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EAS celebrates its 40 years

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ARTICLES

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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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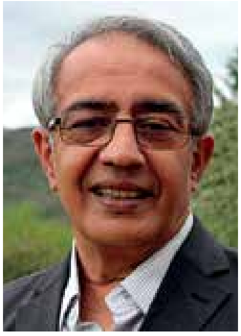


Dear EAS member(s),

This year is a special year for EAS.

EAS celebrates its 40th anniversary this year and it is indeed interesting to see how the Society has evolved since its inception in 1976. The magazine contains a four-page timeline of the major milestones of the EAS and we hope you will find this of interest. For our annual AE20106 meeting at Edinburgh, the board of EAS has decided to invite all the Past Presidents of EAS to join us. We hope that most of the current EAS members will also be there to celebrate this big EAS milestone with us.

AE2016 in Edinburgh is already generating a very high interest. With the event being held in September, we have had to bring forward the abstract submission deadline, but you can submit abstracts now and then amend them up until July. This will hopefully give the session chairs an easier job than they had in Rotterdam to produce the programme and it should also mean that the programme is online earlier.

This is also the year of the elections for renewing the Board of EAS. Now is the time for each of you to consider if you would like to play a leading role in EAS. We need you for keeping up the strength and spirits of EAS over the coming years. The election is open for the President-Elect, Treasurer and five Board Members. You can submit your application(s) to the EAS secretariat until 17h00 CET on Friday, April 29th. Between then and our event in Edinburgh, the elections will be over and the new board nominated for approval by the General Assembly in Edinburgh.

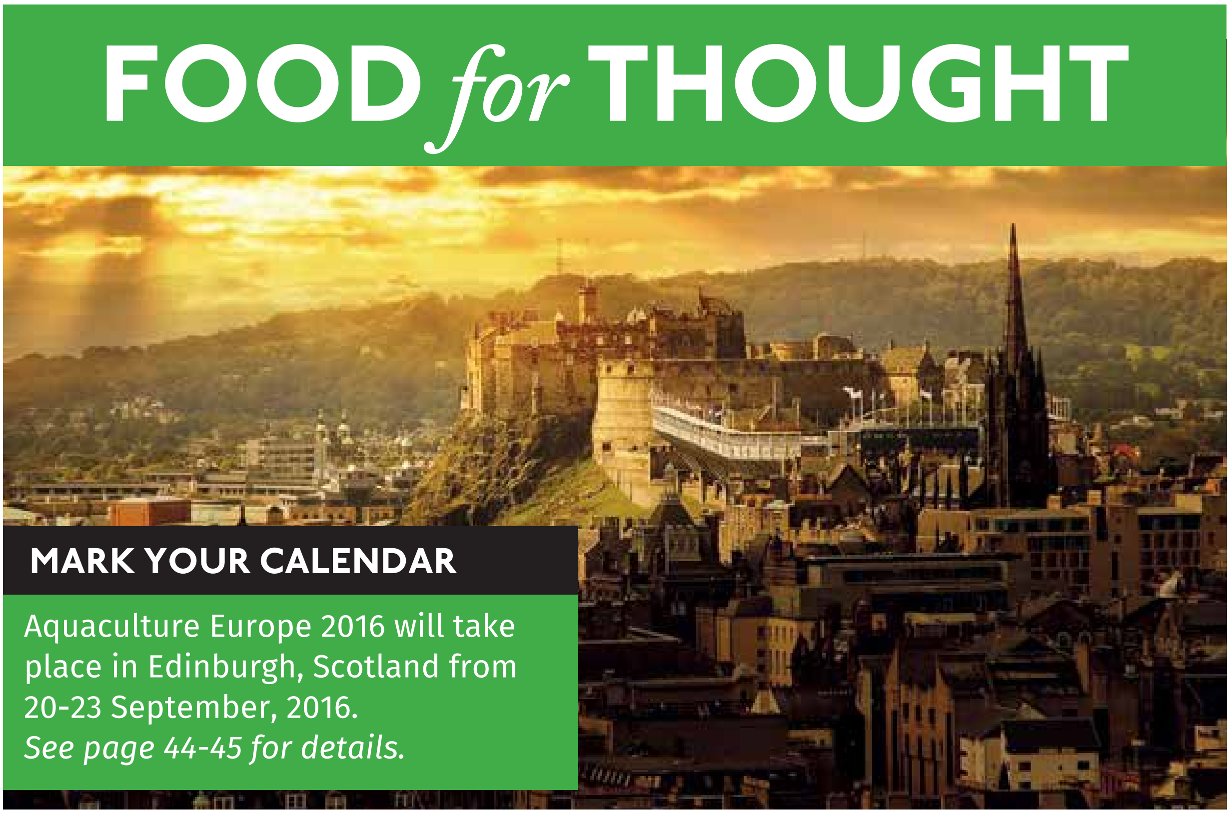
In the present edition of the magazine, you will also find an interesting feature article entitled "Integrated Multi-Trophic Aquaculture in Europe: will it work for us?" from Adam Hughes from SAMS and featuring news from the EU IDREEM project. The article clearly lays out the bottlenecks for the implementation of IMTA in Europe and tools that would re-align the mismatch between who bears the cost and who receives the benefits.

Of course, my warm welcome to all of you to the forthcoming AE 2016 in Edinburgh for a promising event dealing with "Food for thought…"

Our calendar is also set for the next three years: Aquaculture Europe 2017 will be held in Dubrovnik. Montpellier will host AQUA 2018 which will be a EAS-WAS joint event and Berlin will host AE2019.

Awaiting to see you all in Edinburgh.

Sachi



IMTA grid in Scotland

Integrated Multi-Trophic Aquaculture in Europe: *will it work for us?*

ADAM D HUGHES

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The idea behind integrated multitrophic aquaculture (IMTA) does on the face of it seem to be a bit of a 'no brainer'. The concept that you take waste products from one aquaculture operation, normally finfish, to use as nutrients and energy to grow another crop is beguilingly simple. And it is not really as if it is a new idea. In Asia the idea of integrated aquaculture where farmed animals such as ducks or pigs are grown together with aquaculture such as fish ponds has been around for centuries. It uses the same principle of one component, the ducks or pigs, fertilising or feeding another component, the finfish. There are also direct parallels in the ancient Chinese art of polyculture where five or more species of carp would be grown within the same pond, each feeding on different components of the ecosystem and each cycling nutrients or benefitting the other species. In a modern context an IMTA system is normally based on a fed component such as fin-fish or shrimp. From this fed component there are normally two waste streams; particulate waste (such as uneaten feed, feed fines, and faecal matter) and dissolved components (such as metabolic waste nitrogen). The particulate matter, which falls out of the water column first, can be a food source either for bivalves suspended in the water column or for detrivores, and the nitrogenous dissolved waste can be used as a nutrient for macroalgae production. This produces a classic win/win situation, where the extra nutrients increase the growth of the extractive crops such as shellfish and seaweed, and in doing so reduce the amount of waste material entering the wider environment. Within this basic concept there are normally two forms of IMTA, either land based or open water. In land based systems the water movement, and therefore the movement of nutrients is regulated by the flow of water from one pond or tank to another. In open water systems that movement of water is supplied by natural currents or tidal movements of water.

Given the appeal of the philosophy of IMTA and its long history in Asia, as well as almost forty years of scientific research in the western academic literature, there has been very little adoption of this technology in either Europe or north America. This is puzzling because the concept of IMTA is very much related to the concept of the circular economy where waste streams from one industry provide the raw materials for another which has gained ide acceptance across a range of European industriess. A good example of this would be Kalundborg Eco-industrial Park in Denmark, where waste material or heat from one industrial

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process such as gypsum from a power station gas scrubber is used as a raw material for another, such as plaster board manufacture.

It was to answer this quandary that the IDREEM project was set up (Increasing Industrial Resource Efficiency in European Mariculture) under the FP7 Resource Efficiency research theme. The idea was, over the course of the four years of the project, to follow seven finfish producers from across Europe as they developed pilot scale or commercial scale IMTA operations within their existing businesses and to support and document this process. In order to achieve this, three academic institutions and four aquaculture support industries were included in the project along with the seven finfish producers. The €5.7M project is being led by the Scottish Association for Marine Science and has received funding from the European Commission under grant agreement 308571. The project is currently in the final year of its four year course, and as such there is still more data and analysis to be done. However, the project has made significant advances into understanding why IMTA technology has not been more developed in Europe and the Americas and to understand how any bottlenecks can be overcome.

The concept of IMTA is often characterised as a win-win situation where the twin benefits of increased productivity and reduced environmental impact are coupled together. However, as with most things in life, it just isn't that simple and there is a cost to pay for the development of IMTA, and we are discovering that it isn't always those who pay the cost who reap the benefit. Through the process of the IDREEM project we have been able to systematically look at the process of technology adoption in aquaculture across Europe and that has allowed us to better understand the challenges aquaculture producers face when they try and adopt a production system such as IMTA. Although each company faced their own unique issues during this process, by looking across seven companies in six different countries it was possible to discern some common themes around the challenges of adopting IMTA. These challenges can really be broken down into three different organisational levels, those that concern regulation, those that impact investment decisions by companies, and those that effect the farm management.

THE GAP BETWEEN POLICY AND REGULATION

One of the first challenges facing a company who want to develop an IMTA system is that of regulation, or rather lack of it, specific to IMTA. The IDREEM project found that across Europe the regulatory framework is complex and far from unified. There is a lot of policy within Europe that supports the development of more sustainable forms of aquaculture, and as such would support the development of IMTA. However the IDREEM project found that there was a gap between policy and regulation in a number of countries, and that while obtaining permission for small scale experimental IMTA is possible, the regulatory framework in some countries represents a significant barrier to the development of commercial scale IMTA operations in a number of countries. Even where the regulation is in place, early adopters of IMTA may find a lack of experience or clarity amongst the regulators is a considerable hindrance leading to lengthy delays as they go through the process of licencing an IMTA farm for the first time. This lack of clarity at the first step of IMTA may be enough of a barrier to halt a company's plans to develop IMTA, especially if the company is small and has limited resources to dedicate to working through the process with the regulators. Part of this policy gap may be as a result of the regulators' feeling that they do not have enough evidence on which to base the development of new regulations. Although there are a large number of scientific studies looking at different components of IMTA, the lack of commercial scale trials means there is a lack of evidence of the impacts of IMTA at a commercial scale. When we are discussing impacts in this context, we are not only discussing the environmental impacts (which are fairly well demonstrated for the different IMTA components) but broader impacts such as the effect on bio security and disease management, or the impact on the visual amenity associated with more aquaculture infrastructure. In the realm of early technology adoption, this policy/regulation gap is a common phenomenon, as technology will always develop faster than regulation. However to ensure that it does not stall the development of IMTA there is a clear need for close collaboration between the technology adopters and regulators, with research playing a crucial role in providing the evidence needed to fill the policy gap with evidence based management.

GETTING THE BUSINESS MODEL RIGHT

Once permissions have been granted then the next set of challenges really operate at the level of the company. The biggest barrier to a fin-fish company adopting IMTA is a simple matter of the scale of investment and uncertainty over the level of return that investment will realise. One reason to invest might be that the sale of the additional products (the extractive products) will increase the profits of the company. While it is true that there are valuable markets for shellfish products in Europe there is little evidence to suggest that the returns in the shellfish industry are higher than for the fin-fish industry, and when we look at the seaweed industry, aquaculture production is still in its infancy with very uncertain level of returns. This begs the question, why make a decision to invest in IMTA when it may be easier at an organisational/operational level to invest in more fin-fish production? This leads to the second reason why a company may choose to invest in IMTA, that there is limited space available to increase the fin-fish production. It is generally accepted that site availability is one of the limiters on traditional aquaculture expansion. There are three ways in which IMTA may allow a company to increase production capacity:

Firstly the inclusion of extractive organisms at an existing site simply increases the biomass of total product that can be produced at any one site (as long as the regulation allows for this) and therefore if a company is site limited then these additional products may allow an increase in turnover and perhaps profit. There have been academic studies to show that increasing

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IMTA mussel cultivation in Cyprus

IMTA scallops being produced in Scotland

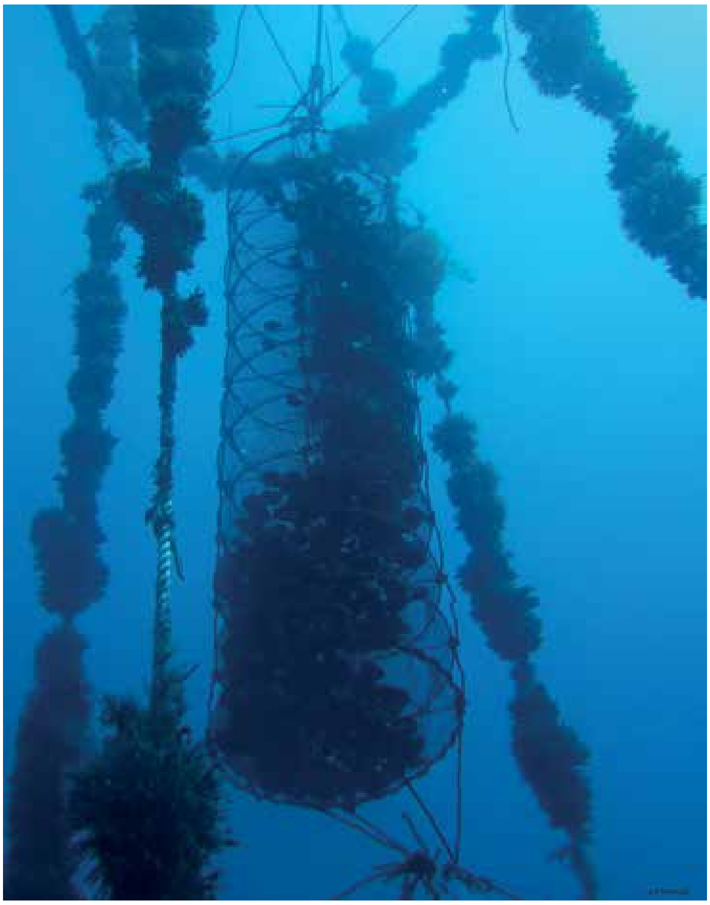
IMTA *Crassostrea gigas* produced in Italy

Alaria esculenta *Photo by F.O'Mahony*

Organic salmon cages with Mytilus edulis lines in the background


IMTA oysters being produced in Scotland


Lantern nets used to grow osters next to seabream in Italy


IMTA oysters growing in Italy

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the range of products a company produces increases the resilience of the company to economic or environmental shocks.

The second mechanism may be through the regulators allowing additional biomass of fin-fish to be produced on the condition that this extra production is to be balanced against the reduction in nutrient emissions to the environment associated with the IMTA production. This idea is similar to what is reportedly occurring in Denmark. The Danish government have stipulated that the nitrogen emissions per kg of fish must be reduced by 40% and the legislative body have recognised the bioremediation potential of mussels and seaweed in relation to their ability to uptake nitrogen. As such, additional biomass of fish production and the nutrient output from that additional biomass has to be balanced by nutrient reduction measures such as those offered by IMTA. This is a good example of where regulation could drive the adoption of IMTA.

The third mechanism is where the existence of IMTA operations adopted by a company adds value to the fin-fish production through the selling of the fin-fish at a premium. It is known that organic and sustainability labelling adds value to retailed fin-fish products and work undertaken in the IDREEM project suggests that there is a willingness within the general public to pay a premium for IMTA-produced fish. However for this potential to be realised there is a need to be able to certify IMTA products in a similar way to current sustainability standards in aquaculture. For this to happen a much clearer definition of IMTA is required, and an understanding of what does and what does not constitute IMTA. This definition and certification needs to be suitably robust to allow an aquaculture company to make the considerable investment that is required for a meaningful IMTA operation to be set up.

AN INDUSTRY DEFINITION OF IMTA

Though the concept of IMTA is relatively simple, its definition is far from simple. From an industry point of view, it might be best to define IMTA in terms of its environmental performance, given that this is the criteria that the company want to differentiate their products by. There are a large number of ways in which the environmental performance of an IMTA system could be classified or measured. A starting point for an industry definition might be how effective the IMTA system is at removing excess nutrients from the environment, and maybe more specifically how effective a system is at removing nitrogen from the environment.

The IDREEM consortium

This is in line with the approach taken by the Danish government. So if it is decided that nitrogen reduction is going to be the metric against which IMTA is to be measured, we then need to set levels to allow certification, and this begs the question, what percentage reduction constitutes an effective IMTA system. Setting this figure correctly is crucial to the success of any IMTA certification. If it is set too low, then the certification becomes meaningless; set it too high and IMTA becomes too difficult to implement. This idea of certification based on a percentage reduction in nitrogen emissions raises two crucial issues to the future development of IMTA and relates directly to company level decisions on adopting IMTA. The first is scale and the second is of integration.

THE ISSUE OF SCALE

Let us look at the issue of scale first. Fin-fish production in Europe is an intensive industry with large biomasses produced per m^2 of surface area. The cultivation of extractive organisms such as mussels and seaweeds is much more extensive, with much lower production densities per m2. As such there is a mis-match between the scales of production between fin-fish and extractive organisms in terms of the space required to make a meaningful reduction in the nitrogen emissions. Modelling studies suggest that to remove 10% of the nitrogen from a 1000 tonne salmon farm would require approximately 10 hectares of seaweed. This obviously represents a significant space requirement, and operational input. It is interesting to note that initial modelling work carried out in Canada suggests that benthic IMTA may be far more efficient in terms of space requirements. This type of IMTA involves the use of detritivores underneath the fin-fish cage within the benthic foot print of the cage, which can consume the large particulate waste which falls directly to the bottom. Species such as sea urchins and sea cucumbers have been piloted for this type of IMTA, although there are still considerable technical barriers to the commercial development of these systems.

INTEGRATION

Recent studies have shown that both the dissolved and particulate nutrient plumes from fin-fish farms are very hard to detect at distances of more than a couple of hundred meters away from the farm. If you think about some of the scales that were discussed earlier, then even if the culture area of the extractive organisms is directly adjacent to the fin-fish cage, a large percentage of the extractive organisms will be outside the measurable plume of waste nutrients. So it will be essentially impossible to prove that the nitrogen taken up by the extractive organism originated from the fin-fish cage. But does this matter? Is there a need to prove that there is direct transfer of nutrients from fin-fish to the extractive organisms for it to be classified as IMTA? Not if we are using the definition of IMTA we discussed earlier (a nitrogen-reduction of some predetermined percentage). In that case is it better to look at the scale of a water body, bay, loch or fiord? If we consider IMTA at the wider scale and not the farm scale, then the twin issues of integration and spatial scale are easier to manage. There is an increasing drive to manage disease and parasites at the loch or fjord scale in the salmon industry, so why not nutrients? This way of thinking about IMTA is very much in line with taking an ecosystem approach to aquaculture, where consideration is given for managing the whole water body. For a company to develop an IMTA system, where the integration occurs at a broader geographic scale may be a more attractive proposition. In addition to allowing much more effective disease and parasite control through their management at the level of the water body as opposed to the level of an individual site, this broader scale would allow much more effective biomass and emissions control. The locations and set up of farms could be planned and modelled to ensure that they are placed to balance maximised nutrient recovery while allowing the optimal biomass for the ecological limits of the system to be achieved. This type of area management may also be a valuable tool to increase the social licence for aquaculture companies to operate within the locality. Social licence is a concept that has come principally from the mining industry, and can be roughly defined as the on-going approval or acceptance of a project or operation within a community. As discussed earlier,

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availability of sites is becoming an increasing issue for the aquaculture industry, and applications for new sites are often slowed by objections from sectors of the local community. By using IMTA as a tool to create an ecosystem approach to aquaculture management, with such a management framework including a large component of bio mitigation in the form of extractive aquaculture integrated into the management of the fin-fish cultivation, you create a platform that can be used to build a social licence to operate for the aquaculture industry. This social licence is generated in a number of ways; firstly through increased employment in the local area from an increase in aquaculture activities, primarily through an increase in extractive aquaculture. The second mechanism is through an understanding that the aquaculture industry is acting in a responsible manner towards the environment and is taking actions to mitigate its environmental impact, and thirdly through better community engagement across the whole water body area and not just for a specific site.

FARM OPERATIONS

The final set of challenges is very much focussed at the level of the farm management and operation. Probably the largest challenge faced by the companies in the IDREEM project was a short fall in 'know how'. Fish farming is a technically and knowledge intensive industry, as is shellfish farming, and as is seaweed farming. For a fin-fish farm to start farming extractive species such as mussels or shellfish requires that the knowledge or know how to do this becomes in bedded within the organisation. There are a number of ways that this can happen. The knowledge can be brought in from outside the company through hiring the suitable technical expertise. This represents a significant investment which may be beyond a small fin-fish farmer. Another route is through 'learning by doing'. Though the initial investment is smaller, the potential for significant loss is not small whilst staff become proficient in the new production systems. In fact, set backs during this learning by doing period has the potential to stop the development of IMTA for a small firm. There is a hybrid option where a fin-fish farming company and a shellfish or seaweed company chose to develop a site together as a joint venture. While there are obvious advantages to this approach, there is a need to ensure there is integration between the separate companies at an operational level as well as at a biological level. This operational integration is another area that has been highlighted by the IDREEM project as another potential barrier to the successful implementation of IMTA. The level of organisational integration will depend on the nature of the IMTA operation, but there will be multiple aspects to consider. For example the layout of the farm, as the fin fish industry becomes more technical and specialised: there is less flexibility in how the cages are laid out or in the grid which is used to moor them. This is particularly the case for the salmon industry which is reliant on well boats of increasing size. These well boats require considerable sea room to operate, and as such their operation may limit how close the other components of the IMTA system can be to the fin-fish cages. However if IMTA is fully operationally integrated, then the mooring grids of the cages can be designed to incorporate the IMTA components within the grid while retaining full access to the outside of the cages, but this level of integration can only be achieved if IMTA is considered to be fundamental to the farm design and its operation and is included in the planning stage of infrastructure development. The issue of bio security was highlighted as one of the challenging aspects of organisational integration. This was perceived as a risk by most of the fin-fish producers prior to the start of the IDREEM project. The concerns centred around issues of disease management and different production cycles and whether the IMTA products would act as a potential reservoir for pathogens. Although highlighted as a perceived risk, there have been no reported issues of biosecurity within the project to date.

Other operational challenges include processing the different components of the IMTA system. This has been especially true for the large amounts of seaweed cultivated during the project. Again the processing challenge relates to know how imbedded within the company but also to its available infrastructure. In the case of seaweed, drying is perhaps the most cost effective way to process the product, but this drying is space and energy intensive, and the large scale infrastructure required to deal with large volumes of seaweed are rare in Europe. The issue of processing is directly related to the issue of finding markets for the additional extractive organisms. For shellfish these markets are well developed and it may be a simple case of producers connecting directly to these distribution networks. However for products such as seaweeds these markets are poorly developed and this may act as a large disincentive to the development of IMTA.

WHAT DO WE NEED TO MOVE FORWARD?

As we said at the beginning, the IDREEM project was set up to understand some of the reasons as to why IMTA had not been more widely adopted, and we have gone through some of those reasons and the different operational levels at which they act. But the IDREEM project was also about finding tools to allow that benefit of the win/win to be enjoyed by the European aquaculture industry and by the wider European society. Although we have extensively listed challenges and bottle necks it does not mean that benefits of IMTA are not obtainable. IMTA has the potential to deliver greater productivity and reduced environmental impact; it also has the potential to decouple economic growth in the European aquaculture industry from resource depletion. However at the moment there is a mismatch in who bears the cost and who receives the benefits of IMTA. Most of the costs of adopting IMTA (and not just financial ones) are borne by the industry and yet their benefits are not being accrued by the industry. As such there is relatively little incentive for the industry to invest in its development.

However the IDREEM project has identified a number of tools that would allow this mismatch to be re-aligned:

1. Firstly there needs to be a **definition of IMTA that the industry can adopt**, a definition that can be understood by consumers and industry alike. Following on from this definition there needs to be a

certification for IMTA, so that industries who invest in IMTA can protect their investment from cheaper copies who have the potential to devalue the IMTA 'brand'.

2. Secondly, industry needs to be given the **flexibility to deal with the spatial mismatch in scales** described earlier between the extractive components of IMTA and the fin-fish production. The only way to do this for the dissolved component of the farm wastes is to pursue a water body approach to IMTA and to the management of aquaculture. There are clear drivers as to why the management of aquaculture at the loch/fiord/bay level would be attractive to fin-fish companies. Using IMTA as a way to 'balance' aquaculture within a wider ecosystem and to manage the social and environmental impacts will require a change in policy and regulation but offers the best chance for wider scale adoption of IMTA.

3. Thirdly the **technical and biological constraints of benthic IMTA need to be overcome**. Aquaculture in Europe is mainly managed on its benthic impact and at the same time this is the most concentrated source of nutrients that leave fin-fish production sites. Therefor this is the most obvious target for the IMTA win/win, but conversely because it is the most technically challenging it is the least developed. There is a clear need for further research spanning the disciplines of engineering and biology in order to come up with a workable solution for benthic IMTA.

4. The fourth condition that needs to be in place is the development of a **market for aquacultured seaweed in Europe**. Globally the seaweed industry is worth approximately $7bn and Europe imports approximately 90,000 tonnes of seaweed annually but only produces a tiny amount of seaweed domestically through aquaculture. Seaweed is a crucial component of most IMTA systems and we know that for it to make a significant contribution to nutrient reduction it needs to be grown in large volumes. These volumes of seaweed, though they have a high intrinsic value as a raw product, have a very limited market in Europe. The development of processing plants and bio-refineries for seaweed would allow for the expansion of this important component of IMTA and for it to reach its true economic value.

So what is the future of IMTA in Europe? There is growing commercial interest in its development, as well as clear policy drivers for its further development. The economic and environmental win/win is achievable, but currently the conditions are not yet in place in Europe to allow for its wide scale adoption. If these could be developed, then IMTA could become an important tool for the development of the economic and environmental sustainability of the European aquaculture industry.

Queen scallops ready to go into net at IMTA site in Scotland

Queen scallops growing as part of IMTA in Scotland

Oysters harvested from IMTA site in Italy

Advances in greater amberjack (*Seriola dumerili*) research: the DIVERSIFY project

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The greater amberjack (*Seriola dumerili*) is a species with high potential for the EU aquaculture due to its fast growth (6 kg in 2.5 years), excellent flesh quality and global market. Its farming in the Mediterranean region started in the 1990s with wild-caught juveniles, but the production is still negligible, as several bottlenecks exist for its industrial production. These include the absence of reliable reproduction, limited availability of juveniles, lack of knowledge on the nutrient requirements and pathology of the species. The EU FP7-funded DIVERSIFY project (www.diversifyfish.eu) examines the major aspects of greater amberjack aquaculture in order to overcome these bottlenecks and develop appropriate rearing methods for commercial production. This article provides some highlights from the first 2 years of the project.

Reproduction & Genetics

The research activities on greater amberjack reproduction have focused on three aspects. Firstly, on the identification of the reproductive dysfunctions in greater amberjack reared in captivity compared to fish in the wild, in terms of sex steroid plasma levels, histological and nutritional assessment of gonad maturation, the vitellogenic process (liver vitellogenin synthesis and oocyte yolk accumulation), as well as male germ cell proliferation and apoptosis. Secondly, on the development of a spawning induction protocol and an egg collection method for wild-caught greater amberjack maintained in land-based tanks and cages in the Mediterranean Sea and in the eastern Atlantic Ocean. Finally, work has focused on the development of an optimized spawning induction protocol for a greater amberjack broodstock born in captivity (F1 generation) in the eastern Atlantic.

Sex steroid plasma levels and histological evaluation of ovaries and testes underlined that gametogenesis in some captive-reared greater amberjack broodstocks is unreliable and may be seriously impaired (**Fig. 1**). Although liver vitellogenin gene expression was lower in captive fish, the capacity of the oocytes to accumulate yolk did not seem to be affected compared to wild fish. In the males, an early decrease of germ cell proliferation was observed and spermatogenesis ceased completely during the natural spawning period in captivity. In addition, captive male germ cells appeared to be affected by

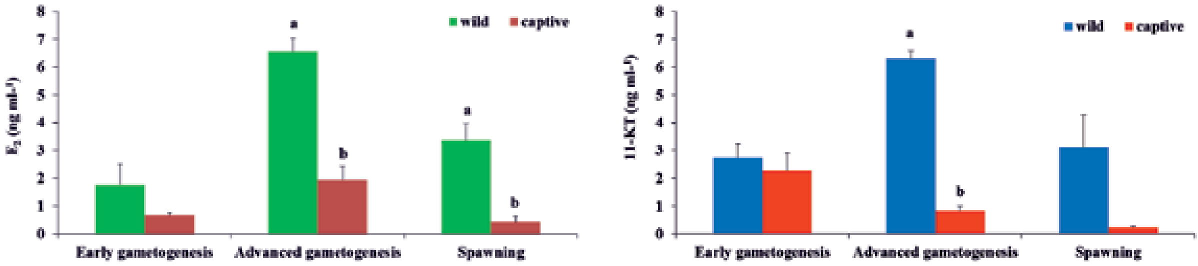

Figure 1. Plasma levels of 17β-Estradiol (E_2) in female and 11-ketotestosterone (11-ββ) in male wild and captive greater amberjack during the reproductive season. Asterisks indicate significant differences between wild and captive fish (ANOVA, $P < 0.05$), both in males and females.

an unnaturally high rate of apoptosis. It is hypothesized that the reproductive dysfunctions observed in captive-reared greater amberjack might result from the combination of captivity-induced stress, the lack of appropriate 'natural' spawning conditions, as well as nutritional deficiencies.

Experiments to induce maturation and spawning in the Mediterranean greater amberjack broodstocks by means of gonadotropin-releasing hormone agonist (GnRHa) implants, showed difficulties in obtaining eggs from broodstocks maintained in tanks. On the contrary, encouraging results toward the development of methods for reliable egg production have been obtained from fish maintained in cages (**Fig. 2**). Good quality of sperm during the spawning period, better development of the ovaries and better response to hormonal treatment with good fertilization of eggs was obtained when fish were maintained in sea cages during the year and either allowed to spawn in the cage or transferred to land-based tanks for spawning and egg collection. Unfortunately, egg collection in sea cages was either inefficient or negligible, and more effort is needed to develop appropriate egg collection methods for sea cages. However, the alternative method to transfer the fish to tanks for spawning after GnRHa induction was very effective, leading to the collection of ~22 million eggs from a small number of broodfish (n=6).

Experiments carried out in the eastern Atlantic Ocean (Canary Islands) demonstrated that wild-caught fish adapt readily to the captive environment and are capable of undergoing complete reproductive maturation, and are spawning spontaneously without the need of any hormonal therapies. Also, for the first time F1 generation greater amberjack at the final stages of vitellogenesis and at spermiation, were induced to spawn with treatment with GnRHa implants (**Fig. 3**). The fish underwent repeated spawnings for a period of 3 months, with a total production of about 15 million eggs. A major difference observed between the Mediterranean and Canary Islands broodstocks was the timing and duration of the reproductive season. Spawning started earlier (May) and lasted much longer (September) in both broodstocks in the Canary Islands, whereas in the Mediterranean the spawning season was limited to June and early July. These differences are probably due to differences in photoperiod and water temperature fluctuations, although genetic differences between the stocks have not been ruled out yet.

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Figure 2. Induction of spawning in a sea cage-reared broodstock in Greece (left), after evaluation of oocyte maturation stage (right). Some fish were transferred to land-based tanks for spawning after GnRHa treatment, but the majority of the fish were allowed to spawn in the cage (bottom).

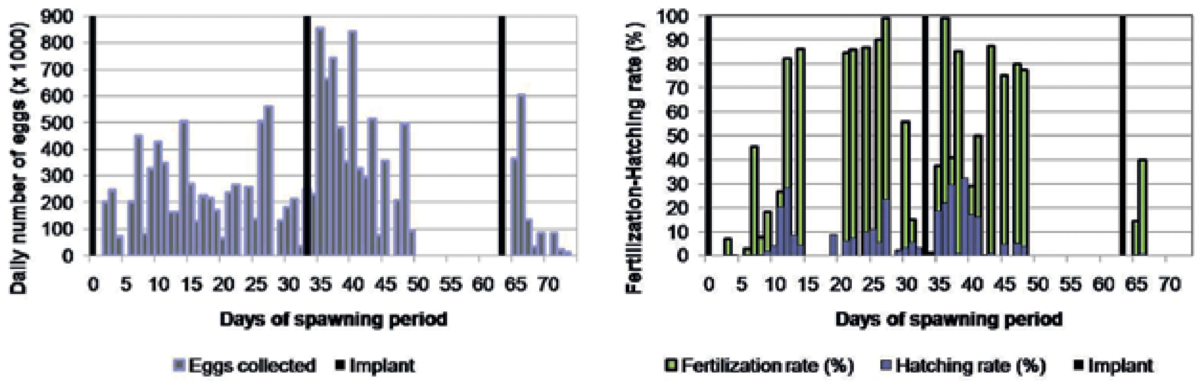

Figure 3. Induction of spawning in an F1 greater amberjack broodstock in Tenerife, Canary Islands (Spain) after three consecutive treatments with GnRHa implants.

Nutrition

The scarce knowledge on greater amberjack larval nutritional requirements leads to low larval survival and performance, and poor juvenile quality. Under this perspective, the overall objective of three feeding experiments performed by FCPCT and IEO/ULL was to determine the optimum levels of long-chain poly-unsaturated fatty acids (LC-PUFA) such as docosahexaenoic acid (DHA), eicosapentaeonic acid (EPA) and arachidonic acid (ARA), as well as the combination of LC-PUFA and carotenoids in enrichment products for rotifers and *Artemia*. Trials were performed using different lipid and antioxidant sources, and evaluations included their effects on survival, growth, welfare, stress resistance/tolerance, bone development and tissue composition of the larvae. The results suggested that *Artemia* enriched with DHA at levels of 1.5 g 100 g^{-1} dry weight and a 1.6 DHA/EPA ratio is sufficient to promote fast growth, whereas increased levels were associated with skull anomalies (**Fig. 4**). Skeletal elements such as the maxilla or mandible that develop from a cartilaginous precursor would be more sensitive to oxidative risks and, therefore, to dietary DHA elevation. Results also suggested that essential fatty acid requirements during rotifer and *Artemia* feeding are similar to those reported for larvae of other marine fish species. Requirements of greater amberjack larvae for DHA were higher than those found in other marine fish species and similar to those for other fast growing species, such as the yellowtail (*Seriola quinqueradiata*) or striped jack (*Pseudocaranx dentex*), whose larvae require 1.3–2.6 g and 1.6–2.2 g DHA 100 g^{-1}, respectively.

In addition, an enrichment protocol for rotifers was developed, containing 10 ppm of astaxanthin-based carotenoids, and a DHA-rich marine lecithin (LC-60) supplemented slightly with ARA (E1-10). Its use for just 3 h resulted in rotifers with high contents of DHA in the polar lipids, and a 2.7 DHA/EPA, resembling the composition of greater amberjack eggs. Feeding trials showed also improved larval performance (**Fig. 5**), and we expect that the data obtained will be used to design well-balanced enrichment products and weaning diets for this species.

Husbandry

The specific husbandry requirements for the rearing of greater amberjack are studied at different developmental stages to define appropriate and efficient practices. Preliminary results studying light conditions (photophase, intensity and background color) during the larval stages showed a beneficial effect of the long photophase on growth and survival of the larvae. Rearing trials comparing intensive and semi-intensive conditions are also implemented, and analysis is underway relating the ontogenetic changes of the digestive system with the expression of somatotropic axis genes. Results until now showed that intensive rearing conditions favor amylase, alkaline protease and pepsin activities in 30 days post hatching (dph) larvae, while in earlier stages (12 dph) amylase activity was also higher, in contrast to alkaline protease and lipase activities (**Fig. 6**).

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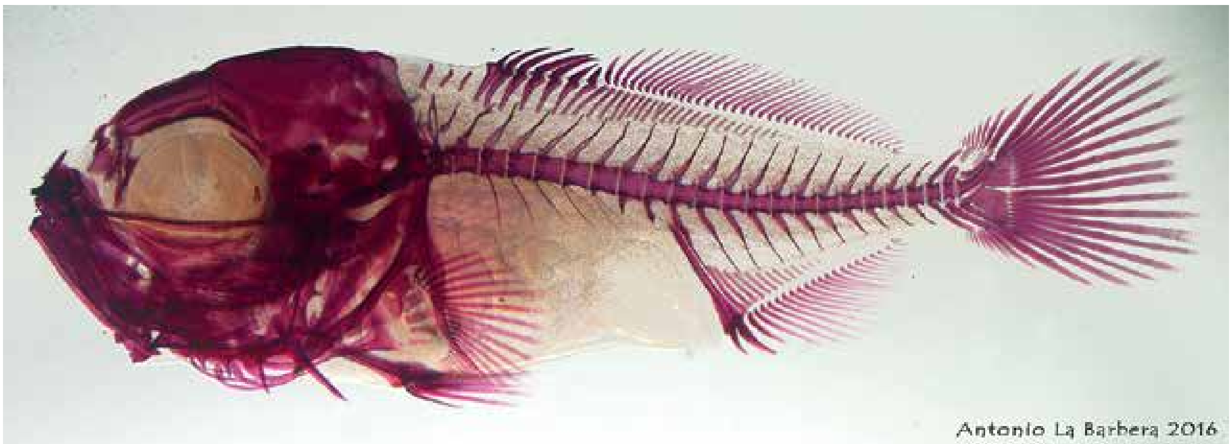

Figure 4. Greater amberjack juvenile with cranial malformation from the study of the effect of dietary Artemia DHA content.

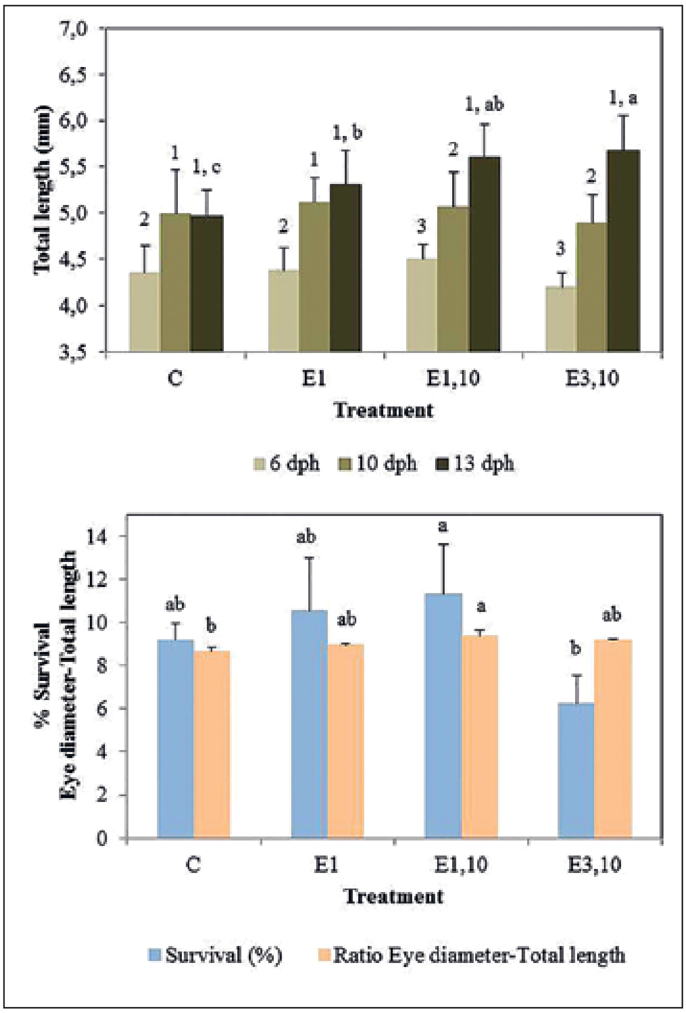

Figure 5. Effect of rotifer enrichment protocols on greater amberjack larval performance (a) Evolution of total length, (b) survival and eye diameter-total length ratio at the end of the experiment. Different numbers indicate significant differences along the feeding period, different letters indicate significant differences among dietary treatments. C, commercial enrichment; E1, LC-60 based emulsion; E3, triacylglycerol (TAG) DHA-rich emulsion; 10, 10ppm astaxanthin-based carotenoid supplementation.

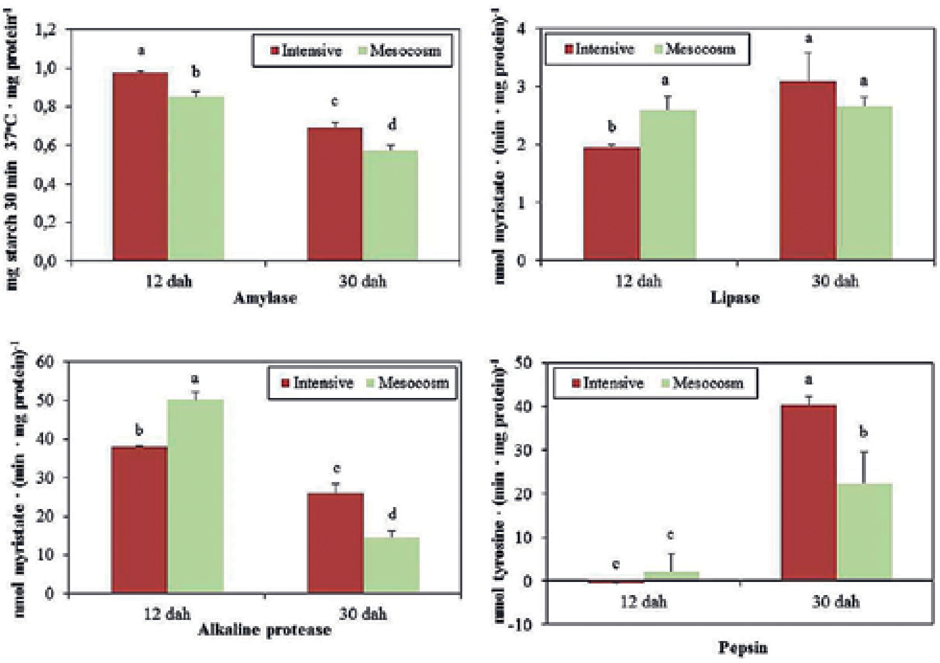

Figure 6. Comparison of digestive enzyme activities in greater amberjack larvae reared using intensive and Mesocosm protocols.

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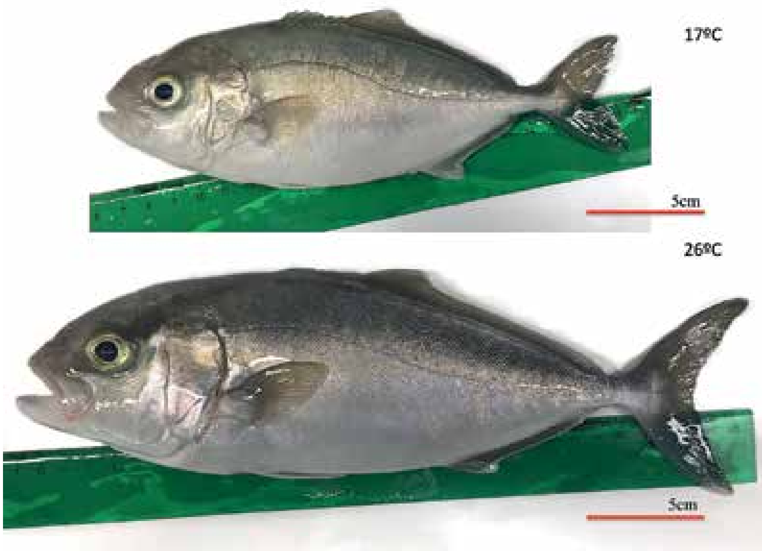

Figure 7. Greater amberjack reared at 17°C (above) and 26°C (below) showing the effect of rearing temperature on body morphology.

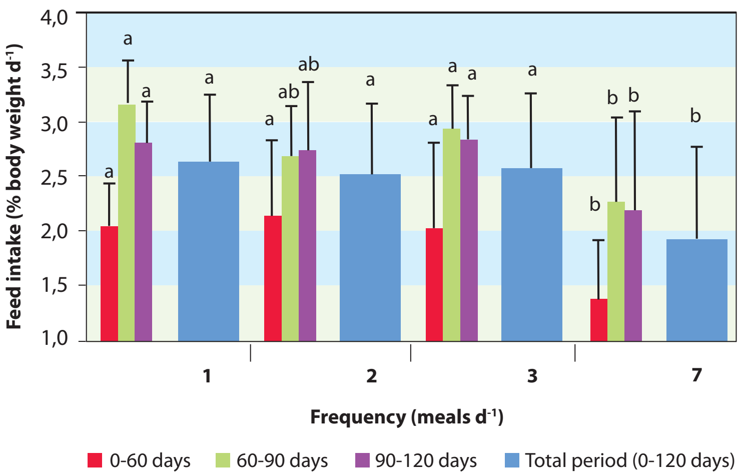

Figure 8. Feed intake (% of body weight d^{-1}) of greater amberjack juveniles at various feeding frequencies, at different times during the experiment (0-60 days, 60-90 days, 90-120 days and the overall effect). Different letters indicate significant differences (ANOVA, P < 0.05) for each period.

A study has been implemented examining the effect of stocking density during on-growing (initial densities of 0.2, 0.3 and 0.5 kg m^{-3} reaching 3.5, 5.7 and 7.4 kg m^{-3} after 4 months) on growth. The first results with juveniles (5 g) showed significantly lower specific growth rates (SGR) and condition index at high-density conditions. A second trial is currently under way with 200 g individuals, looking at feed intake, immune and welfare conditions. Regarding temperature tolerance, we have evaluated the performance of juveniles at 17, 22 and 26°C, with the latter being the most effective for growth and feed utilization. Furthermore, the body morphology of the individuals was affected by the temperature, with 26°C resulting in a better, more elongated body shape (**Fig. 7**).

The effects of different feeding rhythms on growth performance and welfare status were also examined. A trial was implemented with juveniles (~200 g) fed 1, 2, 3 and 7 meals day^{-1} for 4 months. Fish fed 1 meal day^{-1} showed the lowest SGR, condition index and hepatosomatic index, while those fed 7 meals day^{-1} showed the lowest feed intake (% of body weight day^{-1}) suggesting greater feed efficiency (**Fig. 8**). Although some monthly differences in mucus immunological, hematological and biochemical parameters, as well as oxidative stress enzymes in several tissues were observed, at the end of the study there were no statistical differences suggesting that greater amberjack juveniles are able to adapt to the different feeding frequencies under the particular culture conditions.

Health

Over the past 2 years, we have been studying the disease issues that impact production of greater amberjack, by monitoring several populations of cage-cultured fish for their health status. In Greece the main pathological problems have been caused by opportunistic bacteria and parasitic infections, especially during the transitional period between the hatchery and on-growing at the open sea. The most important bacterial infections were caused by *Vibrio harveyi*, which causes typical vibriosis (**Fig. 9**) and may result in high mortality, especially when water temperature rises above 20°C. The monogenean parasite *Zeuxapta seriolae* (**Fig. 10**) was the most prevalent and important parasitic pathogen. It is transmitted to cultured fish from wild populations and since its life cycle is direct (not requiring an intermediate

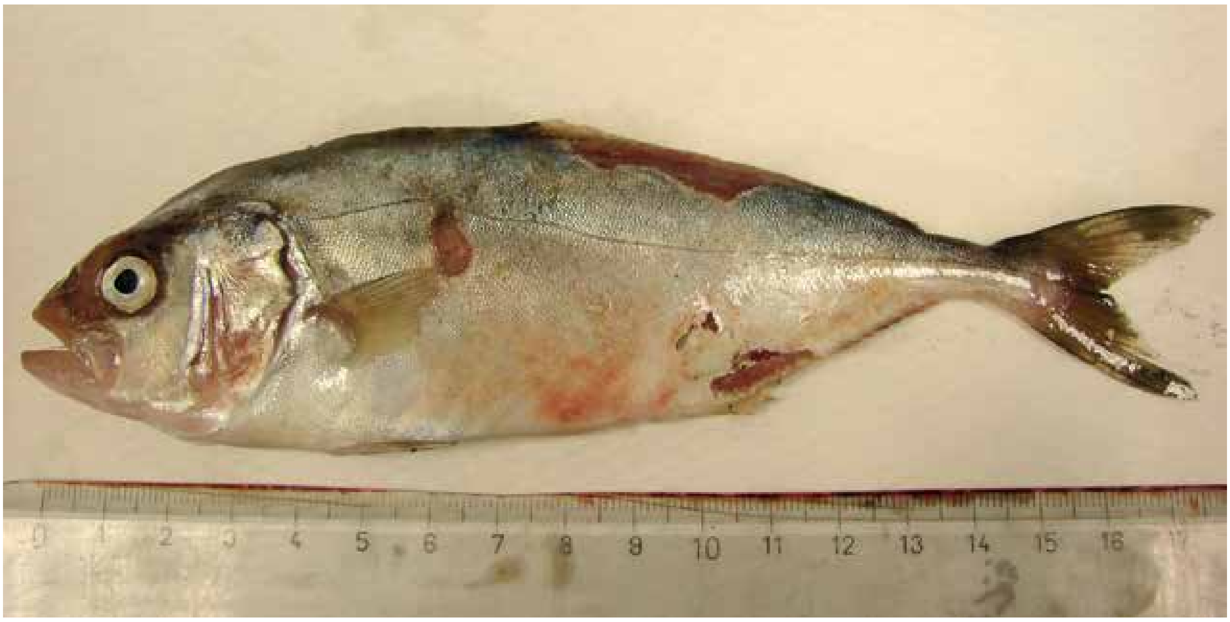

Figure 9. Juvenile greater amberjack infected by *Vibrio harveyi*.

host), it can propagate rapidly, reaching enormously high numbers on the host fish. The parasite is attached on the gills and feeds on blood, causing severe anaemia. Currently there are no adequate registered therapeutics for this parasite and we are investigating several experimental drugs that can be used to mitigate its impact on greater amberjack aquaculture.

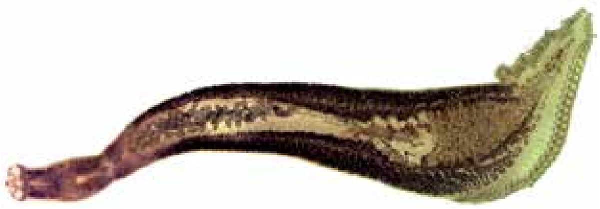

Figure 10. The polyopisthocotylean monogenean parasite *Zeuxapta seriolae*.

Apart from *Zeuxapta seriolae*, we have also identified the blood fluke *Paradeontacylix* sp. to be present in greater amberjack reared in Greece. This digenean parasite resides within the blood vessels of the fish and releases its eggs into the blood stream. The eggs and the encysted metacercariae obstruct the gill capillaries, causing severe inflammation and damage of the gill tissue (**Fig. 11**). There is scarce information on the biology of this parasite and almost nothing is known about its life cycle. We are currently investigating possible alternative or intermediate hosts, and we are trying to locate the source of infection. In parallel, we are aiming to develop tools to treat this parasitic disease. The skin fluke *Neobenedenia spp.* is a monogenean parasite that is especially important for aquaculture due to his broad host range and the damage that it causes to cultured greater amberjack (**Fig. 11**). The parasite is well distributed in temperate waters around the world and it caused mortalities to one of our stocks in the Canary Islands. In Japan, infection prevalence rates of 70% have been reported for reared amberjack. Once infected, fish scratch the nets and tanks in order to remove the parasite, producing wounds that cause important injuries on the skin, leading to secondary infections, immunosuppression and, in most cases, the death of the fish.

For this reason strategies for reducing skin fluke incidence are being examined. For example, ways to promote the fish mucosal immune system, particularly skin mucus production (quality and quantity) are being studied since this is the host's first defensive barrier against this parasite. Thus, histopathological analyses for evaluating the derived-skin mucosa wounds, mor-

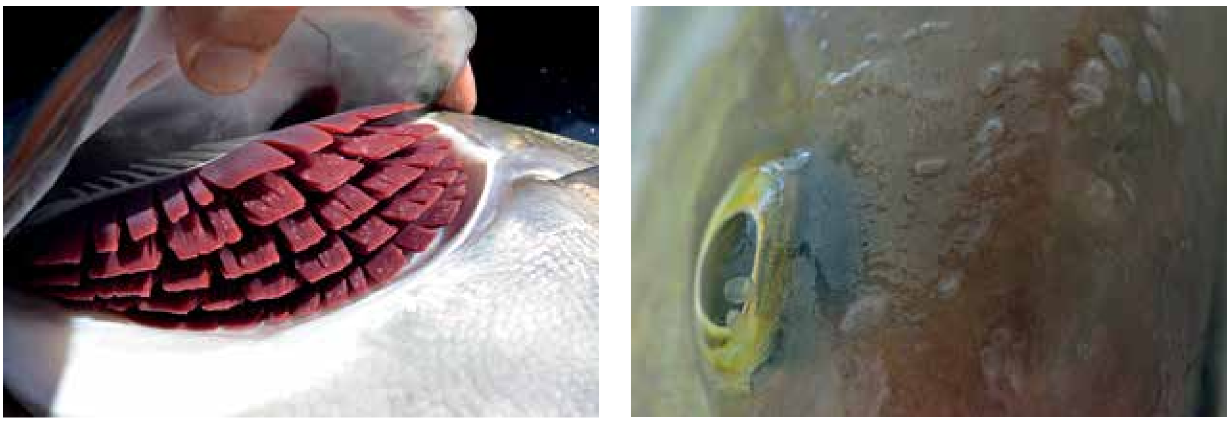

Figure 11. Numerous visible white nodules on the gills of greater amberjack caused by the eggs of *Paradeontacylix spp* (left) blocking the capillaries. Greater amberjack infected by the skin fluke ***Neobenedenia spp*** (right).

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phometric studies for determining skin mucus quantity and an evaluation of the host immunological status are being conducted. The morphological and hydrodynamic differences between cranial and dorsal regions suggest that the cranial region is an easier place for the attachment of the parasite. *N. girellae* attachment induces epidermis disorganization, increase of goblet cells and massive migration of immune cells (mononuclear lymphocytic type) around the site of parasite attachment. The attachment of *N. girellae* in greater amberjack causes a dermatitis that can be the site for opportunistic pathogens to occur. The incidence of *Neobenedenia* seems to be related to fish size and temperature, with outbreaks of parasites observed in animals larger than 100 g and temperatures above 20°C. These studies are being completed with biochemical and immunohistochemical analysis and examination of the expression of immune and mucus production related genes.

New product development

The technical characteristics and muscle composition of greater amberjack were studied in two different size groups (**Fig. 12**), in order to define both the range of these quality characteristics and the effect of fish size on them (**Table 1**).

Figure 12: Farmed greater amberjack during yield measurements and filleting.

	Group A (small fish)	Group B (big fish)
Size (fish weight in Kg)	1.19±0.19	13.00±1.62
Dressing yield (% of body weight)	92.8±0.79	94.7±0.39
Filleting yield (% of body weight)	50.5±2.89	
Visceral loss (% of body weight)	5.60±0.71	2.89±0.83
Fillet composition (%)		
Protein	22.9±1.29	20.5±0.56
Fat	3.87±0.93	12.3±0.11
Moisture	71.03±1.07	65.5±0.55
Ash	1.35±0.49	1.31±0.04

Table 1. Somatic yield and fillet composition of farmed greater amberjack


Figure 13. Sample preparation and testing of great amberjack (taste panel, IRTA – Spain).

groups was the much higher fillet fat contents in big fish. The sensory characteristics of the species' fillet have been examined analytically with descriptive sensory analysis by trained panelists (**Fig. 13**). In summary, the great amberjack fillet exhibits homogenous color, laminar structure, high juiciness and acid and butter flavors, while its texture is characterized by high teeth adherence and chewiness but of medium hardness (when compared to other fish species). Based on the technical and sensory characteristics of the species and out of a list of 43 different products of variable process, three products have been chosen to be generated as prototypes: frozen fish fillet that is seasoned or marinated (product 1), ready-made fish tartar with additional soy sauce (product 2) and fresh fish steak for grilling in the pan (product 3). One of these products will be selected for consumer acceptance in the near future within the DIVERSIFY project.

This 5-year-long project (2013-2018) 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). The consortium includes 38 partners from 12 European countries –including 9 SMEs, 2 Large Enterprises, 5 professional associations and 1 Consumer NGO- and is coordinated by the Hellenic Center for Marine Research, Greece.

DIVERSIFY

Co-funded by the Seventh Framework Programme of the European Union

Further information may be obtained from the project site at "www.diversifyfish.eu".

AQUAculture USEr driven operational Remote Sensing information services

COLLATED BY JOHN ICELY ON BEHALF OF THE CONSORTIUM (SEE BELOW)
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Introduction

There is an increasing demand for aquaculture production throughout the world as populations increase and fisheries can no longer meet demand. This growth requires the development of more efficient systems, but this has increased pressures on near shore coastal ecosystems. In the case of aquaculture production in Europe, there is concern, that apart from Norway aquaculture production in many countries is declining (Fig.1), and the EU research programmes have been providing research funds to understand and reverse this decline. One aspect that is negatively affecting aquaculture in Europe is that the available data for management and monitoring is often of poor quality and with inconsistent coverage. One of the approaches to reducing these limitations could be to use remote sensing as a cost effective technique for water quality monitoring in terms of spatial and temporal coverage. However, these advantages have yet to be fully realised for aquaculture due to uncertainties associated with remote sensing products adjacent to the coast and the lack of satellite coverage at sufficient scale to cover individual farms. Nonetheless, in recent years, there is a well described and accessible archive from the European Space Agency (ESA) environmental satellite ENVISAT. Although this satellite is no longer

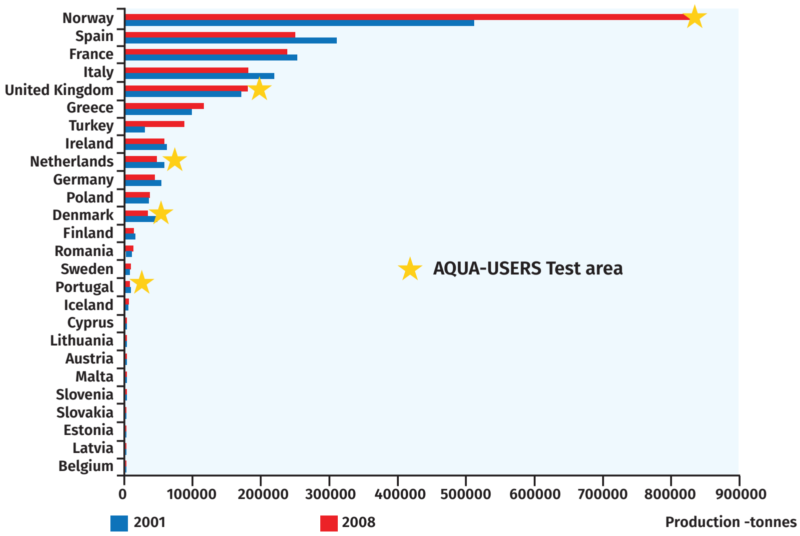

Fig. 1: Evolution of European aquaculture production and AQUA-USERS test areas. *(Data source: FAO FISHSTAT Plus 2010; Ref: EEA, 2011).*

THE CONSORTIUM

MARNIX LAANEN[1], STEEF PETERS[1], KATHRIN POSER[1], NILS DE REUS[1], SEMHAR GHEBREHIWOT[1], MARIEKE ELEVELD[2], PETER MILLER[3], ANDREY KUREKIN[3], VICTOR MARTINEZ-VICENTE[3], STEVE GROOM[3], OLLY CLEMENTS[3], VANDA BROTAS[4], ANA AMORIM[4], ANA BRITO[4], ANDRÉ B. COUTO[4], CAROLINA SÁ[4], CAROLINA BELTRAN[4], VERA VELOSO[4], TRINE DALE[5], KAI SØRENSEN[5], ANNA BIRGITTA LEDANG[5], LARS BOYE HANSEN[6], SILVIA HUBER[6], HANNE KAAS[7], HENRIK ANDERSSON[7], JOHN ICELY[8], BRUNO FRAGOSO[8]

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sending data, there is an upcoming data stream from the ESA Sentinel 2 and 3 satellites. that would be very timely for addressing monitoring by remote sensing for both the aquaculture community and the agencies responsible for environmental monitoring.

AQUA-USERS project

The overall objective of the EU FP7 funded project "AQUAculture USEr driven operational Remote Sensing information services" (AQUA-USERS) is to turn remote sensing data into services providing user-relevant and timely information for the aquaculture industry based on the EU programme Copernicus, an extension of the Global Monitoring for Environment and Security (GMES) programme. The AQUA-USERS project is a highly user driven project with the key purpose of AQUA-USERS is developing, together with users, an app and Web portal that bring together satellite information on optical water quality and temperature as well as *in-situ* observations collected by project partners and users on optical water quality, temperature and ecological parameters. Additionally, the application will collect relevant weather prediction data and met-ocean data (wind, waves etc) from e.g. the marine core services and models that are run by partners on a routine basis. The application and underlying database and decision support system will link the information to a set of (user determined) possible management decisions. The application will help the users to make decisions using remote sensing, *in-situ* and model data based on the following items:

1. Concentrations of chlorophyll-a, total suspended matter (TSM), coloured dissolved organic matter (CDOM) and diffuse attenuation coefficient (Kd), from optical satellites, models and *in-situ* data;
2. Sea surface temperatures (SST) from satellite and *in-situ* observations;
3. A Harmful Algae Bloom (HAB) risk indicator;
4. Aquaculture related indicators such as: abnormally low or high phytoplankton abundance; abnormally high or low SST; early or late start of the spring phytoplankton bloom, and further indicators to be chosen in concert with users;
5. Weather prediction information;
6. Met ocean data (wind, waves);
7. *In situ* data (historical research data, oceanographic buoys, farm data);
8. Water Insight Spectrometer with 3 channels (WISP-3) *in situ* spectral data.

AQUA-USERS user community

The project partners have developed a close relationship with a core group of aquaculture users since the start of the project through a User Board that represents the interests and points of view of both end-user organisations. The users represent different geographical regions of Europe (see stars in Fig.1) as well as different categories of aquaculture in Europe, including fish, shellfish and seaweed aquaculture. A User Board was established at the start of the project to ensure the channels for future communication between the users and the project partners. Information on two levels of requirements will be provided: 1) Data on water quality and previous bloom occurrences has been set up for site selection at new aquaculture/mariculture sites; and 2) Near real time (NRT) information on water quality, and alerts on harmful algal species for active aquaculture concessions. The technical basis for establishing a satellite data infrastructure, as well as for the design of applications for site selection, has been established. The training course activities for the use of WISP-3 by end users and partners has taken place during the first two years of the project. Technical protocols have been provided and a data policy and communication scheme has been elaborated.

Site selection (CS1)	Daily management using the WISP-3 (CS2)
Bathymetry of area (depth)	Met-Ocean data
Seabed characteristics	HAB's
Swell / wave heights	Chlorophyll-a
Currents / Water renovation	TSM
Food supply / Chlorophyll-a	Secchi depth
	Water transparency

Fig.2: Information considered important by the users for Case study 1 and Case study 2.

We have worked from the start of the project to establish the requirements of the users through answers to three formal questionnaires and also more informal meetings between, the users and project partners with whom they have regular contact. In addition, the users have attended two project meetings, one at the start of the project and one midway through the project. Fig.2 summarises the parameters and data that are of most interest to them. Obviously, there are differences between the requirements of different types of aquaculture, with fish farming requiring more intensive monitoring compared with bivalve or seaweed farming. Nonetheless, many parameters are relevant to all the users such as weather conditions, and for example Harmful Algal Blooms (HABs) that can constrain all aquaculture and where early warning systems would be particularly relevant.

After the initial phase of user requirements specification, technical specification, method development and application implementation, the project has engaged, together with the users in two case studies: Site characterisation and selection based on historic satellite, *in-situ*, and model data; ; and daily management using WISP-3 and satellite data, with operational runs using the AQUA-USERS app.

We provide an example of a method developed within the project (i.e HAB classification) and then examples of the case studies.

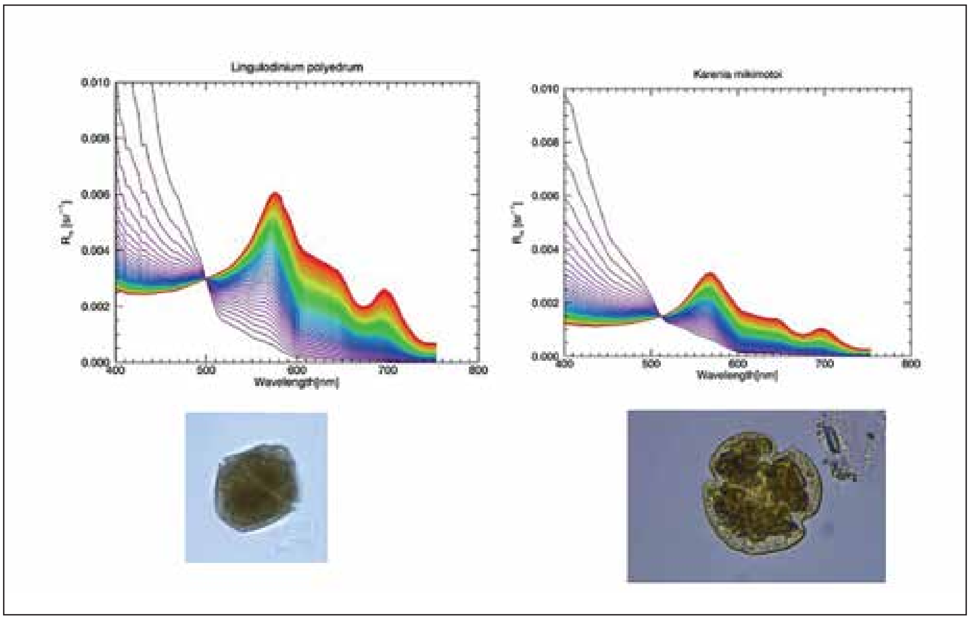


Fig. 3: Modelling water reflectance for HAB species *Lingolodinium polyedrum* (left panel) and *Karenia mikimotoi* (right panel) under culture conditions.

HAB classification method

A number of methods have been developed within the auspices of the project. However, information on HABs is considered highly important by our users for the management of aquaculture sites, both for fish and shellfish, and is the example that we present here. Detection of HABs is carried out by analysis of ocean colour measurements using a HAB classification method. Two alternative approaches have been developed for training of the HAB classifier. The first one is based on using multispectral measurements of HAB events provided by satellite ocean colour sensors. The image scenes with HABs were identified using case studies and historical records of HAB events. These scenes were applied to train a HAB classifier to discriminate *Karenia mikimotoi* in the UK Southwest approaches, *Phaeocystis globosa* in the Southern North Sea and *Lingulodinium polyedrum* in Portuguese coastal waters. The second approach is based on constructing a simulated dataset of HAB measurements using harmful algal cultures grown in laboratory conditions. Promising experimental results have been obtained for *Karenia mikimotoi* through HAB classification based on laboratory measurements (Fig.3).

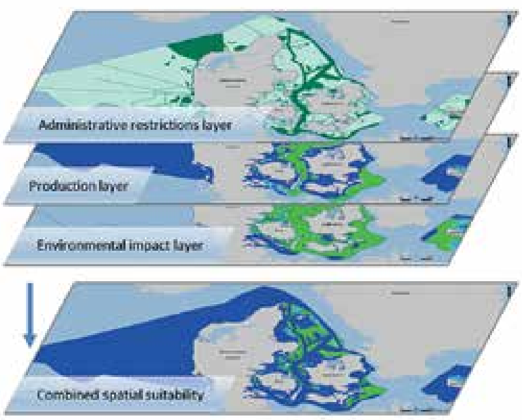


Fig.4: Illustration of the scheme applied to attain a final suitability map for offshore rainbow trout production in Danish territorial waters.

The method for HAB detection developed by Plymouth Marine Laboratory was implemented to identify the specific characteristics of water leaving radiances and to derive quantities of particular HAB species for automatic detection of HAB events. It uses a fully automatic approach by allowing the classifier to recognize and train itself to the specific characteristics of a HAB. This method can be easily adapted to discriminate different HAB species and extended to work with different sensors, such as MODIS, MERIS or OLCI in future. These measurements are gathered in a dataset, covering key test areas and HAB species identified by the project partners and users. The performance of the implemented HAB detection algorithm depends on the accuracy and the choice of training data and this project has applied a range of methods for generating a training dataset for the HAB classifier.

Case Studies

Case study 1: Characterization of the aquaculture operations area and wider surroundings based on historic GMES satellite data to evaluate the site characteristics and to study possible location optimisation.

Together with the users, a number of case studies have been conducted in order to demonstrate the practical usability of the results of the project for operational marine aquaculture. The accumulated knowledge, data and methodologies are integrated and transferred into information for management and decision support. The focus is on geo-referenced information and a key analytical instrument is geographical information services (GIS). The tasks have investigated the application of the spatial information for site characterisation or site selection for different production types and locations; involving identification of relevant data, testing optimal data processing and how to communicate the information. Site characterisation supports the daily operation of the aquaculture production by increasing the knowledge of the production. Site selection does on the other hand have a longer perspective by supporting the optimal sites for future production. Site selection may also support administrative management in regulation and licensing. The case studies are defined in close cooperation with the users. In all, four studies are conducted with focus on fish and mussel production and geographical scales from local through to national. Based on the objectives, determinant factors for the site characterisation/selection are identified and (historical) data collected. In most cases, the primary data source is earth observation data, but *in situ* data measured by the project and external parties as well as deterministic modelling data are also important. For each case, an analytical framework is defined (dependent on case and data types involved) and implemented and analysed in a GIS environment. The outcome of the GIS analyses is maps describing production sites and identifying sites suitable for aquaculture production of the given species and in the given geographical area and scale. An example is provided in Fig 4 for where GIS maps have been plotted to identify areas suitable for the production of rainbow trout in Denmark, the suitable areas are shown in green.

Case study 2 Pre-operational service development in close cooperation with the users to fine-tune and tailor the AQUA-USERS application (APP).

In this phase, we use *in-situ* optical observations as a proxy for satellite observations e.g. the WISP-3 (Water Insight Spectrometer with 3 channels) in Fig.5. The objective is to fix a viable set of management options based on the data provided to the users through the prototype APP.

Water quality is a critical factor affecting fish health and performance in aquaculture production system. Optimal water quality varies by species and must be monitored to ensure growth and survival. The WISP-3 is a hand-held instrument that allows for a quick measurement of water conditions. It uses the colour of the water to derive a number of important water quality parameters including transparency, chlorophyll-a concentration as a proxy for algal biomass, total suspended matter concentration and phycocyanin concentration as a proxy for cyanobacteria. At the push of a button, the WISP-3 gives instantaneous readings of these parameters. In AQUA-USERS, the WISP-3 results are integrated into

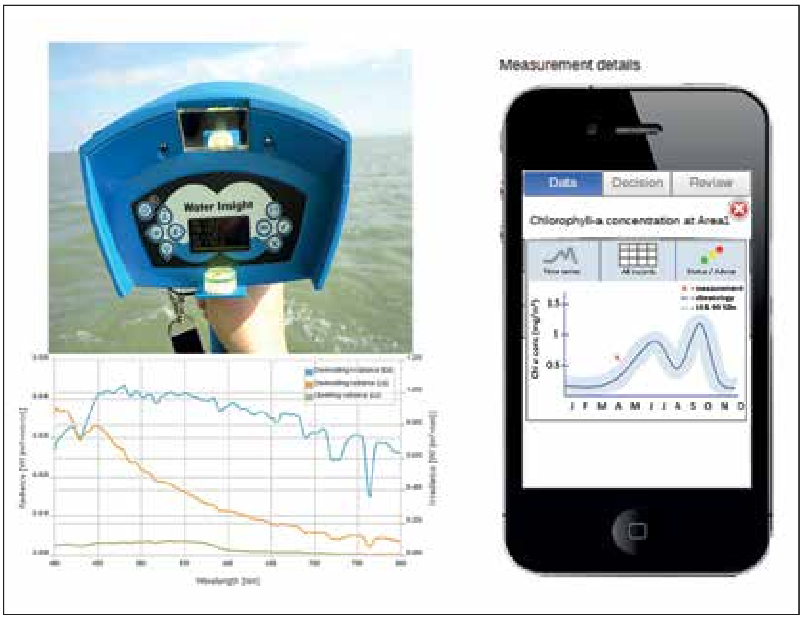


Fig. 5: In situ measurements taken with the WISP-3 (top and bottom left panel) and converted into data for chlorophyll which can then be sent to the user´s AQUA-USER's app (right panel).

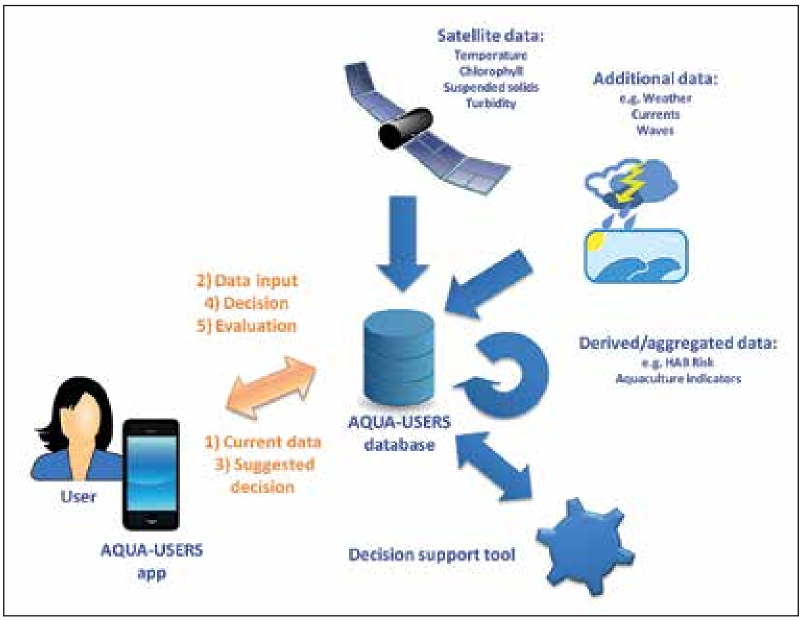
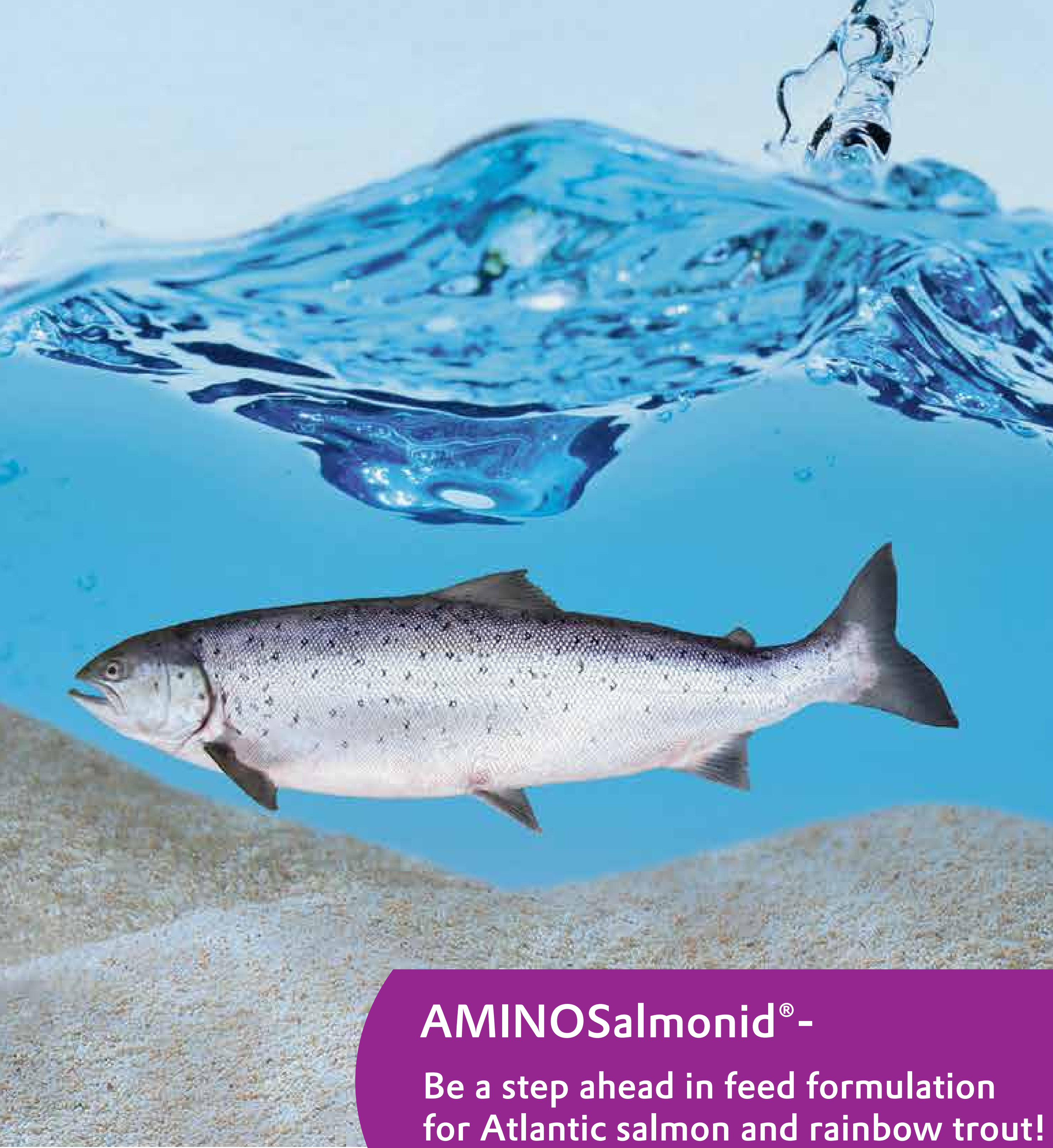


Fig. 6. Scheme illustrating the integration the different elements of the AQUA-USERS project for daily management.

the mobile app in support of daily management operations. They also serve as a basis to validate and improve satellite observation of water quality. Current developments include a more user-friendly instrument with a direct data link to a web system and indicators of the presence of harmful algae in the water.

Conclusions

The final phase of AQUA-USERS is the daily management using WISP-3 and satellite data in near real time with the collaboration of the core group of users to instigate operational runs with the AQUA-USERS app. In effect, Fig. 6 illustrates how we hope to integrate the different aspect of the project to provide user-relevant and timely information to aquaculture industries based on earth observation data and innovative optical *in-situ* measurements.



Caspian farmed sturgeon using innovative equipment and marketing campaign

The Russian company Sokoloffcaviar partners, founded by Aleksei Sokolov is using a new type of rearing cage with stainless steel ring mesh to produce sturgeon and caviar. The company also has an innovative promotion campaign that includes refrigerated home delivery of caviar.

Based in the Bushma, a feeder river to the Volga Delta and 7Km from the shorte of the Caspian Sea, the company has three lines of cages for breeding and holding of spawning caviar stock with 12 536m^2 of cages – each 5x5m and depth 3-3.5m. The company also has hatchery and nursery facilities.

It produces Russian Sturgeon, Sterljad and Beluga for restocking (200 000 juveniles of 3-150 g) as well as growing of mature fish for caviar production with production of 40 tonnes per year, giving 2.5 tonnes of caviar.

The ongrowing cages are made of ring-mesh steel nets and patented by the company.

The large mesh size reduces the need for cleaning and there is no biofouling. It lasts longer than fibre nets and also allows 'natural food' to come into the nets to supplements the extruded feeds that are provided and to maintain the highest nutritional value of the growing fish.

The company has also produced an innovative promotional campaign, focussing on quality, authenticity and tailored delivery services.

Since operations began in 2002, the company has increased production by 60-70 tonnes per year and will produce 310 tonnes in 2016. The total potential of the site is a production of 600 tonnes.

Screen capture of their YouTube promotional video.

See the promotion campaign at https://www.youtube.com/watch?v=aMfen8ZJJ-g
Take a tour of the farm at https://www.youtube.com/watch?v=0J4ATdvXBiY
Contact Aleksai Sokolov for more alex-future@mail.ru

eas 40 years
european aquaculture society

Since EAS was founded in 1976, much has happened in European aquaculture. We have put together a series of milestones to give you an overview of what EAS has achieved during the last 40 years. Some you will know and others (I hope) will be a surprise for you. In any case, I hope you enjoy this summary of the life of our Society.

Sadasivam Kaushik. EAS President 2014 – 2016.

EAS 40th Anniversary Timeline

Several delegates at the 10th European Symposium on Marine Biology in Oostende get together to lay the plans for a European society for the development of marine aquaculture.

The European Mariculture Society changes its name to the European Aquaculture Society, to better reflect its field of activity.

Linda Aspeslagh joins EAS as Assistant Office Manager

Due to the difficulties for marine fish hatcheries in Europe to secure a regular supply, EMS sells San Francisco Bay Brand *Artemia* to its members. The quality of the cysts was deemed to be satisfactory by Dr. Patrick Sorgeloos of the State University of Ghent.

1975 **1976** **1977** **1978** **1981** **1984**

european mariculture society

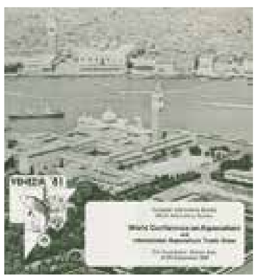
The European Mariculture Society (EMS) is founded and registered as a non-profit association in Belgium. Its core objectives are to promote contacts between all involved or interested in marine and freshwater aquaculture; to facilitate the circulation of aquaculture related information; to promote the sponsorship of multi-disciplinary research concerning aquaculture; and to enhance cooperation among governmental, scientific and commercial organizations and individuals on all matters dealing with aquaculture.

The first EMS Board, with Martin Bilio as President, meets in at the Institute for Marine Scientific Research (IZWO) in Bredene, Belgium with founding members J. Arnal (Spain), J.V. Bannister (Malta), M. Bilio (Germany), S.J. De Groot (The Netherlands), J. Fluchter (Germany), E. Jaspers (Belgium), B. Myrseth (Norway), F. O'Brien (Ireland), G. Persoone (Belgium), S. Von Boletzky (Switzerland) and T. Vukovic (Yugoslavia).

The EMS launches its first quarterly Newsletter and its first "Special Publication".

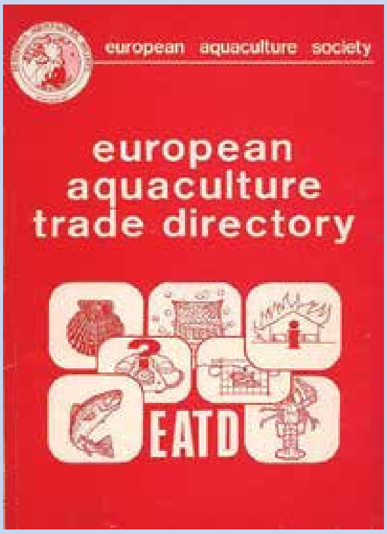
Hilde Joncheere is employed as EMS Office Manager

EMS joins up with the World Mariculture Society (WMS) to organise the first World Conference and Trade Show in Venice, Italy with the theme "Realism in Aquaculture: Achievements, Constraints, Perspectives".



1985

EAS publishes the first "European Aquaculture Trade Directory".



1986

500

EAS has more than 500 members.

1989

EAS organises the first of several Aquaculture Europe events in cooperation with the Bordeaux aquaculture exhibition.

BORDEAUX AQUACULTURE

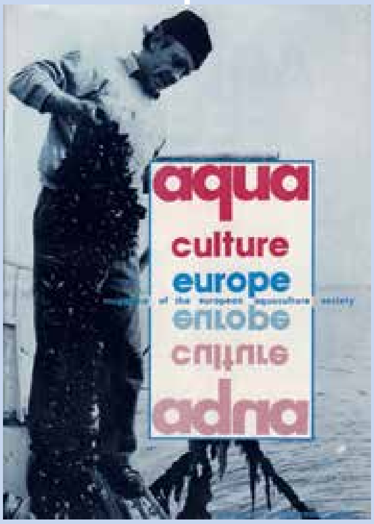
EAS publishes the International Aquaculture Trade Directory.

1990

EAS moves its office to Ghent

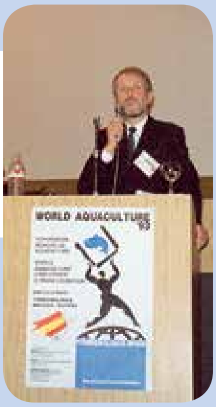
1991

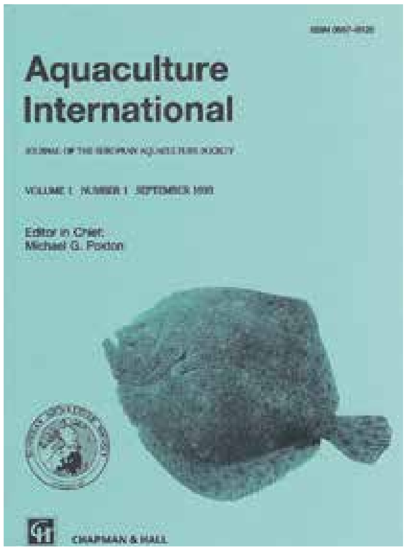
The EAS quarterly newsletter becomes the "Aquaculture Europe" magazine.



1993

World Aquaculture 1993 is held in Torremolinos, Spain.





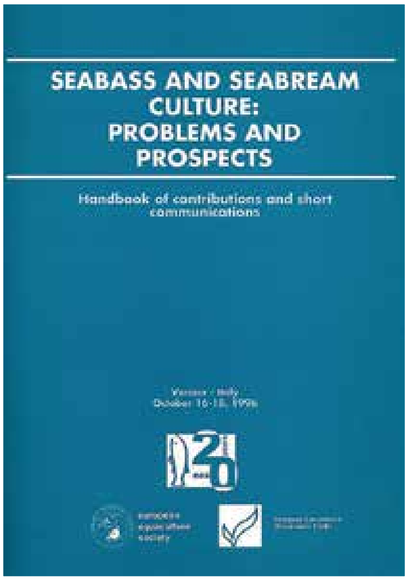
Volume 1 Number 1 of the EAS peer-reviewed scientific journal "Aquaculture International".

1995

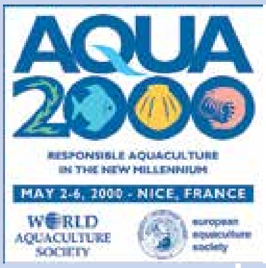
EAS signs agreement with Nor Fishing to organise Aquaculture Europe every second year with the Aqua Nor exhibition in Trondheim, Norway. The agreement lasted until 2013.

AQUA NOR

EAS moves its office 'back to its roots' in Oostende.



EAS organises the highly successful workshop "Seabass and Seabream Culture: problems and prospects" at the Verona Aquaculture Fair in Italy.

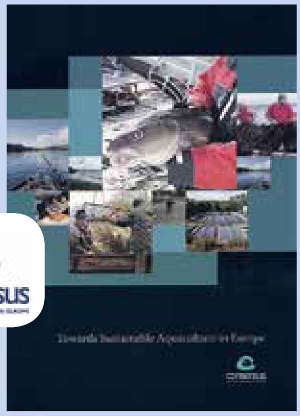


EAS and the World Aquaculture Society co-organise the first of the six-yearly AQUA events, held in Nice, France.

EAS appoints Alistair Lane as its Executive Director.

Rosa Flos becomes the first woman President of EAS.

The EAS Student Group is officially launched.



EAS coordinates CONSENSUS to define sustainability indicators for European aquaculture and employs Joke Charles.

1996 | 1998 | 1999 | 2000 | 2002 | 2004 | 2005

EAS coordinates the first EU-funded aquaculture dissemination network AquaFlow.

Sofie Vanroose joins EAS as Conference Administrator

EAS contributes to the first European Commission strategy for the sustainable development of European aquaculture.

EAS employs Els Vanderperren as AquaFlow project assistant.

2007

EAS makes a new brand logo for its Aquaculture Europe events and organises its first AquaNor Forum in Trondheim.

2008

EAS is a founding member of the European Aquaculture Technology and Innovation Platform (EATiP).

EAS organises its first 'new format' Aquaculture Europe event in Krakow, Poland with its own trade exhibition and industry forums.

2009

EAS co-authors a report for the European Parliament on the competitiveness of the European aquaculture sector.

EAS produces an evaluation for the European Parliament on the impact of "A strategy for the sustainable development of European aquaculture" COM (2002) 511 final.

2010

1000

Attendance at Aquaculture Europe (AE2010 in Porto, Portugal) exceeds 1000.

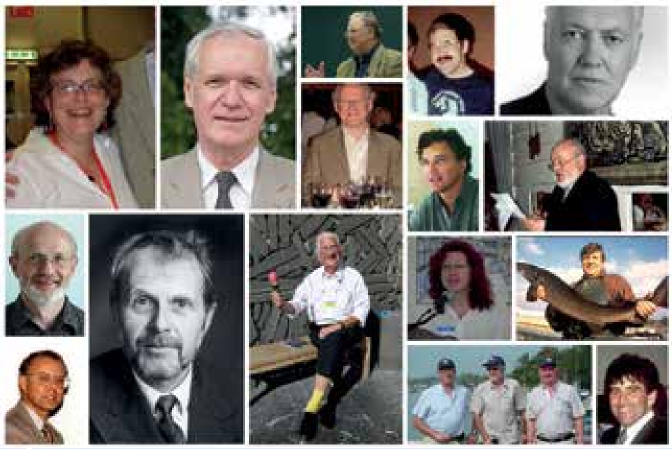
EAS co-authors the FAO Regional Review on Status and Trends in Aquaculture Development in Europe.

2011

EAS updates its logo after developing new logos for Aquaculture Europe events and the Aquaculture Europe magazine.

2014

EAS leads a study for the European Parliament on the Long-Term Economic and Ecologic Impact of Larger Sustainable Aquaculture.



EAS Presidents

1976-1980 Martin Bilio (Germany)
1980-1982 Guido Persoone (Belgium)
1982-1984 Harald Rosenthal (Germany)
1984-1986 Alan Jones (UK)
1986-1988 Hans Ackefors (Sweden)
1988-1990 Jean-Jacques Sabaut (France)
1990-1992 John Joyce (Ireland)
1992-1994 Bjorn Myrseth (Norway)
1994-1996 Michael Poxton (UK)
1996-1998 Patrick Lavens (Belgium)
1998-2000 Philippe Ferlin (France)
2000-2002 Rosa Flos (Spain)
2002-2004 Michael New (UK)
2004-2006 Johan Verreth (The Netherlands)
2006-2008 Laszlo Varadi (Hungary)
2008-2010 Selina Stead (UK)
2010-2012 Yves Harache (France)
2012-2014 Kjell Maroni (Norway)
2014-2016 Sadasivam Kaushik (France)

EAS Honorary Life Members

Gino Ravagnan (Italy, since 1981)
Dr. E. Monten (Sweden, since 1987 †)
Bernard Chevassus-au-Louis (France, since 1989)
Eric Edwards (UK, since 1991)
Peter Hjul (UK, since 1993 †)
Trygve Gjedrem (Norway, since 1995)
Jean Bally (Martinique, since 1997)
Colin Nash (USA, since 2000)
Courtney Hough (UK and Belgium, since 2010)
Pascal Divanach (Greece, since 2011)
Patrick Sorgeloos (Belgium, since 2012)
Michael New (UK, since 2014).

EAS Award for distinguished services

Guido Persoone (Belgium)
Niels De Pauw (Belgium)
Yves Harache (France)

21st century Red sea 'Ocean Park' is a source of food, feed, biologics, water, energy and jobs

***ABDULLAH W. AL-ZAHRANI,**
****YOUSEF S. AL-HAFEDH AND**
*****R.K.MUTHUNAYAGAM**

*JEDDAH FISHERIES RESEARCH CENTRE, MINISTRY OF AGRICULTURE, BOX 9612, JEDDAH 21423, SAUDI ARABIA.
**CENTER OF EXCELLENCE FOR WILDLIFE RESEARCH, NATURAL RESOURCES & ENVIRONMENT RESEARCH INSTITUTE, KING ABDULAZIZ CITY FOR SCIENCE & TECHNOLOGY, RIYADH, SAUDI ARABIA.
***FAO OF THE UNITED NATIONS, BOX 9612, JEDDAH 21423, SAUDI ARABIA

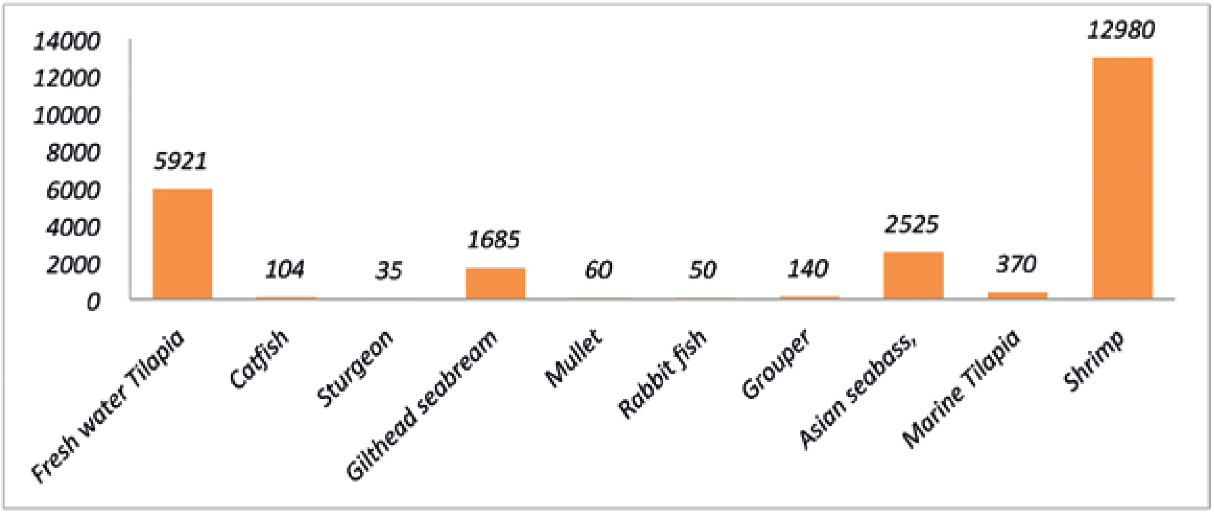
RESOURCES:

The Red Sea is among the world's top marine biodiversity hotspots, coral cover increasing significantly towards the north but mirroring the reverse pattern for mangroves and other sedimentary ecosystems (Price and Ghazi, 2014). The Kingdom of Saudi Arabia occupies 80 percent of the Arabian Peninsula land surface with the length of its coastal belt along the Red Sea and the Gulf exceeding 2 400 km (FAO National Aquaculture Sector Overview – Saudi Arabia). Aquaculture is considered the most promising national sector for food production, food security and employment opportunities. The government of Saudi Arabia has embarked on an ambitious reform program to encourage greater participation by the private sector in a more open and competitive, young knowledge economy. The Saudi Arabia of the twenty-first century must deal with massive ongoing social changes, growing demographic problems, and the need to fundamentally restructure and diversify the Saudi economy (Cordesman, 2003). About 51% of the Saudi Arabian population is under the age of 25 (Caryle, 2014).

SEAFOOD POTENTIAL:

Indeed, the country's Fisheries and Aquaculture Sector Development Plan has set an annual production target of 1 million tonnes by 2030, starting from current levels of less than 30 000 tonnes per year. Annual fish consumption per capita in the Kingdom increased from 3 kgs in 1977 to 6.5 kgs in 1998 and touching around 8 kgs in 2007. Per capita supply is just 11.5 kilograms now in the Kingdom. (FAO, 2012). The Saudi Arabian economy will undoubtedly be impacted development in marine aquaculture sector by the fact that more than 50 percent of the population of Saudi Arabia lives within 100 km of the Saudi coastline. Agricultural Development Fund speculates the 27,500 tons aquaculture production in 2009 is expected to touch 770,000 tons by 2024 (ADF, 2011). Marine fish culture helps to feed the rising demand for nutritious fresh sea protein. Controlled fish culture is more environmentally sound with clear traceability than open sea water

Sea cages in the Northern Red sea



Aquaculture production (in tonnes) of different finfish / shellfish in the Kingdom (2014 statistics)

fishing. Marine fish culture-on-sea requires less land resources. Aquaculture along warmer Red sea results in more units of energy of protein produced for each unit of energy it took to raise the fish. Red sea aquaculture causes less detrimental impact on marine ecosystem than fishing; generates income and employment to thousands of coastal living communities; generates trade in marine and freshwater products helps alleviate economic downturn and poverty contributing to national economic growth and expansion.

Aquaculture greatly reduces the pressure on ocean fish populations of the Red sea. Industrial scale aquaculture is a national priority to the Kingdom projecting a national strategy of economic diversification to the prospective national investors and foreign partners. Fish culture reverses unsustainable trends and make increasingly positive contribution to the fish supplies in the Kingdom.

AQUACULTURE GOVERNANCE:

The Kingdom advocates responsible and sustainable aquaculture projects that are environment-friendly, socially acceptable, and technically and economically viable. Several marine fish cage culture industries are

continued on page 32

emerging within Saudi territorial waters with several projects and associated land-based hatchery facilities under development. Furthermore, there is a growing interest among national and foreign entrepreneurs to invest as a result of pristine waters and the attractive markets. The Ministry of Agriculture (MoA) adopts practices that are politically enforceable and economically as well as socially feasible in the Kingdom. Greening blue revolution in the Kingdom of Saudi Arabia is the nearside dream ahead and a reality in the near future. MoA supports applied research and innovation on adapting proven technologies to local conditions and build mechanisms to pilot and transfer the innovations and knowledge to farmers. The vision of sustainable aquaculture demands not only a favorable business climate, but also a governance framework that embraces social objectives and enforces environmental standards.

Asian seabass juveniles in production at Jeddah Fisheries Research Centre

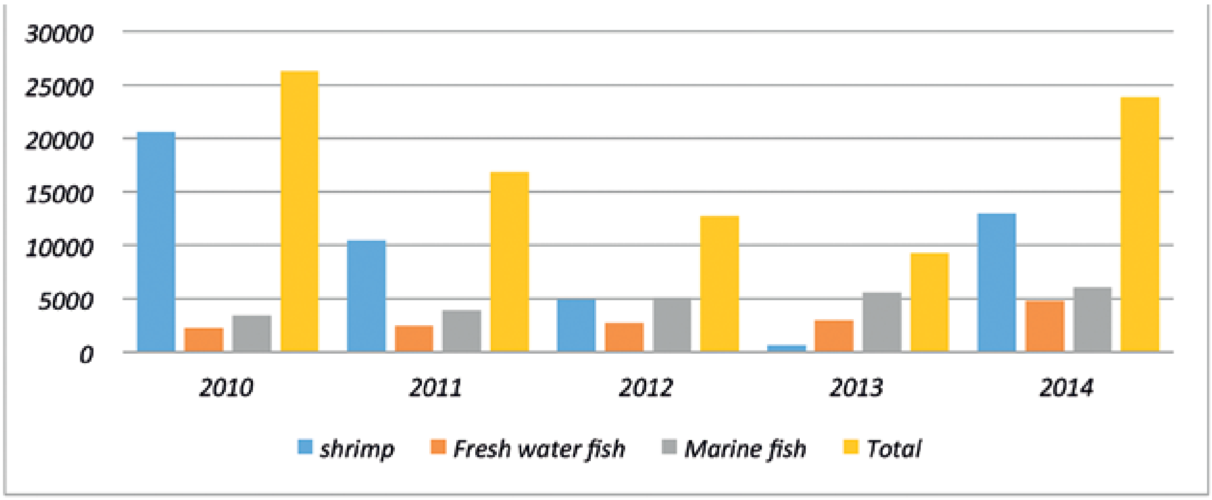
Sea cucumber nurseries with a private farmer in the Kingdom

MoA offers improved regional learning network, where new technologies and sustainable methodologies are disseminated to the needy farmers; render aquaculture not limited to its negative impact on the environment and not stymied or shortened by inconsistent regulations but availing renewed policy assistantship; Developing a coordinated consistent aquaculture policy with a robust regulatory and management framework between the public and private sector. MoA helps developing and implementing overall sustainable production practices and resource management; continue to evaluate trends in aquaculture as the field develops and offer constructive mandate for the aquaculture future roadmap; establish and enforce regulations to protect coastal ecosystems backing-up new initiatives by the Government and above all a shared vision of sustainability and expanding the aquaculture industry diminishing pressure on ocean fish stocks.

PROMISES:

Aquaculture in the Kingdom offers an effective utilization of natural economic culture resources and climatic growth assets of the Kingdom. Fish aquaculture development would have a significant socioeconomic impact on the coastal fish workers and instill border security to the Kingdom. Scientific awareness and enrichment is enhanced through aquaculture technology transfer and adoption. Saudi fish culture production improves the Kingdom's trade balance through aquaculture product exports and the reduction of seafood imports. Cultured fish reduces the gap between local production and consumption. Aquaculture generates secondary business or income and job opportunities. There is a very big opportunity for the Kingdom to be a fish exporter to other Arab countries. Economic feasibility analyses of using offshore oil and gas platforms as bases for open ocean aquaculture concluded in Gulf of Mexico that offshore platform-based mariculture may be commercially viable under favourable assumptions, that its viability requires economies of scale and depends principally on the yield per unit of cage volume achieved (Kaiser et al., 2010). Renewable energy sources, e.g., solar and wind appear to be a potential solution to current environmental problems in Saudi Arabia caused by the direct and indirect use of fossil fuel sources, particularly oil and natural gas (Dincer et al., 2005). If a major breakthrough is achieved in the field of solar-energy conversion, Saudi Arabia can be a leading producer and exporter of solar energy in the form of electricity. The geographical location of the country, its widespread unused desert land, and year-round clear skies, all make it an excellent candidate for this (Hepbasli and Al suhaibani, 2011)

Breeding & farming strategy should be diversified to minimize risks involved in single species commercial farming systems. Yellowfin seabream (*Acanthopagrus latus*) off the coast of Dammam (Eastern Saudi Ara-



Aquaculture production of different fish / shrimp in the Kingdom bia), Bahrain, Kuwait and Qatar spawns from February; Sobaity seabream (*Sparidentex hasta*) spawns from March, Grouper (*Epinephelus coioides*) spawns from June, Asian seabass (*Lates calcarifer*) spawns during May-June. Exotic captive European seabream spawns fertile from September onwards. R&D studies related to culture of local species, larval rearing, genetic improvement, aquaculture-agriculture integration, polyculture, organic farming, and low-cost feed formulation, disease control etc are essential segments today.

Amberjack broodstock held by a private farmer

Future focus onto economically significant species like Golden Trevally (*Gnathanodon speciosus* Forsskal, 1775) ; *Mangrove Red Snapper (Lutjanus argentimaculatus* Forsskal, 1775 ; Snubnose Pompano (*Trachinotus blochi* Lacepede, 1801*) ;* Emperor (*Lethrinus nebulosus* Forsskal, 1775) ; Greater Amberjack (*Seriola dumerili* Risso, 1810) ; Meagre fish (*Argyrosomus regius* Asso, 1801) need comprehensive research for future development of breeding and farming expertise along with deciphering the nutritional requirements at different growth stages.

WATER, PIGMENTS, BIOLOGICS AND ENERGY:

Coastal waters have been widely used by the littoral countries of the Middle East for siting desalination and power plants to take advantage of the availability of unpolluted sea water for establishing cost effective feed intake and once through cooling system. Huge quantities of raw seawater are being withdrawn from the sea for the unimpeded production of desalinised freshwater, greatly needed in the region. Surface/subsurface intakes or man-made bays studded to the coast, withdraws large quantities of water for the production of the much needed freshwater in the region (Abdul Azis et al., 2001).

Crude Beta carotene preservation post-harvest by a private farmer in the Kingdom

The generation of saline effluents from desalination plants is normally an environmental problem. *Dunaliella* was introduced into concentrated brine waste (from Desalination plants) in plastic lined channels for resource recovery in the Bedford Groundwater Interception project, at Cookes Plains, in Australia (Fisher, 1998). Products from the evaporation ponds included, fin fish culture (Bream and Barramundi), brine shrimp, *Artemia salina* (introduced to clean up organic matter in the evaporation ponds) and beta-carotene (extracted from *Dunaliella*), which grows in brine. Saline aquifers are wetlands that brings in birds far beyond overseas. Ecotourism or bird watching shall result during the conservative management of the saline waste aquifer or Salinas landscaping process through mariculture. Co-generation of electricity and desalinised water — for water production — is an accepted global practice. Greater efficiencies by reassessing the desalination paradigm considers desalination as only part of the saline water processing chain and it looks at value-adding opportunities the integration of water, salt and power production, as a mutually supporting system. The overall concept of better integration of water, salt and power production has a focus on the utilisation of saline effluent from desalination plants (Ahmed et al., 2001).

Dunaliella as a desert-greening goldmine surviving 200,000 ppm has been studied academically in the Middle East, the field as a whole is still in its infancy for commercial potential. NAQUA group at Al lith, initiated earthern Dunaliella ponds for milking betacarotene but opted for bioconversion into Artemia biomass and cyst production. On a prediction move, from kebabs, soups and burgers to multi-coloured carotenoid algae soup will be a hesitant start for Saudis when this biosaline industry blooms in full. In developed countries they eat between 1 and 1.5 mg/day beta-carotene and in some third world countries this figure is below 0.5 mg/day. Radical scavenging activity of Beta carotene is well documented today (Fujisawa et al., 2004). This presses the need for cultivation of the reddish alga, *Dunaliella* more and more for use as nutraceutical and pharmaceutical. However with our current fast food and hurried sandwich life style, it may not be possible to eat right every day and most do not get this amount. The answer is natural carotenoids from *Dunaliella*. Applied research is indispensable to reap the full benefits, sourcing the local strain, culturing, process scale up, pilot optimization and semi-industrial management are expected to contribute to the objectives. Bird Conservation, Salinas re-qualification, economic rehabilitation through an alternative unconventional productive use are underlined from the photochemical production of *Dunaliella* from the Salinas.

Dunaliella blooms on earthern pans in the Kingdom with a private farmer

Continued on page 34

Projected Coastal Development along the Saudi Arabian coastal cities		
Year	**Arabian Gulf (Km)**	**Red Sea (Km)**
2005	130	352
2020	151	409
2050	203	551
2075	261	706
2100	335	906

Left: Projected Coastal Development (First Natl. Commun. of KSA., PME, 2005)

Seaweed cultivation trials with a private farmer in the Kingdom

Since neither fertile land nor fresh water is needed, there is no competition with food production on arable land. Such a system is entirely energy self-contained, which makes it attractive for this remote coastal desert area. Beta-carotene has the largest share of the market, valued at $247 million in 2007, this segment is expected to be worth $285 million by 2015 (Business Communications Company, BCC Research, 2008). Use of microalgae in feed has already been explored by Tadweer Feed & Fertilizer Co. Ltd., Kingdom of Saudi Arabia. A growing trend for carotenoid-rich algal biomass and purified products thereof in the nutraceuticals and health foods market is also predictable, given the growing economic affluence and the changes in eating modes. The future of micro algal biotechnology for carotenoid production seems very promising in the Middle East and rapid advancement expected in the next few years.

Bioflavonoids like Rutin, Quercetin and Kaempherol are present in high percentages in *Gracilaria dendroides*, *Ulva reticulata*, and *Dictyota ciliolata* found off Jeddah coast in Red sea. In fact, the potential biological resources not been adequately explored and harnessed for biotechnological applications and deriving biopharmaceuticals (Al-Saif et al., 2014). Flavonoids can be clinically used to treat hypercholesterolemia and hypertension (Abdel-Raouf et al., 2011). Quercetin and Kaempherol have evolved as promising pharmacological agents in the treatment of cancer (Jaganathan and Mandal 2009). The Saudi-French Research Programme on Marine Natural Products from the Red Sea focused researches on the huge biodiversity of sponges and biological activities of a host of marine natural products. Several preliminary promising results were presented for anti-malaria, cytotoxicity against KB cells and anti HIV-1 activities (Jean and Al-Lihaibi, 2001). UV-protective Mycosporine-like amino acids (MAAs) are studied in stony coral species (Fungiidae) along the Eastern coast of the Red Sea (Al-Utaibi et al., 2009). UV-B protective effects for Saudis are mandatory and Mycosporine-like Aminoacids (MAAs) are the answer. Cancer Incidence report from the Kingdom of Saudi Arabia indicated skin cancer accounting 4.1% of all the freshly diagnosed cases in 2006 (Haya and Al Eid, 2006). Seaweed, *Asparagopsis taxiformis* shows the most potential for development as a natural treatment to manage monogenean infections in intensive Asian seabass aquaculture with the greatest impact at the embryo stages (Hutson et al., 2012) and its promises for the Kingdom are manifold.

Shrimp feed plants are importing *Ascophyllum nodosum* from Europe to incorporate Ascophyllan content into shrimp feed as an immunostimulant component. Equally, the sulfate group of fucoidan in *Sargassum wightii* acts against WSSV infection (Immanuel et al., (2012) and the fucose, galactan and mannuronic acid stimulate immune system of shrimps against diseases. The biochemical composition of Fucoidan in *Sargassum* is mainly depending on the species of seaweed, anatomical regions and growing conditions. *Sargassum latifolium*, *S.dentifebium*, *S.subrepandum*, *S. crassifolia*, S. *ilicifolium* are all seasonally found in the Red sea environment.

FEEDSTOCK:

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 (Cardia et al., 2015). The shrimp aquaculture industry is developing very fast. This is expected to continue in the next 10 years as evidenced by the increasing number of farms that applied licenses to operate shrimp farms (FAO National Aquaculture Sector Overview – Saudi Arabia). Globally, macroalgae that have been evaluated in shrimp feeds are *Macrocystis pyrifera, Ascophyllum nodosum, Kappaphycus alvarezii, Sargassum* sp., *Gracilaria heteroclada, Gracilaria cervicornis, Caulerpa sertularioides, Ulva clathrata, Enteromorpha* sp., *Hypnea cervicornis, Cryptonema crenulata and Chnoospora minima*. Then, how much microalgae could realistically replace soya in livestock feed assuming the strain/s can be along the Red Sea shoreline? The answer is still awaited. Replacement of alfalfa with other forage crops has already been initiated in Saudi Arabia and neighbourhood. Al Marai got thousands of acres of farmland in Vicksburg, Arizona, US during March, 2014 as part of its efforts to improve and secure its supply of the highest quality alfalfa hay from outside the Kingdom to support its dairy business. This is in obedience to the Saudi government direction toward conserving local resources (Arab News, 2014).

JOBS:

An estimated 21,161 people are directly employed in aquaculture production primarily in shrimp production. This figure includes those employed in construction work for expanding existing farms. There is variability of the rate of employment between culture systems. A measure of the employment is the tonnes seafood produced per person. This varies from 4.3 tonnes per person in shrimp culture to 27.5 tonnes per person in cage culture. There is also variability in the employment of Saudis ranging from 7.2% in freshwater aquaculture production to 27.5% in cage culture (ADF, 2011). Accelerating economic growth, fisheries sector could generate direct and indirect employment of over 400,000 jobs assuring greater availability of affordable, high quality protein (ADF, 2011). The growth in Aquaculture also strongly supports balanced regional development with job creation spread across the Kingdom (ADF, 2011).

OUTLOOK:

Saudi Arabia's coastal zone is rich in a variety for natural, commercial, recreational, ecological and aesthetic resources of immediate and potential value to the present and future well-being of the Kingdom. The development and implementation of management programs should achieve rational use of land and water resources of the coastal zone, giving full consideration to ecological, historic, aesthetic and spiritual values as well as to the needs of economic development. In areas where conflicts between multiple uses endanger economic efficiency and/or natural resources, the preparation of special area management plans is encouraged. Special Area Management Plans provide for increased specificity in protecting significant natural resources, environmentally sensitive areas, areas of special potential for coastally-dependent economic growth, areas with significant natural resources, and areas in which development may be hazardous for property or life, and improved predictability in governmental decision making (First Natl. Commun. of KSA. 2005).

The Kingdom as a national prerogative need to protect their natural environment and exploit the available resources on a renewable basis. Al-Saleh, 2009 gave conscientious suggestions on some crucial factors for more indigenous renewable energy industries in Saudi Arabia viz., Strengthening the Kingdom's educational system and providing vocational training ; Enhancing coordination and links between Saudi universities and industry ; Allocating budgets to support the fields of science and technology, as well as widening R&D activity in both public and private Saudi sectors ; Buying into international energy companies which conduct a lot of R&D ; Continuing to reform the investment climate in Saudi Arabia ; Developing a culture of patenting and entrepreneurship in Saudi Arabia; Rewarding innovators and researchers in all relevant fields; Setting up more technological and know-how transfer joint-venture programmes ; Inviting leading renewable energy technology manufacturers into the country *et cetera*.

Knowledge of both the ocean, coastal and national economies can help government address the future impact and demand posed by nature and human populations along our coasts and oceans (Kildow and McIlgorm, 2010). A new era of food policies that build upon recognised environmental limits (the 'New Fundamentals') to deliver low carbon, nutritious and sustainable food (Lang 2010) is not far beyond for the Kingdom, feeding sustainably, equitably and healthily as decribed by Hawkes and Buse, 2011. The transition from a carbon intensive to low-carbon energy economies should be the holistic ambition and target of the Kingdom as a whole for the coming decades.

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The impact of physical and chemical indicators of water on growth performance of brown catfish

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Aquaculture is the fastest growing food production sector. Monitoring the physical - chemical and microbiological parameters of culture water is an important factor in the proper management of the aquatic environment. Changes in the quality of water cause stress in some species of fish and potentially lead to disease as a result of interaction with conditional pathogens (Arulampalam *el.*, 1998).

The optimum values of water temperature for catfish (*Ameiurus nebulosus L.*) is from 22° C to 28° C, but lower (18° C), as well as higher temperature value (30° C) allows a good utilization of food too (Melotti *et al.*, 1989).

The level of dissolved oxygen in the water is one of the key parameters in aquaculture production. Even a small reduction of dissolved oxygen below the minimum level in the water can lead to reduced growth and feed conversion for most fish species. However, some fish such as catfish (*Clarias*) and tilapia (*Oreochromissp.*) tolerate low levels of dissolved oxygen without visible consequences (Stickney, 2000).

The pH of rearing water is also very important. If too low, food consumption will reduce and if too highthe external epithelial permeability for passage of gases and salts and disease resistance is reducing. The pH of the fresh water ecosystems can vary considerably, both on a daily basis and over different seasons. Figure 1 shows the range of pH values for the life of the fish.

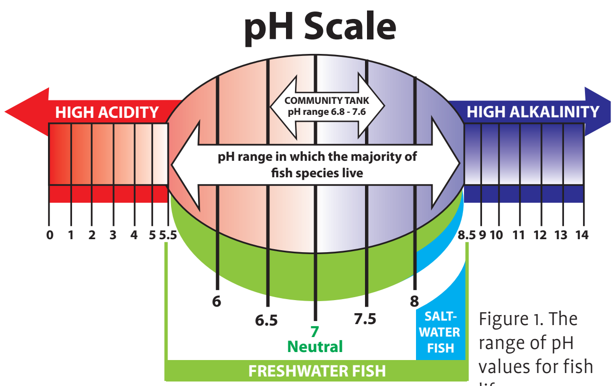

Figure 1. The range of pH values for fish life

Elevated nitrate concentrations are a potential problem for fish, one of the critical consequences of increasing nitrite oxidation of hemoglobin which causes difficult transfer oxygen to the blood (Kroupova *et al.*, 2005). In fish, nitrates are linked to hemoglobin in the blood and produce methemoglobin and a condition known as methemoglobinemia. The high amount of nitrite in the water can cause severe physiological disorders or result in mass mortality of fish (Kroupova *et al.*, 2005).

Ammonia and nitrite, pollutants of aquatic systems, are toxic to fish (Rodrigues *et al.*, 2007; Miron *et al.*, 2008; Zhang *et al.*, 2012). Nitrites are well known as the killers of several physiological functions, including regulation of ions, breathing, cardiovascular function, hormone function and secretion processes (Kroupova *et al.*, 2005). Elevated concentrations of nitrite cause significant problems in the intensive cultivation of commercial species of fish and ornamental fish (Dvorak, 2004; Svobodova *et al*, 2005). High levels of nitrates in water can cause several physiological disorders or massive mortality of fish (Kroupova *et al.*, 2005).

Figure 2. Production of the aquarium *(Photo: Roberta Skukan)*

The excretion of ammonia in fish depends primarily on protein intake and metabolic efficiency of the fish, which is specific to each other under

24 h light					
Parameters	13.4.2012.	20.4.2012.	27.04.2012.	04.05.2012.	11.05.2012.
Temperature °C	20,4	20,1	22,1	23,1	23,3
O_2 mg L^{-1}	5,21	4,46	4,07	3,38	4,8
O_2 %	44,8	39,3	37,3	34,5	37,9
CO_2 mg L^{-1}	0	0	0	0	0
pH	7,89	7,76	7,72	7,65	7,73
Oxidation reduction processes ORP mV	-65	-58	-56	-52	-57
Conductivity µS cm^{-1}	690	758	720	653	635
Ammonium nitrogen mg L^{-1} NH3-N	1,04	0,92	1,33	0,86	1,41
Nitrites mg L^{-1} NO_2^{2-}	0,17	0,08	0,1	0,1	0,3
Nitrates mg L^{-1} NO_3^{2-}	18,8	5,1	3,5	4,5	2,1
Phosphates mg L^{-1}	5,3	3,5	6,4	8	8,3
Alkalinity mg L^{-1} $CaCO_3$	246	300	266	227	268

Table 1. Physical - chemical properties of water in aquarium with 24 h light

the influence of the level of ammonia in water (Dosdat et al., 1996). Ammonia is a killer when present in higher concentrations, and many unexplained production losses have likely been caused by ammonia (Francis-Floyd et al., 1990).

AQUARIUM STUDIES

Three single aquaria with volumes of 115 L of water were constructed for this research (Figure 2). One aquarium was on the whole duration of the experiment under the light, the other was in darkness, while the third, as a control aquarium, was 12h hours under light and 12 hours in darkness. Each aquarium was stocked with 6 brown catfish *(Ameiurus nebulosus L).* Duration of the experiment was 30 days (13.04.2012 - 11.05.2012). Fish in all three aquariums were fed identical pelleted food suitable for thiscatfish species. The temperature of the water and the pH in all aquariums were the same at the start of the experiment.

PHYSICAL - CHEMICAL PARAMETERS

Aquarium with 24h light

Water temperature over the duration of the experiment slightly increased. However, pH level didn´t vary significantly in the measured period, and the mean value was 7.75. The level of oxygen (mg/L) varied over the 30 days of experiment, with the lowest value recorded during the last week. The amount of nitrite also decreased until the last week of experiment when it showed anincrease. The level of ammonium nitrogen oscillated over the observation period, and the highest level was in the last measurement. The level of nitrate reduced significantly in the period of 30 days, the initial value was 18.8 mg/L while the last measured value was only 2.1 mg/L (Table 1).

Aquarium with 24h darkness

Water temperature under this light regime did not change. The level of oxygen showed a significant decline in the last measurement, from the initial 46.5% to the final 25%. The pH level of water in the aquarium also didn´t show significant changes (middle value 7.80). The amount of ammonium nitrogen increased over 30 days of experiment. The amount of nitrate recorded a continuous decrease during the observed period (Table 2).

Aquarium with 12h light/12h darkness

Once again, the water temperature did not change over this regime.Similarly, the pH level in the period did not show significant variation but was still higher than in the other two aquariums (middle value 7.91). The amount of oxygen significantly varied in the period of experiment. Ammonium nitrogen increased slightly during the period of experiment except the last week when it increased significantly (Table 3).

MORPHOMETRIC MEASUREMENTS

The average results of the total length, standard length and wet weight of catfish *(Ameiurus nebulosus L.)* are shown in Table 4. The highest average total length (TL) and standard length (SL) and the weight of catfish were recorded in aquarium in which the catfish (*Ameiurus nebulosus L.*) were kept 24 hours in darkness. Average values of growth of catfish are almost identical in all aquariums. The lowest index of conversion[1] (FCR) was recorded in the aquarium where catfish were in 24h light, while the average value of Fulton's conditioning factor[2] (CF) is almost identical in all three aquariums.

Continued on page 39

24 h darkness					
Parameters	13.4.2012.	20.4.2012.	27.4.2012.	4.5.2012.	11.5.2012.
Temperature °C	20,4	19,8	20,4	20,5	20,5
O_2 mg L^{-1}	4,67	4,88	4,64	4,52	2,8
O_2 %	46,5	44,5	42	41	25
CO_2 mg L^{-1}	0	0	0	0	0
pH	7,9	7,85	7,71	7,74	7,81
Oxidation reduction processes ORP mV	-66	-60	-55	-58	-63
Conductivity µS cm^{-1}	681	729	693	637	619
Ammonium nitrogen mg L^{-1} NH_3-N	0,58	0,64	0,93	0,85	1,38
Nitrites mg L^{-1} NO_2^{2-}	0,11	0,06	0,14	0,1	0,11
Nitrates mg L^{-1} NO_3^{2-}	11,8	6,1	9,1	3,3	6,9
Phosphates mg L^{-1}	4,2	3,8	5,2	6	7
Alkalinity mg L^{-1} $CaCO_3$	247	266	258	244	243

Table 2. Physical - chemical properties of water in aquarium with 24h darkness

Control aquarium - 12 h light, 12 h darkness					
Parameters	13.4.2012.	20.4.2012.	27.4.2012.	4.5.2012.	11.5.2012.
Temperature °C	20,3	20,1	20,5	20,5	20,5
O_2 mg L^{-1}	4,49	4,95	4,21	5,83	3,72
O_2 %	53,2	56,2	46,5	64,5	41,1
CO_2 mg L^{-1}	0	0	0	0	0
pH	8,11	7,89	7,82	7,80	7,95
Oxidation reduction processes ORP mV	-70	-65	-65	-60	-68
Conductivity µS cm^{-1}	712	743	738	676	651
Ammonium nitrogen mg L^{-1} NH_3-N	0,85	0,86	0,92	0,93	1,6
Nitrites mg L^{-1} NO_2^{2-}	0,15	0,11	0,12	0,17	0,14
Nitrates mg L^{-1} NO_3^{2-}	15,3	4,8	6,4	4,3	1,4
Phosphates mg L^{-1}	4,1	4,2	5,3	5,5	6,7
Alkalinity mg L^{-1} $CaCO_3$	263	284	283	258	274

Table 3. Physical - chemical properties of water in the aquarium 12 h light and 12 h darkness

Photoperiod	TL	SL	W	WG	growth TL	FCR	CF	SGR w
Control (12h light, 12h darkness)	23,08±0,50	19,93±0,53	136,91±2,35	3,54±1,193	0,134±0,06	8,73±0,95	1,08±0,01	0,41±0,06
24h light	22,74±0,90	19,598±0,84	124,67±30,05	3,02±1,228	0,144±0,06	9,14±3,64	1,06±0,01	0,41±0,17
24h darkness	23,81±1,34	20,396±1,20	144,21±22,09	3,61±0,252	0,156±0,04	7,90±0,37	1,07±0,01	0,42±0,02

Table 4. Average scores morphometric and production indicators

Figure 3. Aquarium 24h in light

Figure 4. Aquarium 24h in darkness

IMPLICATIONS FOR CULTURE

The reaction of fish to different photoperiod is of high importance in synchronizing the rhythm of feeding and growth of fish. These results show that the photoperiod is an important environmental signal in the control of various key parameters for the growth and development of brown catfish (*Ameiurus nebulosus L.*). Catfish are nocturnal animals and their activity (especially feeding) increased during the night, ie. periods without light. This research revealed there is a significant difference between the impact of photoperiod (24h darkness, 24h light and 12h dark/12 h light) on weight and lenght of brown catfish (*Ameiurus nebulosus L.*).

As found Mustapha et al. (2011.) we explained better growth in weight and length of catfish that were 30 days in the aquarium where it was dark for 24 hours compared to catfish kept in an aquarium that was 24 hours under light or those who were in the dark 12 hours and 12 hours in the light with the reduced stress and aggressiveness of fish as a result of suppressed locomotor activity in the dark. This allows more energy to catfish, which would be wasted in normally conditions on metabolic activity, to be converted into the body's growth. Weak average growth, Fulton fitness factor (CF) and the Index of conversion (FCR) of brown catfish (*Ameiurus nebulosus* L.). can be explained by bad physical - chemical parameters of water, especially nitrates and nitrites which are caused by decomposition of ammonia by bacteria Nitrobacter and Nitrosomonas.

The research results suggest that physico - chemical parameters of water, as nitrogen metabolites which were significantly elevated, could have an impact on reduced growth performance of brown catfish (*Ameirus nebulosus L.*) in the specified duration of the study. The amount of dissolved oxygen, temperature, pH and conductivity were in the optimal range for catfish species. This research showed there is the influence of photoperiod on growth performance of brown catfish. Brown catfish farming in the dark leads to the better growth. The results of this research could help choosing the duration and conditions of keeping catfish which could potentially impact on successful production in aquaculture of catfish species.

[1] Index of conversion is measure of effectiveness in animal feed conversion in increasing body mass

[2] Fulton's conditioning factor is mass of fish in cubic meter of its length


Amphora ovalis in varying growth phases indicated as pigment colorations


Starter stocks of *Amphora ovalis*


Top view of the highly illuminated photosynthetic system

A Disk Brush Fluidized-Bed Pack Photosynthetic System for Epipsammic Diatom (*Amphora Ovalis*) in Marine Hatcheries

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Benthic diatoms are indispensable live nutritive component in sea cucumber rearing and dependable production is a pre requisite for determined hatchery success. Citing a few species candidates commonly cultured by the sea cucumber farmers for larval and juvenile rearing are the motile solitary species like *Amphora*, *Amphiprora*, *Navicula*, *Nitzschia*, *Cylindrotheca* etc. *Cocconeis* is also another promising diet but non-motile prostrate species. Motility of *Amphora, Cylindrotheca, Navicula* colonies usually forms an ellipse. Today, sea cucumber farmers round the globe have innovatively fabricated multiple designs of benthic diatom biofactories across the globe with private, IP-locked proprietary designs – in the form of Inclined planar Cascades, Flat plate opticas, Serpentinam linear bags, Lineari flat walls, Solar insolation modules, Thin laminar polythene hangers, Wire-grid bags, Flat-bed sacs, Shallow mini paddle raceways etc. to intensify cell biomass productivity within a minimal foot-print cultivar.

Feeble reports do exist on benthic diatom photobioreactors (Lebeau and Robert, 2003). Maiden efforts on intensive benthic biofilm formations were from Avendan˜o-Herrera and Riquelme (2007), establishing a diatom-bacterial microfilm of *Navicula veneta* and *Halomonas* sp. bacterium in a tubular photobioreactor provided with bristled substrates. Silva-Aciares and Riquelme, 2008 from Chile, invented a PBB-Bristles photobioreactor (with an airlift system to provide constant water movement) having a “large bottle brush” having PVC bristles (measuring 100 cm x 17.5 cm), positioned throughout the entire inner voluminous length of the cylindrical culture tube. This method showed high efficiency of the PBB in terms of concentration and biomass of the adhesive diatoms *Amphora*, *Nitzschia* and *Navicula* on the support filaments. Their PBB were particularly well-adapted for producing highly adhesive diatoms.

In the design conceived herein, a system was devised to culture *Amphora ovalis* with bioactive stimulants at supra high densities in 18inch dia, 92% transparent fibre-plastic tube frame with solidly sealed translucent bottom. A disc shaped fibril brush was stacked one above the other in the 18 inch dia tube and filled with sterilised seawater at 35 ppt salinity. A bottom aeration collar tube (5 mm dia) ejects 8 mm dia bubbles on a vertical rise up of whole air cells on a continual basis from an air pump kept in room temperature (28°C). With a 360-degree external room fluorescent light banking (60 micromol m^{-2} s^{-1}), the circum-illuminated benthic diatom (*Amphora ovalis*) exploits the biofilm engineering capability of the circum-radial bristles of these vertically atop disc brushes under controlled conditions. The technique advanced presently is yet another improvement in the track history of diatom adherence on hard substrates with portable handling for cell biomass retrieval. This assuming cylindrical long-stubble frame-work stack, submerged in an aqueous medium held in a tubular photobioreactor offers efficient promotion of cross feeding, gliding motility and considerable interaction between the water/biofilm interface and the bristle/biofilm interface and vice versa in terms of nutrients, dissolved carbon and bacterial slimes, evolving a bridging effect of mutual adhesion due to the close orientation of the brush fibrils.

The seawater used for filling the culture tube is a mere dewatering cell-free culture media from a nitrogen-starved *Thalassiosira weissflogii* culture that by default bears abundantly, *Halomonas* and *Flavobacterium* colonies. *Thalassiosira* requires Vit B_{12} for growth (Armbrust, 2004). Vitamin B_{12} biosynthesis

Disk Brush

Disk brush fluidized-bed pack photosynthetic cultivar

Left: Disk Brush in situ

is upregulated in *Halomonas* sp. in the presence of algal extracts and that the products of algal metabolism affect the rate of bacterial growth (Croft *et al.*, 2005). The bacteria were presumably using the products of algal photosynthesis to grow, suggesting that this is a mutualistic relationship (Croft *et al.*, 2005). B_{12}-dependent *Thalassiosira* is thus always supported by the presence of the bacterium *Halomonas* spp. (Croft *et al.*, 2005). After the inoculation of *Amphora ovalis* into the culture reactor system on day zero, pure and crystal clean extract of immature date palm fruit is dissolved into the culture daily until day 3 of culture. Immature date palm fruit decoction contains vitamin B_2, B_6, B_9 and B_{12} (Aslam et al., 2011). From day 4 onwards, siliceous concentrates of *Thalassiosira weissflogii* paste is autoclaved and administered on daily basis to the disk-brush-held tube cultivars alongwith a few drops of mature date palm seed hydrolysate. Date palm seed contains Boron, calcium, cobalt, copper, fluorine, iron, magnesium, manganese, potassium, phosphorous, sodium and zinc in addition to aluminium, cadmium, chloride, lead and sulphur (Besbes et al., 2004). In principle, the distinction between the two niches (bacterial / algal) can affect their respective nutritional needs (Doiron *et al.*, 2012). Pneumatic agitation of culture is initially with 28°C which is increased by 0.5°C per day to reach a microbial maturating 32°C on day 10 (harvest day).

The initial seed stock of *Amphora ovalis* was slated to have a starting density of 1.0 x10^6 cells ml $^{-1}$. Once harvest is decided by day 10, having registered an existing standing crop stock-estimation at a density of 5.2 x10^6 cells ml $^{-1}$, the culture is subject to a hot air bubbling of 34°C for 30 minutes and then 35°C air-bubbling for 10 minutes. The cells start clustering closer more and more in their bioactive phycosphere. Rousch *et al.*, 2004 confirms the formation of stress proteins with more and more heat-exposure. A mechanism involving intercellular communication of stressful conditions and a subsequent response of the individual cells could be verily hypothesised. The localised gliding cell percentage with heat, increases ensuring a viable harvest recovery of cells. The disk brush sets are drawn out manually very gently and relocated into the rotating drum of the front holding washing machine and the glass window shut tight. Strong external flash of light beam (300 micromol m^{-2} s^{-1}) outside the loading glass window is essential. Filling with 60 ppt seawater at 35 o C and subjecting to a mild agitation, the slow rinsing effect will let loose the benthic diatoms (extracellular matrix shed off) to readily re-suspend into water column by hydro turbulent shear stress. After the rinsing process, the disk brush is removed and a slow dry air spinning of the Washing machine chamber will collect the Cell harvest biomass (in a highly dehydrated matrix) through the drain hose.

A crop harvest of 6.03 g dry *Amphora ovalis* cells per litre is evidenced every 10 days cycle. Translated into number of live cell crop, 1040 billion cells of *Amphora ovalis* is accrued as harvest every 10 days cycle from a 200 litre tubular cultivar, improvised with stacked atop disk-brush pile as vertically fluidized mesocosmic bed. The fruits of this study indicate the viability of diatom-bacteria mixed biofilms and related cell productivities of *Amphora ovalis* which is a promising food in marine invertebrate larviculture.

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Aquaculture team grows to meet increasing demand

MSD Animal Health, known as Merck Animal Health in the United States and Canada and the market leader in aquaculture welfare, has strengthened its Aquaculture team with the appointment of a new Technical Manager.

Camilla MacDonald, brings extensive industry experience to the role. She will focus on enhancing technical services to the industry. Camilla's appointment strengthens the team in the UK who work with the top 5 farmed salmon producers on their fish welfare programmes by providing products including SLICE, Norvax COMPACT PD and AQUAVAC PD3, and support programs such as SLICE Monitor and AQUAVAC Monitor.

Dafydd Morris, Business Manager Aquaculture at MSD Animal Health, said: "We are thrilled to have Camilla join our team and bring another level of expertise to the organisation. "We have an important role to play in ensuring the continuing health of farmed fish which will enable the industry to grow". "Having such an experienced and passionate team behind this is key to our success, and we aim to develop our services to bring positive benefits to the industry."

Originally from Perthshire, Camilla graduated from Newcastle University with a BSc in Marine Biology, where her dissertation research on a novel species combination in Integrated Multi-Trophic Aquaculture system, was published in the EAS journal "Aquaculture International". Camilla joins MSD Animal Health from The Scottish Salmon Company, where she had responsibility for the fish health management including implementing the company's Cleaner Fish programme, designed to explore ways of eradicating sea lice in farmed salmon. After three and a half years in this role, Camilla decided she wanted to explore wider avenues in the aquaculture sector, going onto secure her new position at MSD Animal Health Aquaculture, taking with her not only theoretical, but practical skills that makes her the ideal candidate for the role.

The appointment of Camilla completes the senior team of four, including Dafydd Morris, who joined the company in 2009, holding a number of technical positions before taking on the role of Business Manager in December 2014. Dafydd has extensive experience in both the salmon and shellfish sectors, including direct industry and regulatory functions. The full team now includes Campbell Morrison, Senior Key Account Manager, Camilla MacDonald, Technical Manager, Liam Doherty, Technical Assistant and Dafydd Morris as Business Manager, combining over 50 years of top level experience.

New Technical Manager Camilla MacDonald

SAIC in new collaboration with leading European institute

In a move to advance work in its four priority innovation areas (PIAs), the Scottish Aquaculture Innovation Centre (SAIC) has entered into a new collaboration with Nofima, one of Europe's leading institutes for applied research into aquaculture, fisheries and food.

The new Strategic Research Collaboration (SRC) will see SAIC and Nofima work together on projects of mutual interest. In particular, those addressing SAIC's four PIAs: sea lice control, sustainable feeds, rapid detection of pathogens and diseases, and shellfish spat.

A Letter of Intent setting out shared objectives and goals for an initial period of three years was signed during a recent visit to the institute's head office in Tromso, where representatives from SAIC, the Institute of Aquaculture and the University of Stirling were given a behind-the-scenes tour of Nofima's ground-breaking research facilities and activities.

Commenting on the new collaboration, SAIC CEO Heather Jones said: "This is a must-seize opportunity for SAIC to join forces with one of Europe's leading names in aquaculture research and deliver real competitive advantage to the industry. The new SRC will enable us to forge a close working relationship with Nofima; access an even broader range of competencies; and explore possible avenues of funding together."

Scottish Aquaculture Innovation Centre

Added Nofima Aquaculture Director Nils Haga: "Scotland and Norway are two of the most dominant and dynamic forces in aquaculture. Now, thanks to the new SRC, we can bring our collective vision, expertise and resources together to make even more significant advances for challenges common to the fish farming industries in our countries and in Europe."

Keen to capitalise on the new collaboration as soon as possible, SAIC will be involved in the Nofima-chaired ZERO LICE workshop at the North Atlantic Seafood Forum (NASF) meeting, 1-3 March in Bergen, aimed at coordinated industry innovation. In addition, Nofima are invited to participate in SAIC workshops at AquacultureUK 2016, 25 & 26 May in Aviemore. **www.scottishaquaculture.com**

FOOD *for* THOUGHT

Edinburgh to host Aquaculture Europe 2016

Aquaculture Europe 2016 will take place at the Edinburgh International Conference Centre (EICC) from September 20-23. AE2016 is 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. The event is Gold Sponsored by Biomar.

The event theme "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. AE2016 will present the latest science to support further development, and industry panels will discuss key opportunities. It will also 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.

AE2016 Gold Sponsor

Parallel sessions

AE2016 has something for everyone, with a broad proposed list of parallel sessions:

- New advances in trout farming
- Diversification in Aquaculture production
- DIVERSIFY: Exploring the biological and socio-economic potential of new/emerging candidate fish species for expansion of the European aquaculture industry
- Cleaner fish: biology, production and management
- Shellfish production and diversification
- Mariculture and conservation of marine invertebrates and corals
- Macro and Micro algae production
- Laboratory models (e.g. Zebrafish and others)
- Nutrition: New sources of protein
- Nutrition: New sources of omega 3 fatty acids
- Nutrition: Nutritional requirements in marine organisms
- Production of copepods as live feeds
- Arriana: Advanced research initiatives for nutrition & aquaculture
- Recent advances in digestive physiology: The gut, its health and molecular nutrition
- Advances in the mitigation of deformity
- Application of genetics and genomics in Aquaculture
- AquaTrace: the development of tools for tracing and evaluating the genetic impact of fish from aquaculture
- Fishboost: Boosting European aquaculture by advancing selective breeding to the next level
- Hatcheries
- Escapee prevention and management: From systems to biotechnology
- Disease prevention, treatment and management
- Disease description, mapping and epidemiology
- Sealice control
- Gill health and challenges
- Shellfish Health
- Microalgae derived toxins, analysis and regulations
- Predator management
- Finfish welfare
- Fish behaviour in aquaculture systems
- Integrated Multitrophic Aquaculture (IMTA)
- Aquaponics and biofloc
- Advances in recirculation and closed containment aquaculture systems
- Farming operations, cage environment and biology/technology interactions
- Organic Aquaculture
- Aquaculture globalisation: Production and research across borders
- Climate change: Impact, mitigation and ecosystem services
- Understanding public perception and consumer demands
- Labelling and certification of aquaculture products
- Novel tools and approaches to training and teaching in aquaculture
- Governance, Policy and Strategic planning

Special sessions and events

AE2016 will also include other sessions, workshops and events in the trade show area. These include:

- The EAS STUDENT GROUP WORKSHOP - A special forum for students to enable networking and exchange of ideas. The programme will include a focus on entrepreneurship and mentoring. There will be a special student reception.
- The EU FORUM – chaired by representatives of the EC Directorate for Research and Innovation, as well as showcasing recent and ongoing EU projects.
- The AE2016 INDUSTRY FORUMS – Where the latest scientific findings related to a particular issue for aquaculture producers will be presented and discussed. Planned forums for AE2016 include: cleanerfish, RAS, genetics and breeding programmes and shellfish.
- The British Trout Association is planning to hold its Annual General Assembly in Edinburgh at AE2016.
- The EAS – EATiP day. Since 2014, EAS has teamed up with the European Aquaculture Technology and Innovation Platform (EATiP) to organise a special one-day event of panel discussions focussing on relevant and timely issues for the sector.
- The EAS-IUCN panel on Aquaculture in Marine Protected Areas.

An international trade event

Aquaculture Europe 2016 will feature a special international trade exhibition, organised by EAS. Scottish and international companies will present the latest products and services for aquaculture.

Both Standard and Corner booths will be available. Each booth is 6m2 (2x3m) and features: walls, carpet, two chairs , one table, spotlights, one power outlet, fascia identification sign and two free passes for the conference.

For booth information, reservation and advertising opportunities, please contact Mario Stael, AE2016 Exhibit Sales Manager mario@marevent.com

Register early and book your hotel

The Early Bird registration deadline is June 15, where the EAS Member rate is just €395.

We have agreed special rates with several hotels in Edinburgh and these are posted on the AE2016 pages of the EAS web site at www.easonline.org

The Scottish Government
Riaghaltas na h-Alba

marinescotland

eas40
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.

APRIL 2016

European Algae Biomass Conference
Berlin, Germany, April 20-21, 2016
ACI's 6th annual European Algae Biomass Conference will once again bring together senior executives from industry and academia to discuss the latest commercial and technical developments, challenges and research breakthroughs throughout the entire algae value chain. Contact: Dimitri Pavlyk – Marketing/Sales,
Phone: +44 (0) 203 141 0627;
Email: dpavlyk@acieu.net
Web: http://www.wplgroup.com/aci/event/european-algae-biomass-conference/

MAY 2016

Aquaculture Extrusion Technology short course
Ås (near Oslo), Norway, May 9-11, 2016
This 3-day course covers the principles of extrusion, the design of extrusion processes, and the formulation of extruded aquafeeds. Principles learned will be demonstrated using the extruder in the Centre for Feed Technology pilot plant.
Course website:
http://fie.com.au/events/aquafeed-extrusion-norway
Contact: Gordon Young, Food Industry Engineering (Australia) Ph +61 414 681200

Food & Feed Drying Technology short course
Ås (near Oslo), Norway, May 12-13, 2016
This short course in Drying Technology combines the practical perspective of experienced industry professionals with the in-depth technical knowledge of drying processes. This course is about understanding drying technology, and how to use that understanding to improve current processes, or design/select new systems that are both effective and efficient.
Course website: http://fie.com.au/events/drying-norway
Contact: Gordon Young, Food Industry Engineering (Australia) Ph +61 414 681200

Aquaculture UK 2016
Aviemore, Scotland, May 25-26, 2016
Now in its 10th year, Aquaculture UK is the most important aquaculture exhibition and conference held in the British Isles. Each time it is held it gets bigger and more valuable to the industry. It is firmly established as an important and truly international trade venue for the aquaculture industry.
Contact info: Matt Colvan +44 (0)114 2464799
Address:Benchmark House, 8 Smithy Wood Drive, Sheffield, S35 1QN, England.
Email: info@aquacultureuk.com.
URL: http://www.aquacultureuk.com/

JUNE 2016

Future Fish Eurasia & MECAA 2016
Izmir, Turkey, June 2-4, 2016
Future Fish Eurasia, the 8th International Fair for Fish Imports/Exports, Processing, Aquaculture and Fisheries will be organised by Eurasia Trade Fairs at the Izmir International Fair Centre in conjunction with Middle East & Central Asia Aquaculture (MECAA16) – "Towards sustainable aquaculture". The concept of Future Fish Eurasia is a combination of fish products, aquaculture and fish processing equipment. Catering for fish traders, fish farmers & processors.
MECAA16 will bring together over 350 aquaculture industry experts and academics from around the world and offer a state-of-the-art platform to interact, debate and exchange views on recent results, projects and research. Contact info@marevent.com. Info: www.marevent.com

8th International Symposium on Fish Endocrinology
Gothenburg, Sweden, June 28-July 2, 2016
The 8ISFE will highlight important research advances in all areas of fish endocrinology.
Conference Secretariat: Sweden MEETX AB,
E-mail: 8isfe@meetx.se, Phone: +46 31 708 86 90,
Fax: +46 31 20 91 03
Postal address: Sweden MEETX AB, Ref. 8ISFE, 412 94 Gothenburg, Sweden URL: http://8isfe.se/

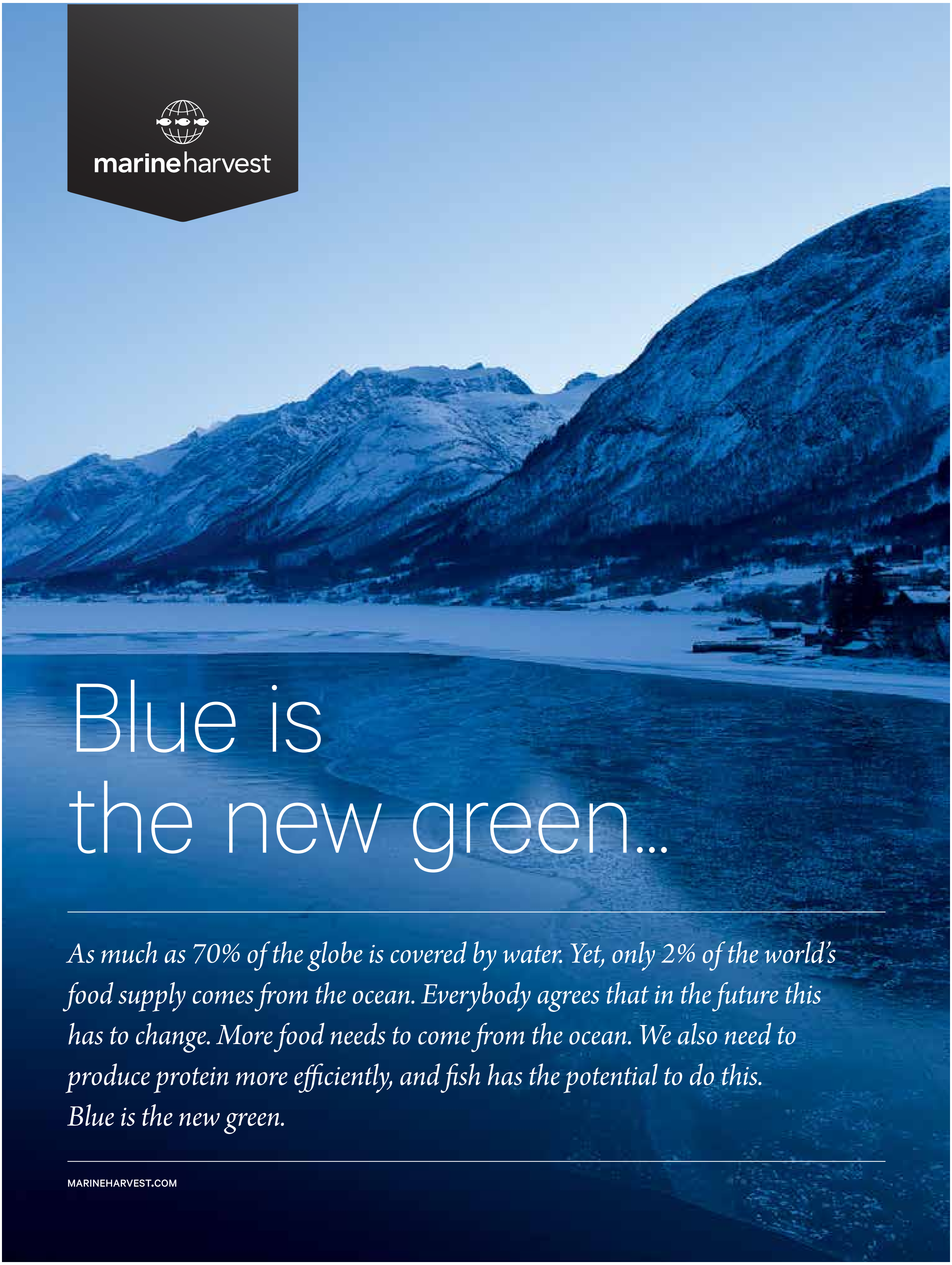
SEPTEMBER 2016

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
The 11th International Sea Lice conference will be focusing on the following key areas: Sea lice biology; Sea lice epidemiology; Sea lice genomics; Integrated pest management and sustainable production. Research covering Caligid copepods, mainly Lepeophtheirus salmonis and Caligus species, are invited.
Contact: Email: sealice.2016@marine.ie.
Web: www.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;
Website 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.
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