major international exports."

For more information, contact info@scottishaquaculture.com

Scottish Aquaculture Innovation Centre

The Aqualife / Scottish Sea Farms / University of Stirling project, being co-funded by the Scottish Aquaculture Innovation Centre, will define effective, welfare-friendly methods for vaccinating cleaner-fish, including lumpfish and wrasse.

This will involve evaluating current vaccination methodologies in terms of fish welfare, effects on growth, survival and vaccine efficacy. The project will then build on those assessments to develop:

- new protocols for effective and welfare-friendly vaccination methods for different lumpfish species
- novel vaccination equipment for cleaner-fish, based on a prototype salmonid vaccination device under development by Aqualife. The device will be adapted to the different anatomy and physiology of lumpfish and wrasse. The device is intended to improve safety for vaccinators, as well as fish welfare and efficacy.

About the Scottish Aquaculture Innovation Centre

Industry success through research partnerships

The Scottish Aquaculture Innovation Centre is one of eight Innovation Centres set up by the Scottish Government in key economic sectors. We are utilising the strength of the research base in Scotland to address the industry's key issues and opportunities.
We instigate and accelerate solutions for industry issues through, e.g.

- grant funding for projects
- forging connections between businesses and researchers, in aquaculture and related areas.

The aim of all our work is commercial success, economic growth, and a more sustainable industry.

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COLUMBUS: BUILDING CAPACITY IN KNOWLEDGE TRANSFER TO PROGRESS THE EUROPEAN AQUACULTURE SECTOR

Innovation is key to the future of Europe. Climate change, sustainability, health and an ageing population are major societal challenges which need innovative actions and solutions. The European Commission has addressed this by putting in place a comprehensive innovation strategy; Europe 2020. One of the identified priorities is the transfer of scientific knowledge, which is recognized as being a major tool for innovation. The recently-started COLUMBUS project, a flagship European Union-funded Knowledge Transfer initiative, directly responds to this mandate with a specific focus on marine related research. This Blue Growth project is designed to ensure that outputs arising from publicly-funded marine research projects, including aquaculture, have positive societal benefit.

"COLUMBUS is a strategic Blue Growth initiative with an overarching objective to ensure that applicable knowledge generated through EU-funded marine related science and technology research can be transferred effectively. By doing so, it will support Europe to improve the competitiveness of European aquaculture businesses, amongst others" explains Cliona Ní Cheallacháin, COLUMBUS Project Manager.

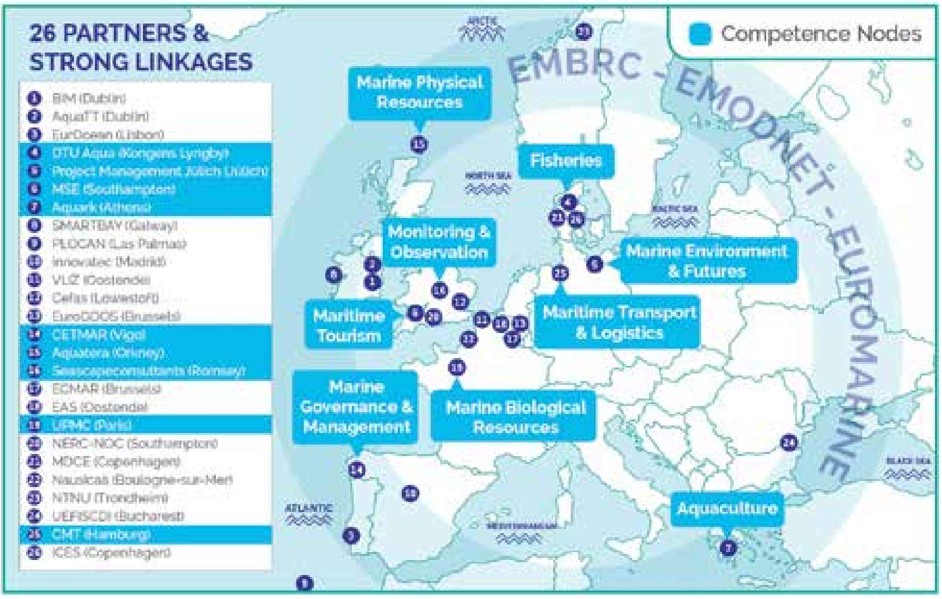
C	**Collaboration** A multidisciplinary partnership to address the challenge
O	**Oceans of Opportunity** Realising the potential of the Oceans
L	**Linking** Balancing growth with sustainable practices
U	**Understanding** How the Oceans function and two-way impacts
M	**Marine Strategy Framework Directive** Supporting implementation
B	**Blue Growth** Realising sustainable growth
U	**User-Focused** Meeting the needs of stakeholders and society
S	**Shaping the Future** Improving processes, capacity, competence and legacy

Our seas and oceans are identified as drivers for the European economy and have great potential for innovation and growth. Blue Growth[1] is the long term EC strategy to support sustainable growth in the European marine and maritime sectors as a whole, with aquaculture being recognized as a key sector having high potential. In the EC strategic guidelines for the sustainable development of European aquaculture[1], the EC states the need to "Promote the transfer of knowledge, best practices and innovation, including EU research project findings" in order to progress the sector. The sustainable growth of European aquaculture is also the main priority of the European Aquaculture Technology and Innovation Platform (EATiP[2]) whose vision identifies knowledge management as one of the critical factors to support European aquaculture. COLUMBUS directly addresses these

[1] EUROPEAN COMMISSION Brussels, 29.4.2013 COM(2013) 229 final COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Strategic Guidelines for the sustainable development of EU aquaculture

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

COLUMBUS will establish a "Knowledge Fellowship", a network of nine full-time node-based Knowledge Transfer Fellows whose role will be to carry out Knowledge Transfer using a methodology based on needs prioritised early in the project. Working together as a team and active network, this combined critical mass will provide a multiplier effect to help achieve measurable impacts and to develop a blueprint for future activities in this field of work, ultimately contributing to the development of a thriving and sustainable marine and maritime economy.



needs and requirements by applying a unique and innovative knowledge transfer approach and by doing so will support a sustainable and globally competitive European aquaculture sector.

In particular, COLUMBUS will:

- Explore the challenges facing the European marine and maritime sectors and create a priority list of our most urgent challenges and important knowledge needs
- Discover results of past and current research projects on marine and maritime subjects, in particular those which could provide the solutions to overcome the highlighted identified challenges
- Pioneer a new technique to better understand who can make use of under-utilised knowledge and make sure that it is used for the benefit of all society
- Ensure the innovative transfer of discovered knowledge to those that can use it
- Make citizens aware of marine and maritime related research results that have an impact on their own daily lives

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- Establish a COLUMBUS legacy which will provide recommendations on how to improve the use of knowledge from research in the marine and maritime sectors

In the context of COLUMBUS, Knowledge Transfer is defined as a two-way, iterative process requiring engagement and networking which requires a deep understanding of the needs of the end-user to ensure transference and impact. COLUMBUS has begun identifying knowledge needs from an end-user perspective so that all activities are focused on knowledge that has a high potential to be impactful if identified and transferred.

To achieve this, a unique new concept will be applied by the COLUMBUS project, namely the establishment of a "Knowledge Fellowship". The Knowledge Fellowship is a network of nine full-time Knowledge Transfer Fellows whom will carry out Knowledge Transfer using a methodology directing their efforts towards the aforementioned knowledge needs prioritised early in the project. Working together as a team and active network, this combined critical mass will provide a multiplier effect to help achieve measurable impacts and to develop a blueprint for future activities in this field of work, ultimately contributing to the development of a thriving and sustainable marine and maritime economy.

The Aquaculture Competence Node within the Knowledge Fellowship will be led by AQUARK[3], an SME based in Greece. AQUARK are involved in leading applied research and consultancy in the field of aquaculture health management. AQUARK bridges the gap between the research community and the fish farming industry at federation and farm level, and facilitates smooth technology and Knowledge Transfer. Other partners supporting the Aquaculture Node include: the European Aquaculture Society (EAS)[4]; AquaTT, DTU Aqua and Bord Iascaigh Mhara (BIM – Irish Fisheries Board). BIM are an Irish public Agency responsible for developing the Irish seafood industry by providing technical expertise, business support, funding, training and promoting responsible environmental practices and they are the coordinator of the COLUMBUS project.

As part of the COLUMBUS methodology, the Knowledge Fellows will be relying on cooperation and collaboration with many of Europe's top aquaculture and marine researchers, in order to collect high potential knowledge and carry out Knowledge Transfer for increased benefit and impact. This interaction will

[3] http://www.aquark.gr/
[4] www.easonline.org

also support aquaculture researchers in complying with current and future funding requirements to ensure uptake and impact of their research. COLUMBUS will provide the resources to carry out this vital work, and also provide capacity training to all researchers with the initiative to upskill in this area. As the former European Commissioner for Maritime Affairs and Fisheries, Maria Damanaki said: "Today, we put the building blocks in place so that tomorrow's generation of Europeans will have the knowledge and skills to better manage our oceans and draw the full benefits they can provide us, while respecting the balance of the ecosystem of the sea[5]."

As a Coordination and Support Action, COLUMBUS represents the most substantial investment by the EC in Knowledge Transfer to date. "COLUMBUS is an ambitious project with the potential to deliver game-changing results. To be successful, we count on Europe's aquaculture researchers to cooperate with us to achieve high impact from their work. The kick-off meeting was a success, with the partnership ready and willing to begin work immediately, particularly in setting the foundations for strong and robust methodologies and processes to be used within the project," Ní Cheallacháin adds.

THE PARTNERSHIP

The COLUMBUS project was designed and written by AquaTT, building upon the successful outcomes of the FP7-funded MarineTT project which was led by AquaTT, and is coordinated by BIM. The project will run for three years and involves 26 partners from across Europe managing knowledge and carrying out Knowledge Transfer of marine research outputs to measurably increase their uptake and application by different end-users, such as industry, policy makers, and society in general.

COLUMBUS brings together a new extended multi-stakeholder, multi-disciplinary, transnational partnership with the experience, strategic positioning and track record in the marine and maritime sectors to achieve its ambitious aims. Understanding that strategic changes are needed in how the marine and maritime community interact and collaborate for mutual benefit, the partnership has been constructed to represent all aspects of the research lifecycle (funding bodies, researchers, communications experts and end-users) and all regional sea basins in Europe.

The COLUMBUS website will be available soon for further information, www.columbusproject.eu. If you would like to know more about the COLUMBUS project or would like to receive regular updates on its progress, please contact its Project Manager.

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[5] EC 2014 EU eyes oceans innovation as source of sustainable growth [http://europa.eu/rapid/press-release_IP-14-536_en.htm]

Advances in pikeperch (*Sander lucioperca*) research during the first 18 months of the project

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Pikeperch (*Sander lucioperca*) is a promising emerging fish species for intensive freshwater aquaculture, based on Recirculation Aquaculture Systems (RAS). During the first 18 months of the DIVERSIFY project, a number of studies have been initiated (a) to obtain knowledge in support of future breeding programs and (b) to solve the major bottlenecks identified previously by fish farmers (*e.g.*, cannibalism during larval rearing and stress sensitivity). This article presents a summary of the main results obtained so far.

GENETICS

The first genetic work was organized under the responsibility of Dr C. Tsigenopoulos (Hellenic Center for Marine Research, Greece). The primary objective was to use genetic markers (microsatellite loci) to evaluate the genetic variability of some wild pikeperch populations in comparison to the variability of captive broodstocks in commercial RAS farms around Europe. Thirteen cultured and eight wild populations with more than 950 fish in total were analyzed for a final set of 10 microsatellite genetic markers. On average, and contrary to what could be theoretically expected, the thirteen domesticated populations exhibited a slightly higher number of alleles compared to the wild ones (2.634 *versus* 2.580, not significantly different with an F-test). Likewise, unbiased expected heterozygosity estimates were slightly higher in wild population (0.573 *versus* 0.553, but again not significantly different with an F-test). Inbreeding coefficient (F_{IS}) values showed that the domesticated populations are in general not inbred and that some wild populations may also suffer from kin mating, too. In general, the mean heterozygosity estimates and the count of the number of alleles per population indicate that domesticated samples do not suffer from inbreeding. There are few domesticated populations that have some level of inbreeding, either due to their small sample size or their use as 'selected' fish.

Our studies also provide evidence that pikeperch populations in Europe are part of at least two genetically differentiated groups (Figs. 1 & 2). The first group is found in northern Europe from the Netherlands/Denmark to the West, Poland (at least) to the East, and to Finland to the North (Fig. 2). The second group comprises all remaining populations in Central Europe to as south as Tunisia (and probably Spain, Italy and northern Greece). In the second stock, the Hungarian

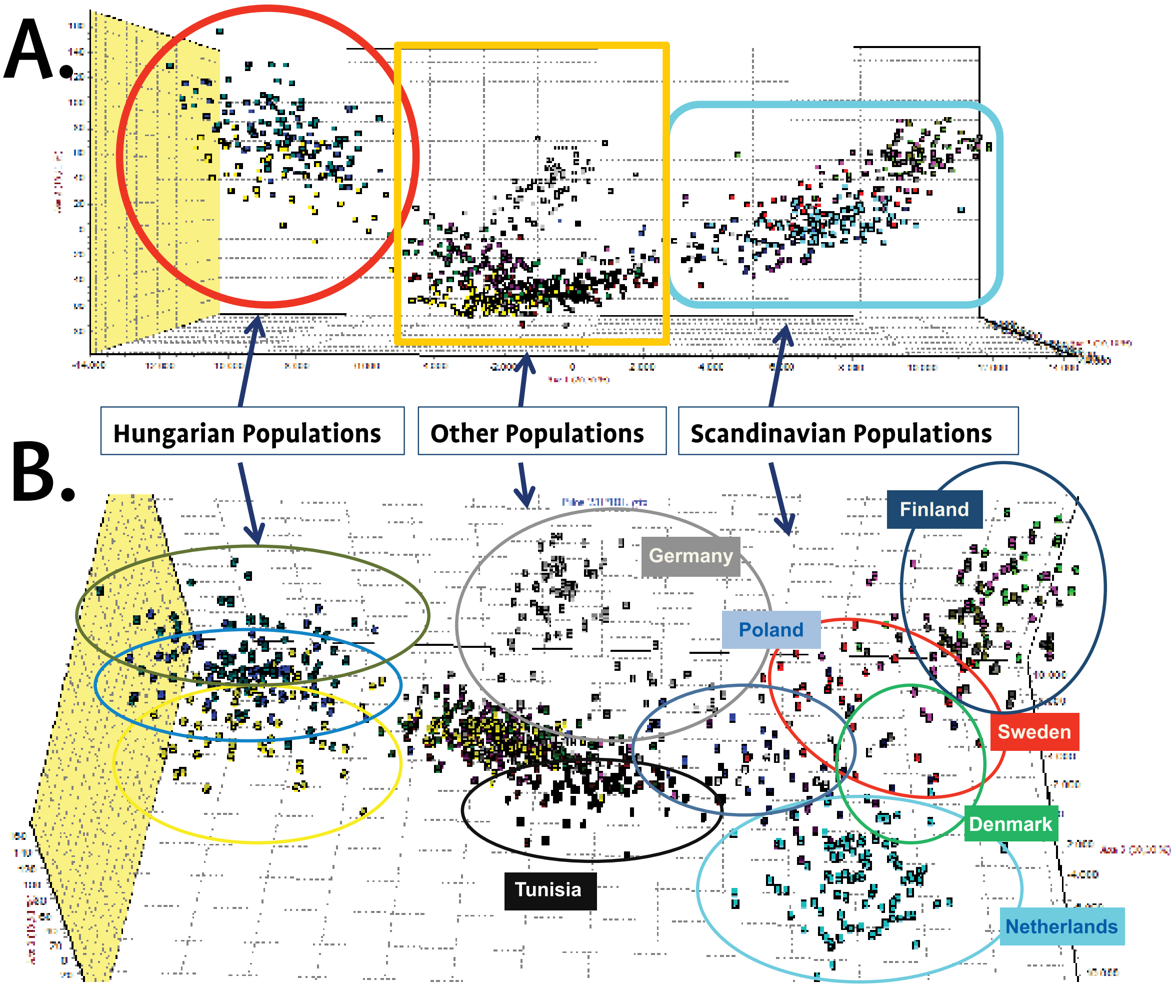

Figure 1. Factorial Correspondence Analysis (FCA) for all twenty-one populations and ten loci using the GENETIX v. 4.05 software.

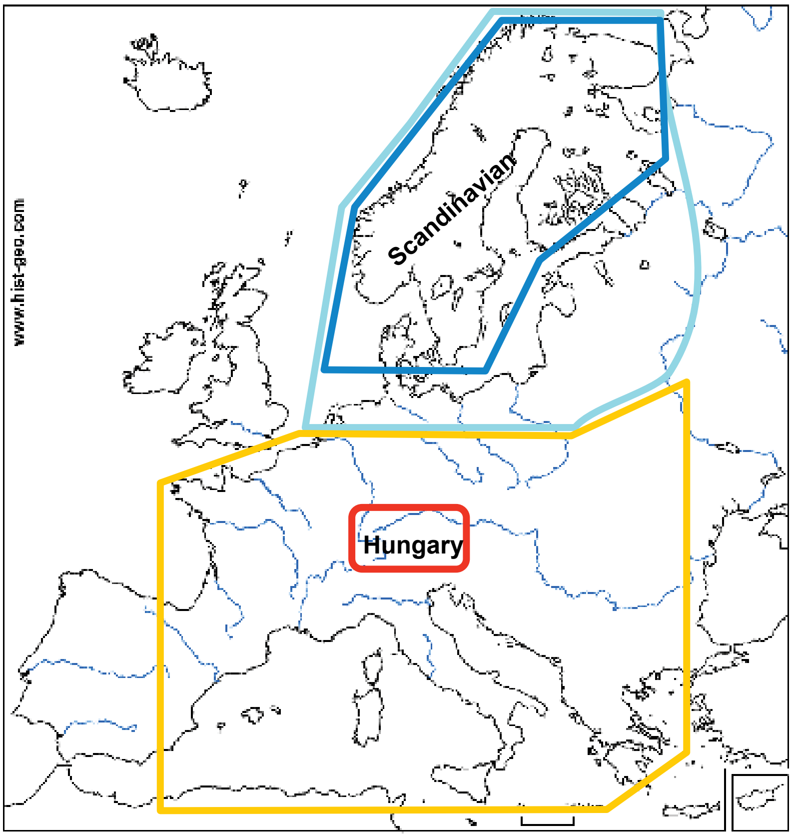

Figure 2. Map of Europe showing the major pikeperch genetic groups included in the study.

Figure 3. Pilot scale larval rearing system used for pikeperch research at the University of Lorraine (France).

populations are having a key-position being different from those found geographically close, *e.g.*, from Czech Republic and Germany. It might be another stock associated with Hungarian lakes, as opposed to all other populations that probably has dispersed through the Danube River west and southwards. Based on this grouping, it can be stated that most analyzed populations seemed to contain fish of a single origin; nevertheless, in few domesticated populations this ratio varied from 5-19%, possibly due to the mixing of fish from multiple sources.

LARVAL REARING

Three main bottlenecks have been identified as preventing the success of larval rearing: a high rate of mortality due mainly to cannibalism, a high rate of deformities and a strong growth heterogeneity characterized by important differences in size between larvae of the same age but at various developmental stages. Several trials have been completed using a pilot scale larval rearing system (RAS, eight 700 L tanks, Fig. 3). The main goal was the identification of optimal combinations of major culture factors (environment, population and nutrition) to increase larval survival and growth. This task has been managed by Pr P. Fontaine (University of Lorraine, France). In a first experiment, the effects of four environmental factors with two modalities were tested (light intensity: 5 *vs* 50 lx, water renewal rate: 50 *vs* 100% per hour, water current direction: up-flow *vs* down-flow, tank cleaning time: at morning just after the first feeding vs at the evening after the last meal). A fractional factorial experimental design (24-1) of resolution IV was used to study simultaneously the effect of these four factors and their possible interactions. Every week, from four days post hatching (dph) and after the first feeding, 60 larvae were sampled in each tank. Individual weight, morphological measurements (total length, mouth size, myotome height and eye diameter), occurrence of deformities, inflation rate of swim bladder and histological analyses (retina, intestine and musculature of jaws, in collaboration with Dr E. Gisbert, IRTA, Spain) were made at 25 and 40 dph. Results showed that light intensity, water renewal rate and cleaning period have a direct impact on growth, deformities and swim bladder inflation success. For example, larval total length at 40 dph was influenced by the interactions between (i) light intensity and water renewal rate (Fig. 4) and (ii) light intensity and cleaning period. The water current direction had no impact on these developmental parameters.

Then, in a second experiment using similar methodology, we studied the impact of four feeding factors on the growth of pikeperch larvae during the first weeks after fertilization. The four tested factors were: quantity of live preys (2,100 or 10,500 *Artemia* nauplii/larvae/day), weaning duration (three or nine days), frequency of food distribution (continuous or a meal each 1.5 hour from 8:30 to 17:30) and use of co-feeding (Prowean Larviva, BioMar) or not. Significant effects were observed in pikeperch larval growth and growth heterogeneity (CV, %) at 11 and 18 dph. At both sampling dates, the mean body weight of larvae was significantly higher when a higher quantity of *Artemia* nauplii were distributed (4.79 mg *vs* 3.07 mg at 11 dph and 20.10 mg *vs* 9.39 mg at 18 dph). Likewise, similar effects were observed on larval length (1.35 cm *vs* 1.08 cm at 11 dph). Moreover, significant effects on growth heterogeneity were caused by the quantity of live preys, the frequency of food distribution and co-feeding. A higher coefficient of variation for body weight at 11 dph was observed in response to discontinuous *vs* continuous food distribution (29.8% *vs* 28.3%) and to a lower *vs* higher quantity of live preys (37.8% *vs* 30.3%). Finally, at 18 dph, a significant interaction between co-feeding and duration of the weaning period was observed. When co-feeding was applied, the duration of the weaning period had no effect on larval size heterogeneity, whereas without co-feeding a significant increase of size heterogeneity appeared when the weaning period was longer *vs* shorter (13.9% *vs* 10.5%). In conclusion, the amount of distributed food was the main factor affecting the development of pikeperch larvae, but some effects of food distribution, co-feeding and weaning duration were also observed.

NUTRITION

Some nutritional bottlenecks remain to be solved to sustain a successful commercial production of pikeperch. Among these is the development of larval diets for optimal growth and performance. Several studies have indicated that low dietary levels of long-chain highly unsaturated fatty acids (LC HUFAs) may cause dysfunctions, such as increased stress sensitivity and mortality and may have long term consequences on brain size, behavior and neuromuscular escape responses. The research undertaken so far in the project (managed by Dr I. Lund, Technical University of Denmark, DTU Aqua) involves a study on larval requirement of phospholipids (PL) and LC HUFAs and a pilot study on tolerance to salinities in order to observe how performance, essential fatty acid (FA) requirements and FA metabolism may be altered by changes in environmental salinity. To study the effects of PL and LC HUFAs, six different diets with increasing content of PL, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were tested (Table 1). The diets were fabricated by SPAROS (Portugal). At 30 dph, larval performance, biochemical composition as well as digestive enzymatic activity, liver proteomics, gene expression and skeleton morphogenesis were evaluated. Larvae were obtained by AquaPri A/S (Denmark) and reared on *Artemia* nauplii until 10 dph and then gradually switched to compound feeds within 5 days. The trial was performed in 18 tanks of 50 L (6x3) in which ~800 larvae were stocked and fed in surplus (approximately 25% of estimated total average wet weight) until 30 dph. Results are still being analysed, but the growth result (Fig. 5) showed that increasing levels of PL had a significant positive impact on larval size and that LC HUFAs such as DHA and EPA may increase those values.

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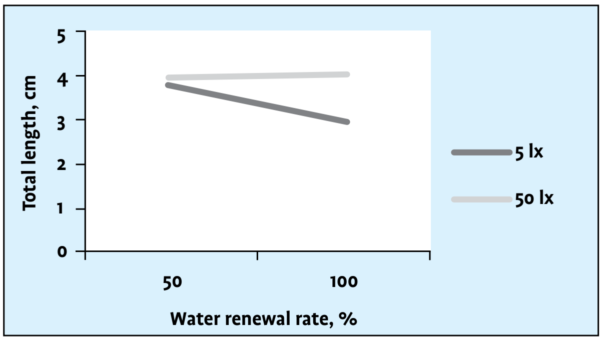

Figure 4. Influence of light intensity and water renewal rate on the total length of pikeperch larvae at 40 days post hatching (dph).

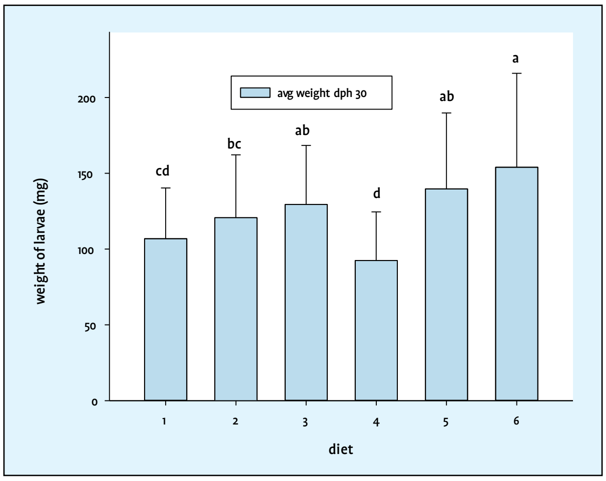

Figure 5. Size of pikeperch (*Sander lucioperca*) larvae at 30 days post hatching (dph) in response to six experimental diets. Means with statistically significant differences (ANOVA, $P<0.05$) are indicated by different letter superscripts.

As fed basis (% wet weight)	1	2	3	4	5	6
Crude protein	52,74	52,72	52,69	52,74	52,72	52,69
Crude fat	27,01	26,99	27,01	27,01	26,99	27,01
Fiber	0,14	0,14	0,13	0,14	0,14	0,13
Starch	4,02	3,90	3,72	4,02	3,90	3,72
Ash	8,12	8,12	8,11	8,12	8,12	8,11
Gross Energy	24,02	23,34	22,48	24,02	23,34	22,48
Fatty acids (% total fat)						
Eicosapentaenoic acid (EPA)	0,41	0,41	0,41	0,47	0,61	0,75
Docosahexaenoic acid (DHA)	0,66	0,66	0,66	1,04	2,06	3,04
Phospholipid classes (% total fat)						
Phosphatidylcholine (PC)	1,51	2,88	4,64	1,51	2,88	4,64
Phosphatidylethanol-amine (PE)	0,62	1,58	2,81	0,62	1,58	2,81
Phosphatidylinositol (PI)	0,69	2,10	3,90	0,69	2,10	3,90
Total phospholipids (TPL)	3,16	7,45	12,96	3,16	7,45	12,96

Table 1. - Dietary content of six formulated weaning diets.

Another pilot study showed that pikeperch larvae can survive abrupt salinity changes of 8-10 ppt directly after hatching without noticeable mortality, but 12 ppt might be the upper tolerance level. A subsequent study involving three salinity levels was initiated (0, 5 and 10 ppt) in a triplicate set-up on larvae fed either *Artemia* enriched with high levels of linolenic acid (ALA, 18:3n-3) or linoleic acid (LA, 18:2n-6). Larvae seemed to grow well, but the study needs to be repeated later this year, as the initial stocked numbers of larvae were too low. The capability of larvae to synthesize LC-HUFAs, as well as the fatty acid esterification pattern into different lipid classes will be studied by *in vivo* radio-tracing of 14C fatty acids and lipid classes (phosphatidylcholine-phosphatidylethanolamine, PC-PE).

GROWTH - STRESS

A first experiment was carried out in order to study the effects of husbandry practices and environmental factors on pikeperch growth, immune and physiological status (task led by Pr P. Kestemont, University of Namur, Belgium). The aim was to optimize the conditions for pikeperch grow out. This study is a screening approach of the main stressful factors identified for pikeperch juveniles reared in intensive culture conditions such as RAS. Eight factors with two modalities have been selected according to the bibliography and fish farmer observations (Table 2). This experiment (June – August 2015) is based on a multifactorial experimental design and new experimental facilities consisting of 16 independent RAS of 3 m^3 each (Fig. 6), located at the University of Lorraine (France). Pikeperch juveniles (70 g) were supplied by the company SARL Asialor, also a partner of the DIVERSIFY project. Different parameters of stress response will be analyzed, including cortisol, glucose or cerebral serotonin. Immune markers will be also investigated, including lysozyme and complement activities, concentration of immunoglobulin (Ig) and the expression of immune genes (*e.g.*, lysozyme, C3-1, TNF-α, IL-1β). Following this multifactorial experiment, a validation experiment will be done at the University of Namur facilities for further investigation, focusing on the interaction between stress intensity and resistance against pathogens. The results will enable the determination of the major aquaculture stressors in pikeperch in order (a) to reduce stress exposure during rearing by applying the optimal rearing conditions, (b) to increase disease resistance and (c) to improve growth performance.

Before the actual start of this multifactorial experiment, two preliminary experiments were planned in order to (i) standardize the analytical protocols for physiological and immune markers using pikeperch submitted to stressors and (ii) define the lethal dose of *Aeromonas hydrophila* or *A. salmonicida* that will be used for the challenge tests after stress experiments. Compared to salmonids, the first observations showed high levels of cortisolemia in pikeperch (88-122 ng/ml), confirming its high sensitivity to captive environmental conditions, and that emersion stress induced a significant increase in plasma glucose.

Factor	Modality
1 - Grading	- 2 times per month - No
2 - Initial rearing density	- 30 kg/m^3 - 15 kg/m^3
3 - Light intensity	- 100 Lx - 10 Lx
4 - Light spectrum	- White - Red
5 - Photoperiod	- L:D 24 : 0 - L:D 10 : 14
6 - Hypoxia	- 50-60 % of O_2 saturation - 90-100 % of O_2 saturation
7 - Temperature	- 21-22°C - 26-27°C
8 – Type of feed	- Semi floating - Sinking

Table 2. - Experimental conditions and modalities

Figure 6. Examples of two environmental conditions applied on pikeperch juveniles to study. Upper photo: white spectrum, 100 Lx, lower photo: red spectrum, 100 Lx

The project DIVERSIFY has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration (KBBE-2013-07 single stage, GA 603121, DIVERSIFY). Further information for the project is available at www.diversifyfish.eu.

FOOD *for* THOUGHT

Aquaculture Europe 2016 will take place in Edinburgh, Scotland from 20-23 September, 2016.

"Food for thought" means something to think about, something to be seriously considered and something that provides mental stimulation and nourishment.

Aquaculture in Europe has plateaued resulting in overall output remaining more or less constant in volume since 2000.

The Aquaculture Europe 2016 will present the latest science to support further development and industry panels will discuss key opportunities and identify areas to encourage further sustainable growth in aquaculture.

The morning plenary sessions will address different aspects of the event theme in a novel way.

Organised by the European Aquaculture society with the cooperation and support of Marine Scotland, part of the Scottish Government, and The Marine Alliance for Science and Technology for Scotland

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Promoting Multidisciplinary Research

In addition to the thematic sessions, AE2016 also includes parallel and poster sessions. The following is a list of the sessions open for submission of abstracts (this list could be subject to change).

- New advances in salmon farming
- New advances in trout farming
- Diversification in aquaculture production
- Cleaner fish: biology, production and management
- Shellfish production and diversification
- Seaweed production
- Laboratory models (e.g. Zebrafish and others)
- Nutrition: New sources of protein for aquaculture feeds
- Nutrition: New sources of omega 3 fatty acids for aquaculture feeds
- What is new about nutritional requirements in marine organisms?
- Recent advances in digestive physiology: The gut, its health and molecular nutrition
- Advances in the mitigation of deformity
- Application of genomics in aquaculture
- Hatcheries
- Escapee containment: From systems to biotechnology
- Disease prevention, treatment and management
- Sea lice control
- Gill health and challenges
- Shellfish health
- Microalgae derived toxins, analysis and regulations
- Predator management
- Finfish welfare
- Fish behaviour in aquaculture systems
- Integrated Multitrophic Aquacutlure (IMTA)
- Aquaponics and biofloc
- Advances in Recirculation Aquaculture Systems
- Offshore production technology, new developments
- Organic aquaculture
- Aquaculture globalisation: Production and research across borders
- Climate change: impacts and mitigation (shellfish and fish)
- Understanding public perception and consumer demands
- Labelling and certification of aquaculture products
- Development, welfare and poverty alleviation
- Knowledge management, transfer and extension networks
- Governance, Policy and Strategic planning

Call for papers deadline: March 21, 2016
Please submit your abstract online: www.easonline.org.

SCOTTISH SALMON

ASSOCIATION OF SCOTTISH SHELLFISH GROWERS

British Trout Association

The Scottish Government
Riaghaltas na h-Alba

marinescotland

eas
european aquaculture society

AE2016 contacts

Conference:
ae2016@aquaculture.cc

Registration:
worldaqua@aol.com

Booth sales & sponsorship:
mario@marevent.com

AQUACULTURE MEETINGS

Direct links, brochures, registration form etc are linked to this information in the EAS website calendar module

This AQUACULTURE MEETINGS calendar is a summary of the new events module of the EAS web site...

To add information on aquaculture meetings that are of relevance to European aquaculture, please send the details to eas@aquaculture.cc and we will then add them to this column.

OCTOBER 2015

European FP7 project FISHBOOST workshop: How to set up a base population and perform selection with control on inbreeding - demonstration of two tools for your aquaculture breeding program
Wageningen, The Netherlands, October 19, 2015
Website: http://www.fishboost.eu/fishboost-workshop-19-october-2015.html

Aquaculture Europe 2015
Rotterdam, The Netherlands, October 20-23, 2015
Organised by EAS in cooperation with IMARES Wageningen UR, and Gold Sponsored by BIOMAR, the event will focus on the role and contribution of aquaculture to the management of natural resources and its importance in society through the provision of high quality, nutritious and healthy food. These are the main thematic areas that will be addressed during the plenary sessions. European and national research is providing highly innovative and integrated solutions to support development and the outputs of this research will be presented in the AE2015 parallel sessions that cover the full scope of European aquaculture and comprise submitted oral and poster presentations.
Contact for abstracts and registration: EAS Conference Organiser, John Cooksey, MF Cooksey Conference Management, AE2015 Conference, P.O. Box 2302, Valley Center, CA 92082, USA. Tel: +1 760 751 5005; Fax +1 760 751 5003; E-mail: worldaqua@aol.com
Contact for industry and media sponsorship opportunities: Mario Stael, MAREVENT, Begijnengracht 40, 9000 Gent, Belgium. Tel/Fax: +32 9 2334912; E-mail: mario@marevent.com; Web: www.marevent.com
General information: European Aquaculture Society, Slijkensesteenweg 4, 8400 Oostende, Belgium. Tel. +32 59 32 38 59; Fax: +32 59 32 10 05; Email: ae2015@aquaculture.cc. Url: www.easonline.org

NOVEMBER 2015

MERMAID end user conference - Multi-use offshore platforms: opportunities and challenges for Europe
Brussels, Belgium, 26 November 2015
The European FP7-project MERMAID deals with the integration of various functionalities (energy production, aquaculture, shipping, etc.) in multi-use offshore platforms. This provides a unique opportunity for the offshore private sector, experts and other stakeholders to share ideas with the European science community. At the end user conference, you can discuss and respond to the newest scientific developments, tools and experiences obtained on these platforms by the MERMAID project (FP7) and other related European projects such as TROPOS and H2OCEAN.
Contact: MERMAID end user conference, Flanders Marine Institute (VLIZ), Wandelaarkaai 7, 8400 Oostende, Belgium. www.vliz.be, T +32 (0) 59 34 21 30, E conference@mermaidproject.eu

JANUARY 2016

EcoAqua International Conference
Las Palmas de Gran Canaria, Spain, January 25-29, 2016
Thematic sessions: Ecosystem Conservation and Aquaculture; Structure and function of coastal & marine ecosystems; Responsible use of coastal & marine resources; Effects of global change in coastal and marine ecosystems; Integrated management of coastal and marine areas
Contact: Parque Científico Tecnológico Marino - Universidad de Las Palmas de Gran Canaria - Ctra. Taliarte s/n, 35200 Telde. Spain.
Email: gcourtois@fpct.ulpgc.es

FEBRUARY 2016

15th fish international & 2nd GASTRO IVENT
Bremen, Germany 14-16 February 2016
Info: Email: info@fishinternational.de; URL: http://www.fishinternational.de; Phone: +49 (0)421 / 35 05 260

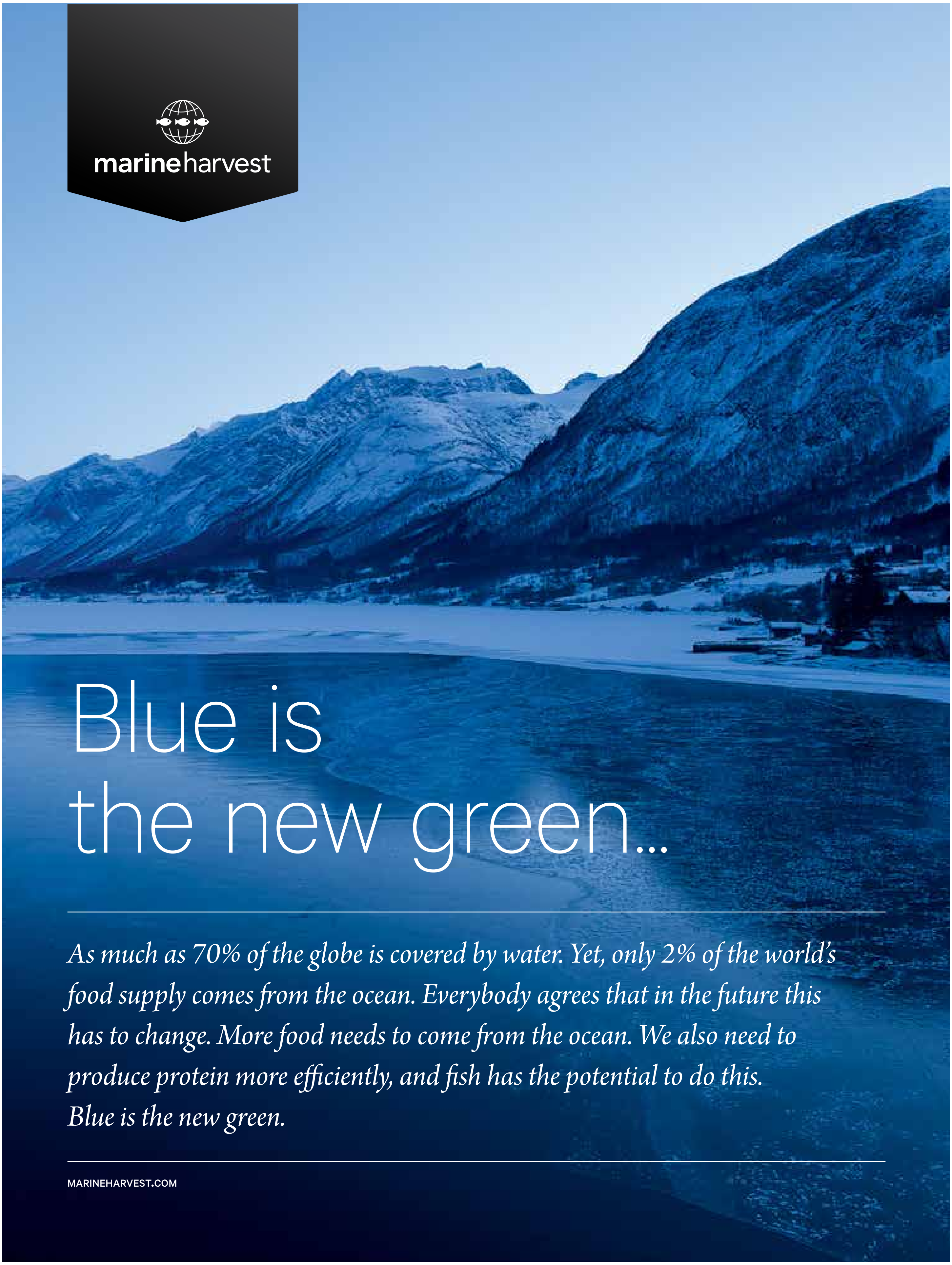
SEPTEMBER 2016

Aquaculture Europe 2016
Edinburgh, UK, September 20-23, 2016
AE2016 will feature a scientific conference, an international trade event, special sessions for aquaculture producers and satellite workshops and events. General information: eas@aquaculture.cc

11th International Sea Lice Conference
Westport, Ireland. September 26th to 28th, 2016
Further information can be found at www.sealice2016.com. Contact: info@sealice2016.com

NOVEMBER 2016

HydroMediT 2016 - 2nd International Congress on Applied Ichthyology & Aquatic Environment
Messolonghi, Greece, November 10-12, 2016
Email: hydromedit@apae.uth.gr;
http://hydromedit2016.apae.uth.gr


marineharvest
Blue is the new green...
As much as 70% of the globe is covered by water. Yet, only 2% of the world's food supply comes from the ocean. Everybody agrees that in the future this has to change. More food needs to come from the ocean. We also need to produce protein more efficiently, and fish has the potential to do this. Blue is the new green.
MARINEHARVEST.COM

SELFIE competition to win a Feyenoord football team shirt at

aquaculture europe 15

TAKE A SELFIE IN ROTTERDAM,
IN FRONT OF SOMETHING THAT MAKES YOU
THINK OF AQUACULTURE

2 shirts to WIN!
Originals, made by PUMA
EAS 15 on the back
Size XL

Post the selfie to *Instagram*
with all the hashtags you want,
but which **MUST INCLUDE #AE2015**

The competition will be open from Monday, October 19 at 09:00 and will close at 21:30 on Thursday, October 22

On Thursday, October 22 at **21:30**, and during the AE2015 Presidents Reception,
the two winners will be announced, based on **the highest number likes of your selfie** over the competition period.

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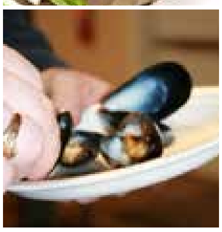
aquaculture europe 16



Edinburgh, Scotland
20-23 September, 2016
Edinburgh International Conference Centre (EICC)

FOOD *for* THOUGHT

Organised by the European Aquaculture society with the cooperation and support of Marine Scotland, part of the Scottish Government, and The Marine Alliance for Science and Technology for Scotland

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