AE2017 – COOPERATION FOR GROWTH

aquaculture europe

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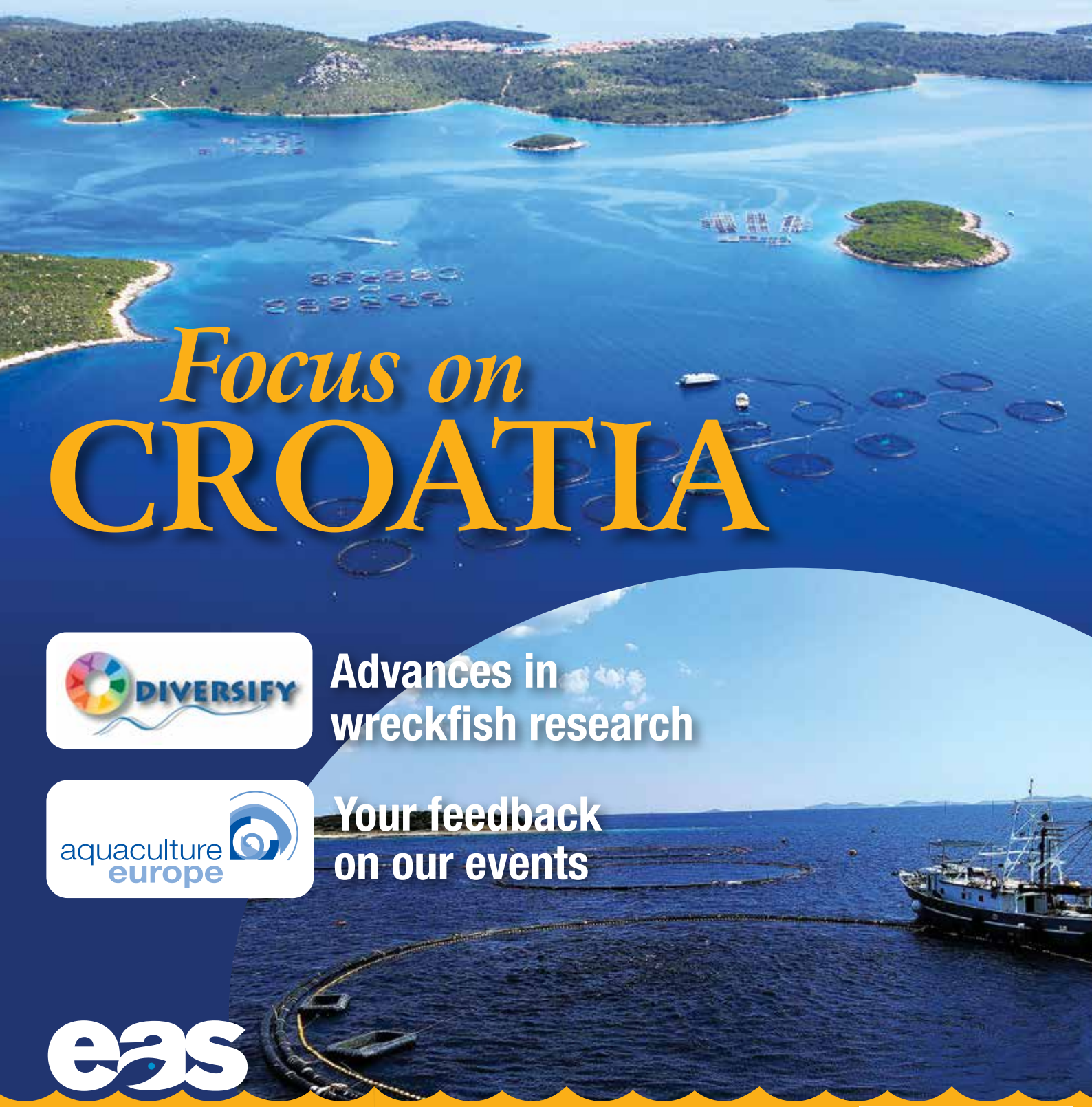

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AQUACULTURE EUROPE
EAS is a non-profit society that aims at promoting contacts among all involved in aquaculture. EAS was founded in 1976. Aquaculture Europe is the members' magazine of EAS.

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Membership of the EAS includes the Aquaculture Europe magazine (2 issues/year; institutional and sponsorial members receive 2 paper copies), Aquaculture Europe e-mail publication (6 issues/year), Online access to our peer reviewed journal Aquaculture International (AQUI). Institutional Members of EAS also receive one free half page advert per year in the magazine.

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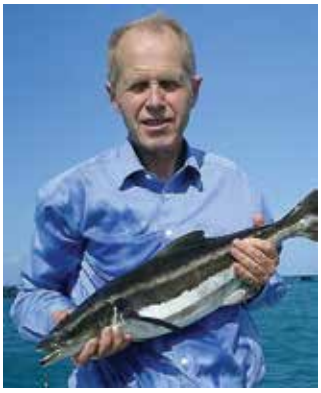

Dear EAS members,

Thank you for having elected me as Vice-President in 2014. It was a good feeling to take up the EAS Presidency in Edinburgh last year – for the second time. I was thinking back to the celebrations last year of the 40th anniversary of the European Aquaculture Society and how things have changed since I was one of the founding members of EAS back in 1976. Especially regarding the great increase in production of farmed sea products that has taken place during these 40 years of existence of EAS.

Global aquaculture production has gone from 5 million tonnes to more than 110 million in 2015 and China has become by far the biggest producer and consumer. In Europe, we can be proud of our achievements, growing from no sea bass and sea bream farming in 1976 and about 2 500 tonnes of Atlantic salmon that year to an annual production of bass and bream of more than 300 000 tonnes and a staggering 1.6 million tonnes of salmon in 2015.

Based on the increased production and growing interest in aquaculture, one would think that the EAS membership has grown accordingly. But this has not been the case. Our membership has for many years fluctuated between 400 and 600 members. But, on the positive side, we have seen growing participation in our Aquaculture Europe events, especially since we embarked on a new strategy in 2007 to combine the scientific conference with a trade show and forums targeted specifically for industry.

After a very successful AE2016 in Edinburgh last September, we did an online survey of the opinion of the participants and we had close to 600 participants from AE events held since 2011 that gave us their opinion and helped us to have a solid basis on which we can further develop the event. The survey report is detailed in this edition of the magazine, but here are some of the highlights:

More than half of the respondents were in the age range 31 to 50.

Most people use the theme/programme of the event as their principal criteria to decide to attend. Around half of them come 'because it is the annual EAS event' and also based on the location.

74% have given presentations and rated highly the 'services' provided by AE management.

People consider a good 'size' for our AE events as being between 1000 and 2000.

In general terms, participants are fine with the plenary, parallel and poster sessions as they are currently organised.

118 free text comments on ideas for future opening plenary sessions and 186 comments on what we could do better were also received.

343 respondents are planning to attend AE2017 in Dubrovnik; 191 AQUA 2018 in Montpellier and 150 AE2019 in Berlin.

This is encouraging, but there was room for more participants. What we really need is an additional survey of people involved in aquaculture that do not choose to attend our meetings!

After 40 years, it is time to take stock and see what strategy EAS should follow in the coming years. The Board will discuss this in a 'Strategy Retreat' this month and the outcomes will be presented at our annual General Assembly in Dubrovnik in October. This is another reason to attend AE2017. An exciting program is being put together and abstract submission is available online now, so make sure you do not miss this meeting.

I look forward to seeing you in Croatia in October.

Bjorn Myrseth

EAS President 2016-2018.

FOCUS ON CROATIA:

PROGRESS TOWARDS SUSTAINABLE AQUACULTURE

IVAN KATAVI, INSTITUTE OF OCEANOGRAPHY, SPLIT

ANA GAVRILOVIC, UNIVERSITY OF PULA

INTRODUCTION

Croatia has great geographical advantages in terms of aquaculture tradition and potential areas suitable for aquaculture. Fish farms used to be local, primarily small farming units. Management was based on experience with no significant involvement of research-generated knowledge. Fish farming without processing plants didn't require many employees. Then, transition from a social to a typically capital oriented economy was followed by "privatization". By the early 1990s the aquaculture sector went through restructuring, and professionals started to run the companies as an integrated enterprise, with ownership across local and even national borders. Research is needed to address every detail, from hatching to the marketing of the aquaculture product. Following the major economic crises in 2008 and nearly 10 years of financial turbulence, the mariculture sector appears to have recovered. The outlook is positive, and the expectations regarding future growth are optimistic. According to the multi-annual National Strategic Plan for Aquaculture 2014 – 2020 (NSPA), further development of aquaculture will require diversification and will be competitive by following high environmental and production standards. As there was no centralized strategy for aquaculture, the planning instruments as well as licensing procedures were mainly left to county and municipal authorities and governed by numerous regulations. Today, a country having 4.5 million inhabitants is divided into 21 counties (7 of which are bordering the sea) and 556 municipalities. As in most of the neighbouring Mediterranean countries, the main obstacles to aquaculture development will be spatial positioning and complicated administrative procedures. In addition to the environmental pressure generated by numerous coastal users, the process of site selection and site management for aquaculture will be quite difficult due to its dependence on the maintenance of the health of the ecosystem.

In this overview Croatian aquaculture and its production trends were analized in the context of the muli-annual NSPA.

Table 1. Croatian 5-years aquaculture production statistic (2011-2015) by species group/year *(source: Ministry of Agriculture, Directorate of Fisheries, 2017)*

Species Group/Year	2011	2012	2013	2014	2015	2020*
Sea bass, Gilthead seabream & others	4.533	4.650	5.854	7.010,5	8.641	(10.000)
Bluefin tuna	3.223	1.907	2.616	2.224	2.603	(3.000)
Shellfish	3.150	3.150	2.000	746	798	(5.000)
Warm Freshwater Fish	3.794	3.209	2.884	3.432	4.153	(5.000)
Cold Freshwater Fish	2.489	1.000	355	391	679	(1.050)
TOTAL (t):	17.189	13.916	13.709	13.803,5	16.874	(24.050)

*Projection by the National Strategic

SECTOR PERFORMANCE

In the period 2011-2015, the changes of production trends within two main aquaculture sectors, mariculture and freshwater aquaculture, were recorded (Figure 1). While total mariculture production showed an increasing trend from 10.906 tonnes in 2011 to 11.244 tonnes in 2015, freshwater aquaculture decreased from 6283 tonnes to 4832 tonnes (Table 1.)

Species distribution in both aquaculture sectors has changed significantly from 2011 to 2015 (Figures 2-5).

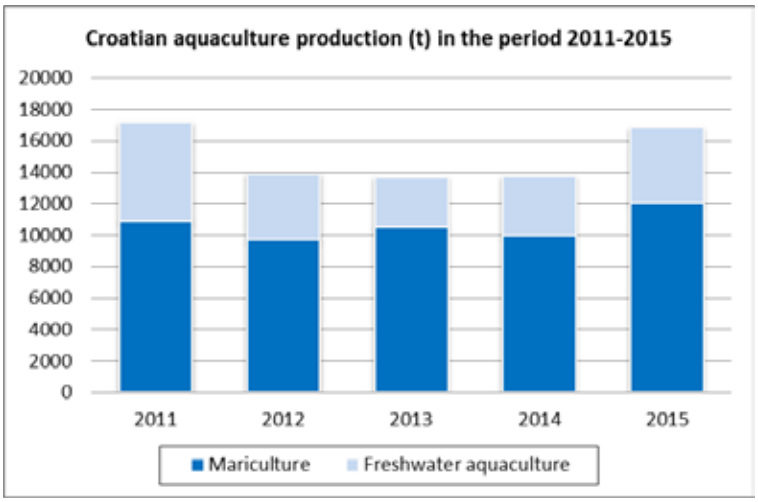

Figure 1. Croatian aquaculture production by culture environment (2011-2015)

MARINE FINFISH SECTOR

Croatian marine finfish production amounts to 11.244 tonnes, representing around two third of total aquaculture production in 2015. More than 76% of marine finfish production is European sea bass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*). Sea bass and seabream production almost doubled from 2011-2015 (Table 1). Other marine finfish species cultured in Croatia include Eastern Atlantic Bluefin tuna (EBFT), which represents around 15 %, while meagre (*Argyrosomus regius*), turbot (*Psetta maxima*) and dentex (*Dentex dentex*) together contribute less than 5%. Today, Croatia is 4th EU producer of sea bass and gilthead seabream, after Greece, Spain and Italy (FEAP, 2016). For Bluefin tuna farming, Croatia is among the three EU leading producers.

The main production technique for marine finfish is cage culture, with fry being produced in land-based hatcheries (Figure 6). EBFT juveniles are captured from the wild, and after 18 to 30 months of growout in semi-offshore cages, are exported to *sushi* and *sashimi* markets in Japan.

The volume of EBFT farming (Figure 7) is entirely linked to the catch quota regulated by the International Commission for the Conservation of Atlantic Tunas (ICCAT), which in 2006 adopted a 15-year recovery plan for overfished BFT stocks in the East Atlantic, including the Mediterranean. Thanks to good management and fisheries sacrifices, a recovery of the stocks has been recorded. Consequently, since 2013 about a 20% increase in the catch quota has been recommended, resulting in 13.500 tonnes of total allowable catch for the EU in 2017. The EU quota is shared by the eight Member States actively involved in harvest of Bluefin tuna - Spain, France, Italy, Croatia, Greece, Portugal, Malta and Cyprus. Spain and France have the largest shares. Those vessels which catch the fish alive for farming purposes share 61% of the total EU quota. An increased fisheries quota allocated to Croatia in 2017 is expected to amount to 3000 tonnes of EBFT that will be available to export to the Japanese market.

The multi-annual NSPA which is being prepared by the Ministry of Agriculture, projected the total production in aquaculture to reach 24,050 tonnes in the time period from 2014-2020 (Table 1). The main challenge to enhance production is to lower conflicts with miscellaneous users in inshore sheltered areas, and move rearing installations towards more open sea by employing semi offshore cages beyond the protected coastal belt (300 m from coastline). To ensure necessary aquaculture locations, a coordinated spatial planning and integration of those activities into the coastal management plan will be considered. Simplification of administrative procedures related to national law is listed among priorities. Production economy may take advantage by combining

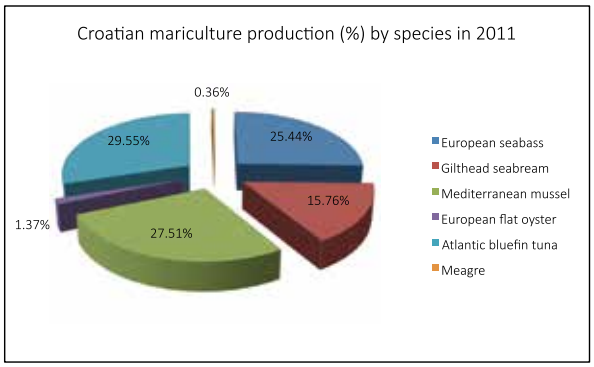

Figure 2. Mariculture production by species in 2011. (source: Ministry of Agriculture, Directorate of Fisheries, 2017)

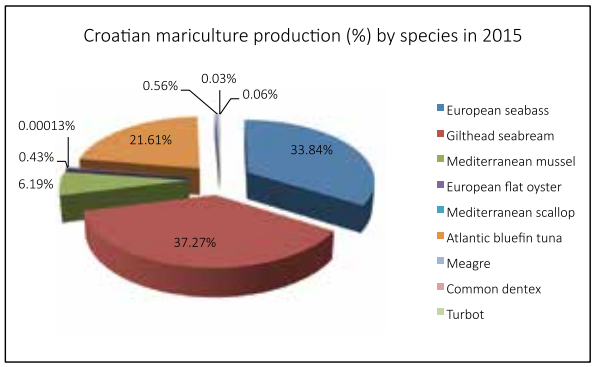

Figure 3. Mariculture production by species in 2015. (source: Ministry of Agriculture, Directorate of Fisheries, 2017)

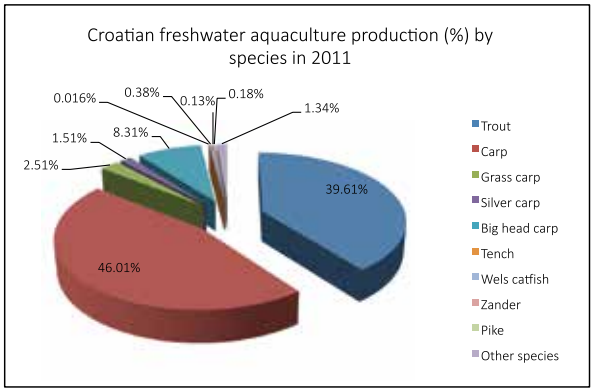

Figure 4. Freshwater aquaculture production by species in 2011. (source: Ministry of Agriculture, Directorate of Fisheries, 2017)

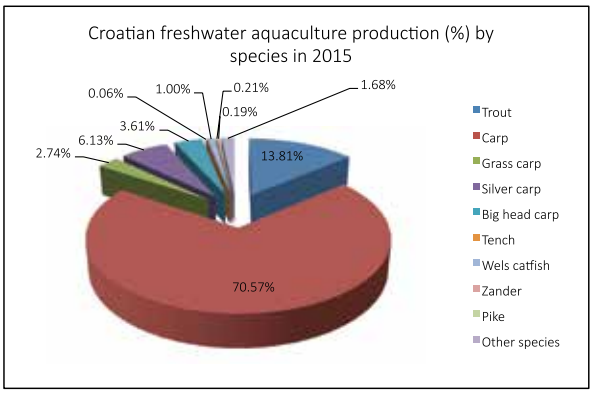

Figure 5. Freshwater aquaculture production by species in 2011 (source: Ministry of Agriculture, Directorate of Fisheries, 2017)

recirculating production systems for the prolonged rearing of juveniles, and offshore technologies for market production. Finfish produced using such a combined production system from 50 to 100 grams is expected to shortened the offshore production cycle, and have much lower carbon footprint than producing fish using an inshore cage system from 5 to 10 grams. This will benefit both the economic and environmental performance of marine finfish production as a whole.

The general objectives of NSPA also include improving the social and business environment in aquaculture development, and increasing the national consumption of aquaculture products. Also targeted is increasing the employment in the handicapped rural and island areas, while furthering the economic development of local communities. Aiming to address this issue the NSPA also depends on the synergy between applied research projects and industrial activities identified. Decreasing genetic pollution by preventing escapement of farmed fish, and applying ecologically sound technologies such as polyculture composed of finfish and non-fed shellfish, may reduce eutrophication and convert organic waste into harvestable crops.

SHELLFISH

The Croatian shellfish sector is going through an unexpected crisis, barely reaching a production volume of 800 tonnes per year, which is a historical minimum. Traditional production of Mediterranean black mussels (*Mytilus galloprovincialis*) and European flat oysters (*Ostrea edulis*) relies on an extensive production model employing hanging structures suspended below floating rafts (Figure 8). Spats are used for both mussels and oyster production collected from the wild. Mussels dominate Croatian production with nearly 96% of the total shellfish volume per year.

An expected increase to 5.000 tons by 2020 (NSPA, 2015) is constrained by low production efficiency of small, mostly family-owned operators with low capacity to invest and modernize production, and also heavy predation by gilthead seabream.

Besides European flat oyster and Mediterranean mussels, according to the official data from Directorate of Fisheries, a small quantity of Mediterranean scallops (less than 1%) was also produced in 2015.

FRESHWATER AQUACULTURE

The freshwater aquaculture sector in Croatia produces primarily common carp (*Cyprinus carpio*) and rainbow trout (*Oncorhynchus mykiss*), which represent 70% and 14%, respectively, of total freshwater aquaculture production by quantity in 2015 (Table 1).

Bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) account for a further 10%, and small volumes of catfish (*Silurus glanis*), tench (*Tinca tinca*), pike (*Esox lucius*), and zander (*Stizostedion lucioperca*) are also farmed (Figure 9). Carp and other warm water fish species are produced in earthen ponds over a three year farming period. For the most part the fish depend on the natural food, which may be supplemented by fertilisation, and additional food, mostly corn.

Coldwater rainbow trout is the main salmonid cultured in Croatia, while the brown trout (*Salmo trutta m. fario*) is farmed in small volumes, less than 1%. Farming is

continued on page 8

Figure 6. Sea bass and sea bream farm in the islands' area of the Zadar County

performed within concrete tanks (raceways) as open gravity flow systems, enabling frequent water replacement (Figure 10). The production cycle is approximately 2 years, using a complete commercial diet.

In geographic terms, the positioning of freshwater farms principally reflects the geomorphology and climatic conditions. Trout are more suitable in a coastal environment rich in freshwater sources, while carp and other warm water species do better in continental conditions.

Although the freshwater aquaculture sector represents less than 29% of the aquaculture sector's total economy, it has an important socio-economic impact on the rural areas of the country, and the potential to boost further development and employment. Its' role in the maintenance and conservation of biological diversity is very important. An ecosystem-based approach is applied with many fish farms making them a part of the Croatian ecological network, and a part of the European NATURA2000 ecological network. It was estimated by the NSPA that with a more efficient organisation of the industry, this activity could continue to grow. However, some challenges were recognised, such as the damage caused by protected cormorants, the problem of seasonality that must to be addressed by promoting processing, and diversifying products coupled with marketing campaigns. In addition to product diversification, introduction of new species and modernization of existing ponds are the main strategic components for further development of the freshwater sector.

SECTOR ORGANISATION

The Aquaculture sector in the Republic of Croatia is organized primarily through a chamber system. There is an Agriculture, Food Industry and Forestry Department within the Croatian Chamber of Economy (CCE) that is organized into associations, councils and groups. One of the associations is the Association of Fisheries and Fish Processing, a part of which is the aquaculture group, acting through the Committee for Freshwater Farming, and the Committee for Mariculture. The Committee for Freshwater Farming consists of the section in charge of warm water farming (carp) and the section in charge of cold water farming (trout). The Committee for Mariculture consists of the section in charge of the farming of "white" fish (sea bass, gilt head bream, meagre, common dentex and others), as well as the section in charge of tuna farming, and shellfish farming (mussels and oysters). The roles of the Department are, among others, (i) coordinating the stakeholders interests in the negotiations and trade agreements with other countries or trade associations, (ii) participating in the development of regulations; (iii) facilitating the connections to research institutions, advising in specific areas, (iv) organizing trade fairs and exhibitions, and finally, (v) preparing projects and studies for international and national institutions.

Apart from the CCE, the Croatian Chamber of Trades and Crafts (CCTC) is also active, as an association of crafts founded for the purposes of promoting, harmonizing and representing common interests of small and medium fishery entrepreneurs.

Besides organizing through a chamber system, Croatian mariculture producers are organized through a Mariculture Cluster consisting of 3 sections: tuna farmers, "white" fish farmers and shellfish farmers. This farmer organization accounts for more than 90% of the total mariculture production. It can be emphasized that the Cluster members might be also members of the CCE and the CCTC.

MARKET

Almost total EBFT production is exported to Japan, while about two thirds of sea bass and gilthead seabream production is exported mostly to EU market. In general, marine finfish species have a better position and a more attractive image among consumers on the local market, in comparison to freshwater farmed species (Aprahanian and Gorea, 2015). Approximately one third of the national carp production is exported to other markets.

Along with small-size companies, the Croatian aquaculture sector includes a few large-scale companies with a vertically integrated system, with their own hatchery and on-growing farms, with processing units and distribution channels. The majority of small-scale farming companies and a few medium-scale companies sell their products in the form of fresh fish mostly through traditional distribution channels, that include direct sales from farms, open markets, and local food service channels.

The recent appearance of the new value-added sea bass, gilthead seabream and carp products, such as cuts, fillets and other products, facilitated the move of farmed fish to the modern retail chains, making finfish available to the larger consumer groups and thus keeping up both touristic and local consumption (Figure 11).

The structure of the national trout supply chain is represented by several small-scale farming companies, with some of them having processing units. Trout is sold through companies' channels mostly as live and fresh product. Fish is cleaned, gutted and vacuum-packaged. A substantial part of processed trout products is made up of hot-smoked trout. Most of this trout is distributed through traditional retail channels

However, compared to marine species, freshwater species, and especially freshwater farmed species, have a weaker position on the local market, lacking an attractive image among consumers. While there

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Figure 7a,b. Bluefin tuna farming in the semi offshore floating cage

Figure 8 a,b. Shellfish production by employing floating longlines with suspended rearing units (pergolas)

continued from page 9

has been an increase in sales of processed carp with the introduction of value-added carp products, the overall sales of live and fresh carp has been stagnant. Consequently, there has been no decline in overall carp sales in Croatia due to the increased supply of carp products in the modern retail stores. At the same time, imports from ex-Yugoslavian countries and Turkey have put the Croatian trout sector into a competitive disadvantage.

EDUCATION AND APPLIED RESEARCH IN AQUACULTURE

Aquaculture education in the Republic of Croatia is carried out by academic institutions, while there is also an informational and educational system implemented by the Ministry of Agriculture Directorate of Fisheries and the Advisory Service. In several research institutes and universities of Republic of Croatia, there are experienced and qualified experts capable of transfering specialized knowledge in the aquacultural sciences as well as related disciplines (Katavic and Glamuzina, 2012). The latest advances in aquaculture development cover a wide range of fundamental and highly specialised education in the universities of Split (UNIST), Dubrovnik (UNIDU), Zadar (UNIZD), and Pula (UNIPU) respectively. Different aspects of aquaculture are also included within the syllabus of the Agricultural faculty, and Faculty of Natural Sciences and Mathematics, of Zagreb University. In addition to the traditional masters and doctorate studies (mainly freshwater) programmes at the Agricultural Faculty of Zagreb University, and a similar one in Oceanology at the Faculty of Natural Sciences at Zagreb University, a joint doctoral programme in applied marine sciencies was initiated by the mid-2000s by the UNIDU and UNIST.

The Ministry of Agriculture and its Advisory Service, and, periodically, other institutions such as the Paying Agency for Agriculture, Fisheries and Rural Development and the Croatian Chamber of Economy has, for almost 10 years, provided international economic and scientific consultation on aquaculture, and has financed the publication of the scientific publication, the Croatian Journal of Fisheries. Education and information is provided through lectures, workshops and consultation, and through publications, brochures, media and the internet. But still there is no defined lifelong educational framework.

Applied research in aquaculture is performed by institutions registered for the prescribed scientific activity, as well as by the companies which perform the farming activity.

The practical application of knowledge and skills in aquaculture is performed by researchers in close coopeartion with industrial partners. On the other hand, univeristies and scientific institutions in the Republic of Croatia have maintained long-standing international cooperation with institutions in other countries (both in the EU and non-EU countries), which in the past has guaranteed a successful transfer of knowledge, technologies and the latest technological solutions. Due to appreciable experience in actual aquaculture production, the cooperation of businesses with producers in other countries has also helped with the transfer of knowledge and technologies.

Figure 9 a,b. Harvesting of warm water species from an earthen pond

Figure 10. Trout production in the raceways

CONCLUSION

Croatia has a unique, beautiful, unspoiled, and healthy environment whose development potential for aquaculture is not yet fully realized. Aquaculture is expected to grow in the near future, contributing to both the national economy and to the socio-economic conditions of local communities. However, future aquaculture development is mainly constrained by complicated administrative procedures and the lack of accurate spatial planning. Suboptimal positioning of aquaculture operations has impacted natural ecosystems, spread diseases and caused pollution. Problems within the aquaculture industry further include water and sediment quality, harmful algal blooms, escapement of farmed species and its genetic impact, biodiversity, loss of aesthetic value, all of which has created a negative image of the aquaculture sector, and consequently the marketing of aquaculture products. Therefore, a balance must be achieved between the users of the natural resources, and eological preservation where the development of one sector does not diminish or degrade the development potential of the other sectors.

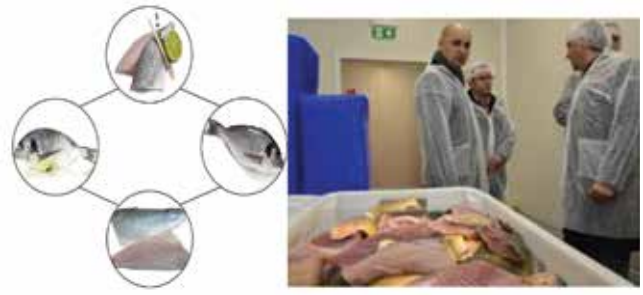

Figure 11. Adding new value to aquaculture products

To ensure integration of aquaculture into county/municipal management plans, an integrative knowledge about the functioning of given ecosystems, a cooperative attitude, and compromise between the different interests and actors should be in place. To maintain a sustainable and globally competitive aquaculture sector, diversification of species and aquaculture products, and further technological improvement with more advanced biotechniques, will be needed. Both economy and ecology may take advantage of semi-offshore technology stocked with more "robust" fry produced in the land based nursery rearing systems. It is hoped that in the years to come, the researchers and the relevant authorities will manage to agree upon efforts towards administrative and production cooperation that will optimize aquaculture potential in Croatia.

Literature:

Aprahanian, A., Corea, PG (eds). 2015. Smart Specialization in Croatia. Imputs from Trade. Innovation, and Productivity Analysis. Directions in Development. Washington, DC; World Bank. http://dx.doi.org/10.1596/978-1-4648-0458-8

Boroša Pecigoš, T. 2015. National Aquaculture Sector Overview. Croatia. National Aquaculture Sector Overview Fact Sheets. *In*: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 27 February 2015. (http://www.fao.org/fishery/country-sector/naso_croatia/en)

EATIP. The future of European aquaculture-Our Vision: a strategic agenda for research and inovation. European Aquaculture Technology and Inovation Platform, 2012; http://www.eatip.eu/default.asp?SHORTCUT=92EC (European Commission)

FAO (2016): The state of world fisheries and aquaculture. Contributing to food security and nutrition for all. Rome. 200 pp. (http://www.fao.org/3/a-i5555e.pdf)

FEAP (Federation of European Aquaculture Producers). Covering the perion 2007-2015. FEAP Secretariat, October 2016.

Katavic, I. and Glamuzina B. 2012. Education in Fisheries Issues in the Mediterranean and in Croatia. In: Education in the Mediterranean Trends and Challenges (Abis, S. ed), International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM). Watch Letter no 22, September 2012:7-21 (www.ciheam.org)

Ministry of Agriculture, Aquaculture production statistics (in tonnes), 2006-2015 (http://www.mps.hr/ribarstvo/default.aspx?id=14).

Ministry of Agriculture. National Strategic Plan for Aquaculture Development 2014-2020 (draft). February, 2015 (http://www.mps.hr/ribarstvo/UserDocsImages/akvakultura/NSPA%202014-2020_eng.pdf).

WELCOMING AE 2017 "COOPERATION FOR GROWTH"

This gathering of high-level experts, international organizations, industry, and civil sevice representatives highlights the tremendous potential of aquaculture as an expanding industry. Aquaculture is pivotal to meeting the needs of a rapidly growing population, and can also contribute significantly to food security and adequate nutrition for a global population expected to reach 9.7 billion by 2050. The latest FAO's annual SOFIA report (2016) notes the shift in seafood production from wild-catch toward farmed seafood product. Along with aquaculture technology development and scientific research, one of the most important factors that may contribute to the positive growth of the aquaculture sector is stronger cooperation between all operators within the sector. Such an opportunity is AE 2017. We welcome you to Dubrovnik!

Let's support the strengthening of aquaculture together! Join as in Dubrovnik, and be a part of the Cooperation for Growth!

Prof. Ivan Katavić,
Chair of the Steering Committee

Dr. Ana Gavrilović,
Chair of the Local Organizing Committee

Aquaculture Europe 2017 Local Organising Committee:

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Zoran Radan (Secretary of the Croatian Aquaculture Association within the Croatian Chamber of Economy)

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Dr. Ana Gavrilovic (University of Pula)

Prof. Ivan Katavić (Institute of Oceanography Split)

Advances in wreckfish (*Polyprion americanus*) research: the DIVERSIFY project

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Why wreckfish?

Wreckfish is one of the largest Serranid species, reaching a size of 100 kg (**Fig. 1**). It is a deep-water fish found almost throughout the world and is characterized by an extended pelagic juvenile phase (Ball et al., 2000). Wreckfish is one of the most interesting new species for aquaculture diversification, due to its fast growth, late reproductive maturation, high market price, limited fisheries landings and easy manipulation in captivity (Suquet et al., 2001). Its large size makes this fish suitable for processing and development of value added products. However, there are major bottlenecks for its incorporation into the aquaculture industry, such as the difficulty in acquiring wild fish for initial broodstock formation, the lack of reproduction control in captivity and the lack of any larval rearing protocols (Fauvel et al., 2008; Papandroulakis et al., 2004; Papandroulakis et al., 2008). Reproduction and larval rearing of a very close relative, the hapuku (*Polyprion oxygeneios*) has been achieved recently in New Zealand (Anderson et al., 2012) providing some information that may be relevant to the wreckfish rearing efforts.

Figure 1. Wreckfish *(Polyprion americanus)* broodstock at the Aquarium Finisterrae, A Coruña Spain.

The EU FP7-funded DIVERSIFY project (www.diversifyfish.eu) begun in December 2013 in order to acquire the necessary knowledge for the diversification of the European Aquaculture production with some new/emerging finfish species. The project has a total budget of 11.8 million € for its 5 year duration (2013-2018), making it one of the largest research projects in the area of aquaculture funded by the

European Commission. In the case of wreckfish, DIVERSIFY examines the potential for wreckfish aquaculture, bringing together almost all partners involved so far in Europe in wreckfish domestication (**Fig. 2**), in order to acquire the necessary knowledge and develop the required procedures for the production of fertilized eggs and high quality juveniles to launch commercial production of this species. This article provides some highlights from the first 3 years of the DIVERSIFY project.

Reproduction

The research activities of DIVERSIFY regarding wreckfish reproduction focus on four objectives:

- Increase the availability of broodstocks,
- Describe the reproductive cycle in captivity,
- Develop spawning induction protocols for tank spawning, as well as artificial fertilization,
- Develop protocols for Computer Assisted Sperm Analysis (CASA) and sperm cryopreservation.

Table 1. Biometric data of wild wreckfish captured by the commercial fishery in the Azores Islands (Atlantic Ocean, Portugal).

	Min-Max	Mean	std
Total length (cm)	54-98	75.36	7.39
Standard length (cm)	48-99	65.99	7.66
Perimeter (cm)	40-81	55.13	6.14
Body weight (kg)	2.6-18.0	7.25	2.22
Eviscereated weight (kg)	2.4 – 16.0	6.73	2.00
Perivisceral fat (g)	0-339.3	70.42	71.93
Stomach weight (g)	54.2-457.2	147.98	72.12
Intestine length (cm)	61-144	96.48	13.96
Intestine weight (g)	34.2-274.0	94.48	61.57
GSI females (%)	0.05-0.65	0.29	0.17
GSI males (%)	0.01-0.54	0.11	0.11
Viscerosomatic index (VSI)	2.40-16.02	7.26	2.11

The collection of wild fish to establish new broodstocks has been carried out along the Galician coast of Spain (**Fig. 3**). It has been hindered by the scarcity of wild wreckfish and unfortunately until now only a limited number of fish (n = 5, 1-4 kg body weight) have been collected. However, this small number of fish adapted easily in captivity and showed resistance to handling, which is very encouraging for the future development of wreckfish aquaculture. Biometric data were obtained from a large number of fish captured by the commercial fishery in the Azores Islands (Atlantic Ocean), and sold fresh at the market in Vigo, Spain (**Table 1**). There was a sexual dimorphism in body size (**Fig. 4**) and fish were mostly immature.

During the years 2014, 2015 and 2016, broodstocks in different locations were followed in order to describe the reproductive cycle in captivity. These fish were maintained in a variety of environmental conditions in regards to tank size and photothermal regime, including indoor and outdoor tanks with natural photothermal conditions, and indoor tanks with simulated natural photothermal conditions or constant temperature. Maintaining these fish for a long period of time (starting well before the beginning of the project), it was quite apparent that this species exhibits a fast rate of growth (**Fig. 5**), and easy adaptation to the captive environment and handling procedures.

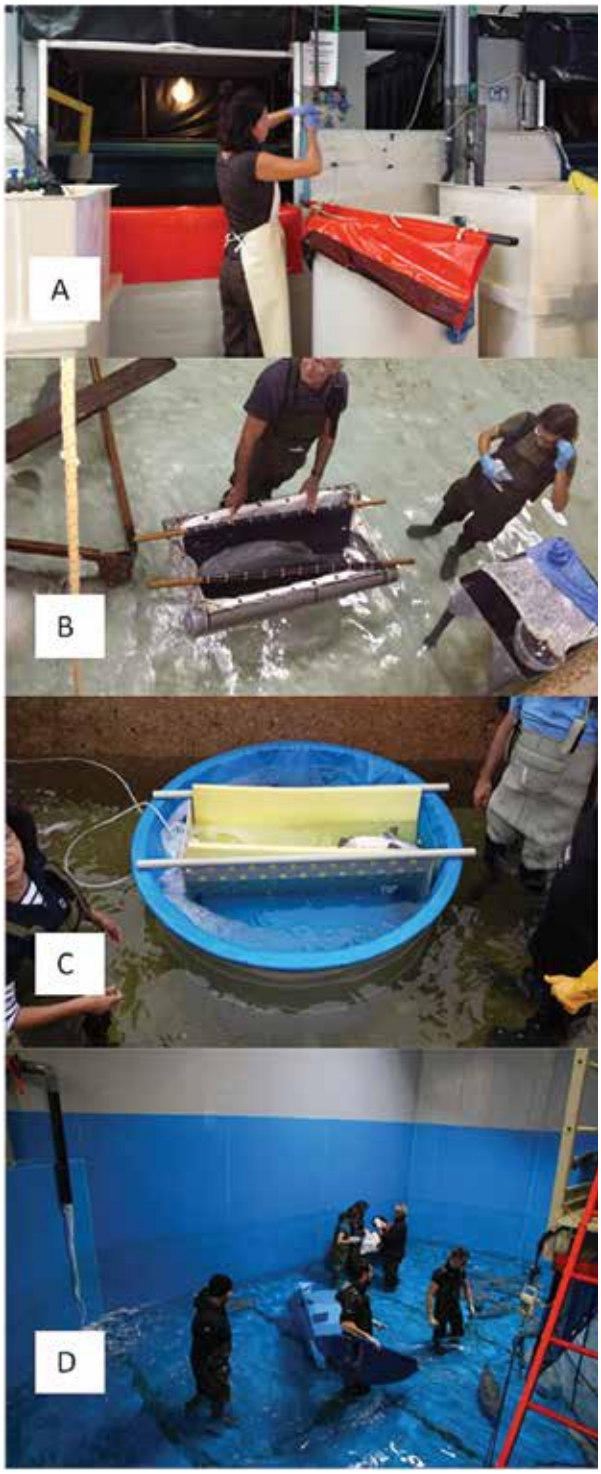

Figure 2. Different facilities working with wreckfish broodstock. (A) Hellenic Center for Marine Research (HCMR) Greece, (B) Institute of Oceanography, (IEO) Spain, (C) Xunta de Galicia (CMRM, IGAFA), Spain, (D) Aquarium Finisterrae, (MC2) Spain.

Monthly or bimonthly samplings were performed and blood, ovarian biopsies and sperm samples were

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Figure 3. Wreckfish captured in the West of Corrubedo Cape, La Coruña, Spain.

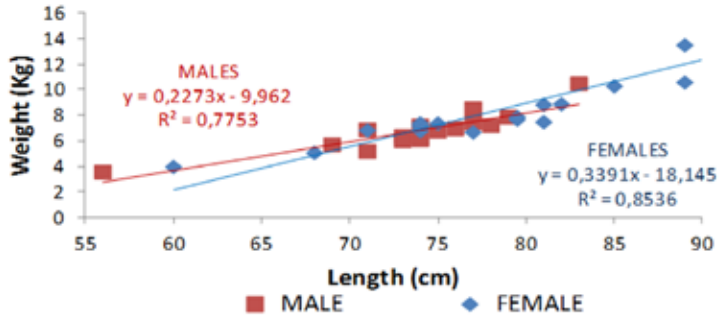

Figure 4. Length-weight relationship of wild wreckfish showing a sexual dimorphism.

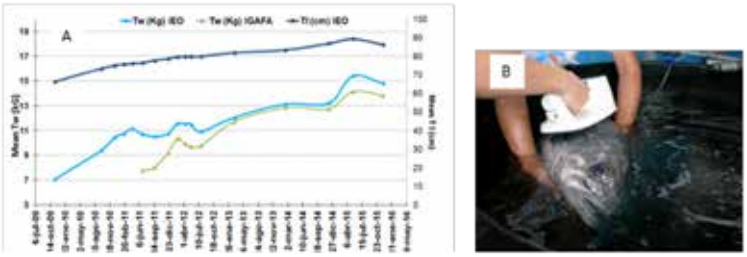

Figure 5. A) Mean total length (cm) and body weight (kg) of two wreckfish broodstocks maintained in captivity since July 2009 at IEO and CMRM (IGAFA), Spain. B) All breeders were individual tagged with PIT tags.

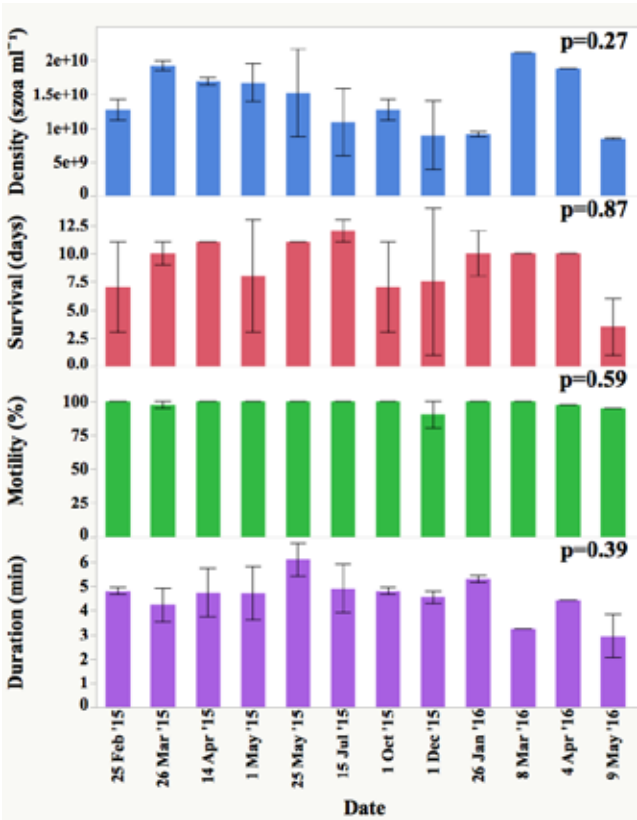

Figure 6. Sperm quality parameters of captive wreckfish that were in spermiating condition throughout the year. The fish were maintained under constant temperature (15-16°C), but simulated natural photoperiod at HCMR (Greece).

obtained. The ovarian biopsies were examined on site, as well as after histological processing, and the blood samples are currently being analyzed for their sex steroid content (testosterone, 11-ketotestosterone, 17β-estradiol, and 17,20β-dihydroxy-porgesterone), which are involved in the process of gametogenesis and maturation. Based on the results obtained from the various broodstocks over the 3-year period, it has been demonstrated that males exhibit good sperm quality with large amounts of expressible sperm during an extended reproductive period (April-July), while a proportion of males were shown to be spermiating throughout the year (**Fig. 6**). Gonadal recrudescence in females begins in the fall, but the main part of vitellogenesis takes place in the Winter (Dec-Feb), and oocyte maturation in captivity starts in March and peaks between April and June. Vitellogenesis continues until the oocytes reach a size of ~1200-1400 µm in diameter, at which time oocyte maturation may take place (**Fig. 7**). The vitellogenic process is long, probably related to the low water temperatures that this species can be found and also to the relatively large egg size for a marine fish.

Spontaneous spawning was observed, even though in an unpredictable pattern, mostly at the IEO and Aquarium Finisterrae facilities. At the HCMR facilities, fish that were in the appropriate reproductive maturation were treated with ethylene-vinyl acetate (EVAc) implants loaded with gonadotropin releasing hormone agonist (GnRHa), and were induced to undergo oocyte maturation and ovulation successfully. Both spontaneous spawning in different tank conditions and artificial fertilization were tried as different methods of viable egg production, since batches of eggs with low fecundity and fertilization rates were produced if the fish were allowed to spawn spontaneously in the tank. This may be indicative of a breeding behavior dysfunction –similar to what has been reported in Senegalese sole (*Solea senegalensis*) (Guzmán et al., 2009)- since the males always produced large volumes of high quality sperm. Using artificial insemination at the HCMR, a number of fertilized eggs were delivered to the hatchery for larval rearing (**Fig. 8**). Unfortunately, the exact timing of ovulation after the hormonal treatment and the post-ovulation survival of the eggs are currently not known and might be the reasons for the low fertilization of the artificially inseminated eggs.

On the other hand, spontaneous spawning in the IEO and Aquarium Finisterrae stocks produced a large number of fertilized eggs and achieved satisfactory

fertilization success (**Fig. 9**). During the spawning season of 2015, a total of 10 spawns were obtained from the IEO broodstock between March and June. The majority of spawns were spontaneous, except for one artificial stripping from the IEO and two from the Aquarium Finisterrae broodstock. During 2016, from April to the end of May, 7 spontaneous spawns were obtained from the IEO, and 12 spontaneous spawns and two by stripping from the Aquarium Finisterrae broodstocks.

Overall, spontaneous spawns were achieved in two of the four stocks (IEO, Aquarium Finisterrae) while both spawning after GnRHa therapy and by artificial stripping and fertilization was achieved in three of the four stocks (HCMR, IEO and Aquarium Finisterrae), with a fertilization success ranging between 49 and 100 % (**Fig. 10**). The wreckfish eggs have a large diameter (1.996±0.034 mm), with a large lipid droplet allowing them to float. Hatching takes place after 5 d of incubation at 16±0.8°C (**Fig. 11**)

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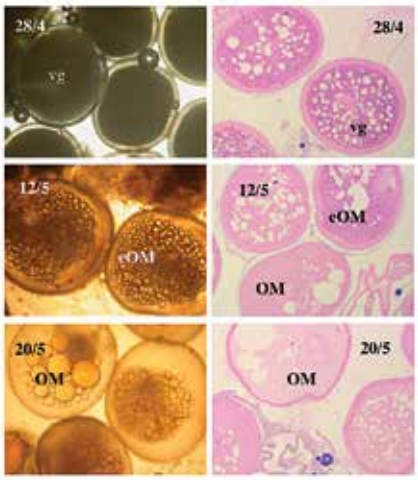

Figure 7. Wet mount and histological sections of biopsies from wreckfish during the 2014 reproductive season (dates on each photo). eOM = early oocyte maturation, OM = oocyte maturation, Vg = vitellogenic oocytes

Figure 8. Artificial insemination of wreckfish at the HCMR facilities.

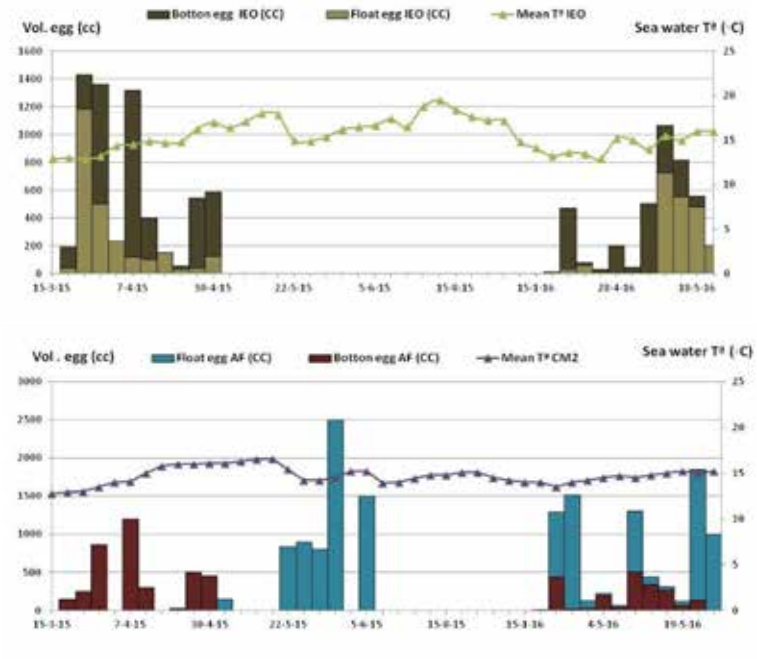

Figure 9. The volume (cubic centimetres cc) of viable floating and non-viable sinking eggs of wreckfish obtained from spawns at the IEO (upper) and Aquarium Finisterrae (lower) facilities between March 2015 and May 2016. A number of spawns were incubated and larvae were obtained.

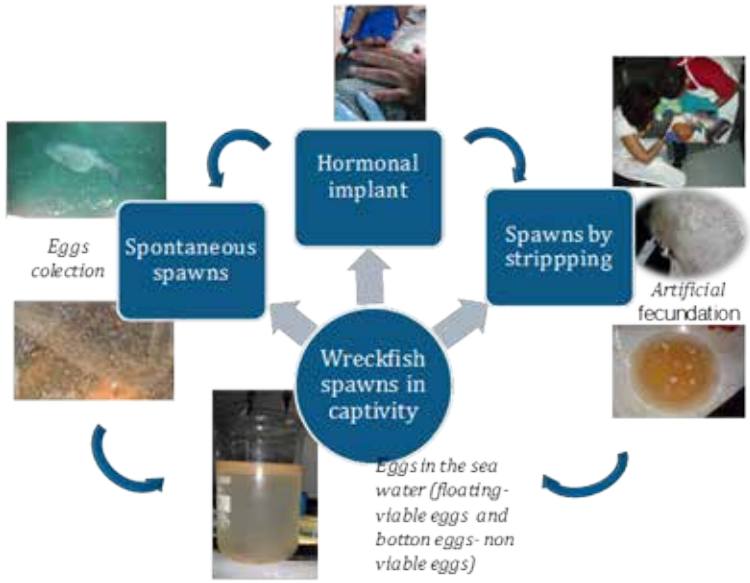

Figure 10. Wreckfish spawned spontaneously in captivity, and after a hormonal therapy with GnRHa implants eggs could be obtained either after tank spawning or using artificial fertilization. In all cases the eggs were collected for evaluation and subsequent incubation and larval rearing.

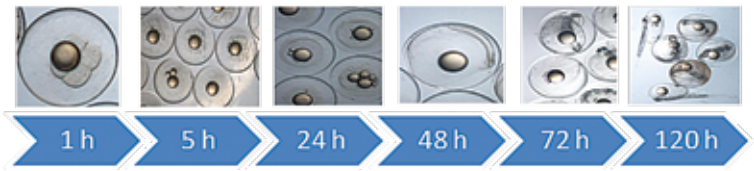

Figure 11. Embryonic development of wreckfish using eggs obtained from captive breeders.

As far as the development of the CASA (**Fig. 12**), wreckfish sperm exhibited a high percentage of motile cells at activation and one of the highest initial speeds recorded for fish sperm. This high speed was associated with a long swimming duration compared to other marine fish. The long duration exhibited a double trajectory shape. The first trajectory was straight (associated with the search of target eggs) and then the trajectory began bending, which was interpreted as a phase of searching for the micropyle on the egg surface. Cryopreservation of wreckfish sperm was achieved, while chilled storage does not seem to be a good solution for the management of sperm for artificial fertilization. The performance of frozen/thawed wreckfish sperm was half compared to samples of fresh sperm in terms of percentage of motile sperm and duration of swimming, while the velocity in modified Leibovitz medium was similar to that of fresh sperm. Since wreckfish produce large volumes of high quality sperm in terms of concentration, velocity and duration of motility, the loss of sperm quality due to freezing may be compensated by increasing the number of spermatozoa used per egg, as is usually practiced in other species.

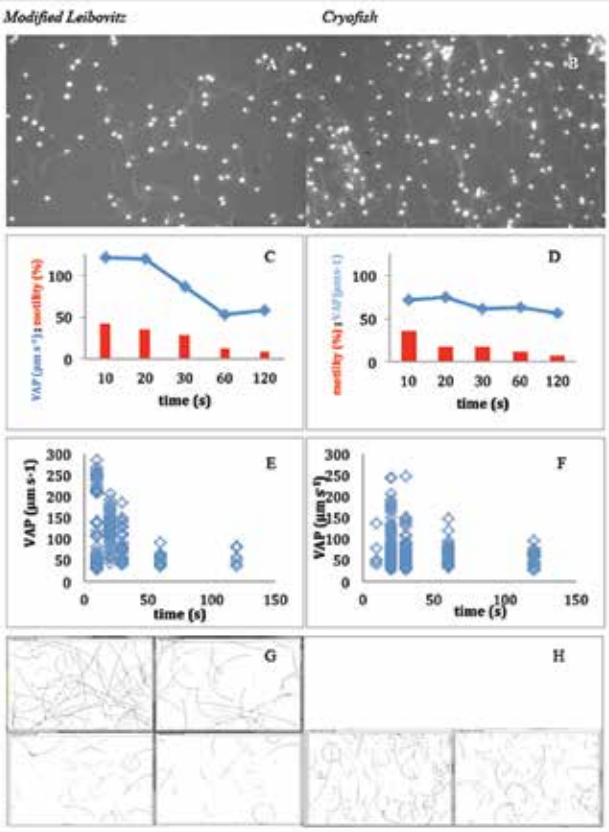

Figure 12. Wreckfish sperm status after cryopreservation in modified Leibovitz and Cryofish media. A and B: Pictures of the spermatozoa diluted in the different media (extracted from video records), Cryofish samples (B) show aggregations of spermatozoa unlike samples cryopreserved in modified Leibovitz (A). C and D: Mean velocity decrease and variations of the percentage of motile spermatozoa with time in the different media. E and F: individual velocities of spermatozoa recorded in the different media showing that modified Leibovitz (E) allows a high recovery of a larger number of spermatozoa compared to Cryofish (F). G and H: illustration of tracks generated by CASA for the spermatozoa stored in the two media: Leibovitz (G) and Cryofish (H).

Larval husbandry

The main objectives of DIVERSIFY are to understand the larval requirements in order to establish a rearing protocol. In particular, the effect of rearing temperature was studied and the description of the ontogeny of the digestive system was considered as a prerequisite for the development of an appropriate feeding protocol.

Progress during the last year was made towards the optimization of the environmental parameters. Taking advantage of the improved spawns and the availability of eggs, which allowed us to perform several trials, testing different incubation temperatures, it was shown that the optimal incubation temperature is 16±0.8°C. At this temperature range we obtained the best results regarding normal embryonic development and hatching rate of the eggs that reached 65%.

Regarding larval rearing, the results were not satisfactory, as the maximum period that the larvae survived never exceeded 27 days post hatching (dph). Several larval rearing trials were performed during the project's life. In all cases, similar rearing results were obtained by both the HMCR and IEO (**Fig. 13**). Larval total length was 4.70±0.27 mm at 1 dph. Yolk sac was consumed by 11 dph at 14-17°C and by 8 dph at 17-20°C seawater temperature. Mouth opening occurred at 7 and 4 dph at 14-17°C and 17-20°C, respectively. Following mouth opening, larvae were fed with enriched rotifers and *Artemia* nauplii, using different enrichment protocols.

During rearing, some malformed individuals were observed (**Fig. 14**). This problem could be related to inadequate nutrition, environmental conditions, oxidative stress, and husbandry conditions. We expect that in the coming year further studies will produce better results, towards the development of an efficient larval rearing protocol for this species.

Nutrition

Wreckfish nutritional requirements and optimum diets are missing. There is only limited information related to feeding habits and rates of wild-caught fish reared in captivity. The research in DIVERSIFY focuses on two main important aspects. Firstly, broodstock nutrition to determine the influence of broodstock feeds on fecundity and spawning quality. Secondly, larval nutrition to test the effectiveness of live prey and the influence of enrichment on wreckfish larval performance.

A comparative study on the composition of wild fish *vs* captive-reared wreckfish broodstocks was conducted. Analysis of tissues of wild and captive-reared wreckfish showed that cultured fish have more lipids in the muscle (27.5% DW) and liver (62%) than wild fish, which have 7% in their muscle and 40% in liver. In contrast, protein content is higher in the muscle of wild wreckfish than in captive-reared fish and some differences were also observed in the fatty acid profile with higher values of polyunsaturated fatty acids (PUFA) and n-3 PUFA in wild than in captive-reared wreckfish. The docosahexaenoic acid (DHA) values represent 11% in the muscle of captive-reared fish and 26% in wild fish **(Table 2)**.

Some commercial broodstock feeds were analyzed, showing that they have a high amount of fat for wreckfish broodstock and a new dry food was formulated on the basis of the data obtained from wild fish (**Table 3**). Our initial results showed that broodstock feed must contain high amounts of protein, low lipid content and a large amount of n-3 highly unsaturated fatty acids (HUFA), and the eicosapentaenoic acid (EPA) arachidonic acid (ARA) ratio must be around 1.5, similar to what has been observed previously in wild wreckfish. A comparison of feeding of broodstock with semi-moist diet and the new formulated diet was conducted, and a clear relationship between fatty acid profile of oocytes from the females and the two diets was found. Furthermore, some differences were observed in the fatty acid profile of oocytes from females of different wreckfish broodstock showing that there is a relationship between fatty acid content and oocyte development.

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Table 2. Biochemical composition of muscle, liver and gonad of wild and captive-reared wreckfish.

	Muscle		Liver	
	Wild fish	Captive-reared	Wild fish	Captive-reared
Proteins(%DW)	84.41±7.34	75.92±8.88	37.94±13.66	31.10±9.42
Lipids(%DW)	6.92±3.39	27.49±10.06	40.19±15.25	61.76±12.18
Fatty acids (% total)				
SAFA´s	28.83±1.28	24.46±1.25	26.11±3.51	22.44±2.27
MUFA´s	32.09±5.43	44.98±1.02	56.23±8.80	60.50±5.45
ARA	3.11±0.79	1.32±0.38	1.55±0.88	0.58±0.12
EPA	4.55±0.70	8.11±1.17	3.09±1.37	2.92±0.19
DHA	26.38±3.33	10.85±2.66	9.31±5.05	7.29±1.71
PUFA´s	39.08±4.41	30.57±0.58	17.66±8.19	17.07±3.32
Total n-3	34.51±3.75	23.78±1.68	14.93±7.01	13.44±2.00
Total n-6	4.08±0.81	6.02±1.85	2.55±1.23	3.48±1.99
n-3/n-6	8.50±1.18	4.51±2.39	5.79±1.42	4.97±3.31
DHA/EPA	5.69±1.23	1.38±0.49	2.99±0.91	2.48±0.47
EPA/ARA	1.54±0.37	6.58±2.15	2.13±0.60	5.16±1.00

Table 3. Composition of a new formulated dry feed from wreckfish broodstocks.

Ingredients	Dry food (%)
Fishmeal 70 LT FF Skagen	25.0
CPSP 90	10.0
Squid meal	34.2
Krill meal (Aker Biomarine)	7.5
Wheat Gluten	7.0
Wheat meal	7.25
Tuna oil	1.0
Algatrium 70% DHA	0.2
Incromega DHA 500TG	1.0
VEVODAR	1.3
Vit & Min Premix PV01	2.0
Lutavit E50	0.05
Soy lecithin - Powder	1.5
Macroalgae mix	1.0
Antioxidant powder (Paramega)	0.2
Antioxidant liquid (Naturox)	0.2
SelPlex - Se yeast	0.02
Carophyll Pink 10% - astaxanthin	0.05
Nucleotides (Nucleoforce)	0.03
L-Taurine	0.5
Total	100.0

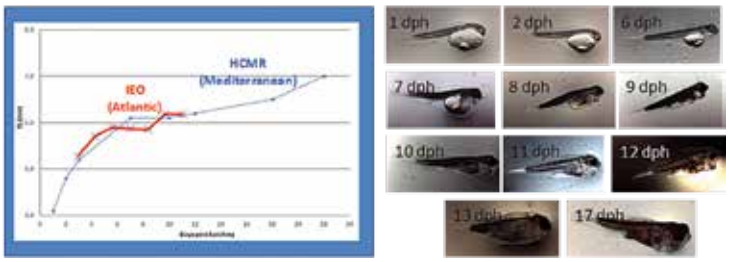

Figure 13. Wreckfish larval growth obtained in the trials that took place at HCMR and IEO (A). Development of larvae for the first 17 days post hatching (B).

Figure 14. Wreckfish larvae with malformations, similar to what has been referred to as "swollen yolk sac syndrome" or the "blue sack disease".

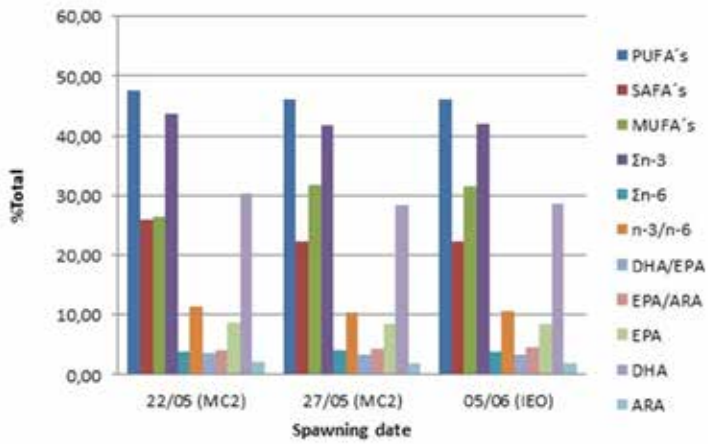

Figure 15. Fatty acid composition of wreckfish larvae at 10 dph, from three different spawnings (two from Aquarium Finisterrae broodstock and one from IEO broodstock).

Related to larval nutrition a new enrichment medium for larval wreckfish was designed on the basis of analyses of wreckfish eggs and gonads, and it will be tested in the next years. In addition, the fatty acid profile of larvae in the first days of life was described. The main fatty acids of wreckfish larvae at 10 dph are shown in **Fig. 15**. It appears that PUFA, saturated fatty acids (SAFA) and mono-unsaturated fatty acids (MUFA) values have a little variation in the first days of life.

The results obtained so far in DIVERSIFY in the studies of wreckfish indicate that acquisition of eggs is difficult but achievable in captivity, either by spontaneous spawns or hormonally induced protocols. However, juvenile production is not yet achieved, and in the following two years of the project it is expected to optimize the larval rearing methods, based on the use of new enrichment media for live food.

References

Anderson, S.A., Salinas, I., Walker, S.P., Gublin, Y., Pether, S., Kohn, Y.Y., Symonds, J.E., 2012. Early development of New Zealand hapuku *Polyprion oxygeneios* eggs and larvae. Journal of Fish Biology 80, 555-571.

Ball, A.O., Sedberry, G.R., Zatcoff, M.S., Chapman, R.W., Carlin, J.L., 2000. Population structure of wreckfish *Polyprion americanus* determined with microsatelite genetic markers. Marine Biology 137, 1077-1090.

Fauvel, C., Suquet, M., Sévère, A., Mylonas, C.C., Papandroulakis, N., 2008. Slow-release GnRHa therapy prevented atresia during vitellogenesis and induced ovulation of captive wreckfish (*Polyprion americanus*). Cybium 32(2) suppl, 191.

Guzmán, J.M., Ramos, J., Mylonas, C.C., Manaños, E., 2009. Spawning performance and plasma levels of GnRHa and sex steroids in cultured female Senegalese sole (*Solea senegalensis*) treated with different GnRHa-delivery systems. Aquaculture 291, 200-209.

Papandroulakis, N., Suquet, M., Spedicato, M.T., Machias, A., Fauvel, C., Divanach, P., 2004. Feeding rates, growth performance and gametogenesis of wreckfish (*Polyprion americanus*) kept in captivity. Aquaculture International 12, 395-407.

Papandroulakis, N., Mylonas, C.C., Syggelaki, E., Katharios, P., Divakaran, S., 2008. First reproduction of captive-reared wreckfish (*Polyprion americanus*) using GnRH implants, European Aquaculture 2008, Krakow, Poland.

Suquet, M., Normant, Y., Sévère, A., Barone, H., Fostier, A., Le Delliou, H., Fauvel, C., 2001. Growth performance of the wreckfish (*Polyprion americanus*) in captivity. European Aquaculture Society, Oostende, Belgium, 586-589 pp.

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IMTA site in Fureholmen, Sogn & Fjordane *(Pierrick Stévant)*

Seaweed aquaculture in Norway:

Recent industrial developments and future perspectives

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Photo credits: Kristin Straumsheim Grønli

Introduction

Aquaculture has a great potential for meeting challenges of increasing demand for food. It is the fastest growing food production sector and accounts for almost 50% of aquatic resources globally (FAO, 2016a). The world's total aquaculture production in 2014 was in excess of 100 million t, of which 27 million t were aquatic plants, which are mostly seaweeds with a commercial value of 5.6 billion USD (FAO, 2016b). Global seaweed cultivation is largely dominated by Asian countries, i.e. China (producing more than 13 million t), Indonesia, The Philippines, North and South Korea and Japan. In these countries, the biomass is either used for direct human consumption (both fresh and dried), or it is further processed for other food applications (mainly phycocolloids such as alginates, agar and carrageenan). In addition, non-food applications include fertilizers, pharmaceuticals, cosmetics. Aside from having multiple industrial applications, brown, red and green seaweeds have other assets which make them suitable alternatives to terrestrial biomass production: as autotrophic organisms, marine macroalgae utilize dissolved carbon dioxide and nutrients (e.g. dissolved inorganic nitrogen and phosphorus) in combination with light for growth and do not require feed nor fertilizer. They can be cultivated on large scales in coastal areas with little or no demand on fresh water resources in production cycles. Moreover, the fact that macroalgal growth rates exceed those of terrestrial plants have spurred the interest for cultivation of seaweed biomass, illustrated by a doubling of global production during the past decade (FAO, 2016b).

Commercial dried *Palmaria palmata* for human consumption *(Pierrick Stévant)*

The rapid development of fed aquaculture (e.g. finfish or shrimps) is often associated with environmental concern regarding the discharge of nutrients to coastal areas, potentially leading to deterioration of local marine environment. Integrated multitrophic aquaculture (IMTA) systems represent a practical solution for mitigating the negative effects of fish

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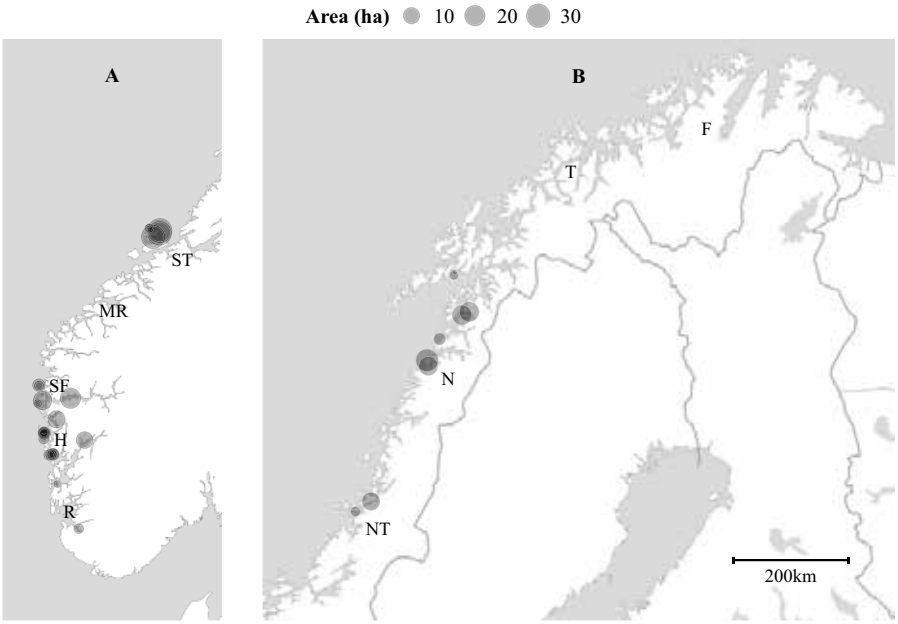

Fig. 1. Surface area allocated to seaweed cultivation sites along the coast of southern Norway (a) and Northern Norway (b) as of January 2017. Counties are listed from south to north: Rogaland (R), Hordaland (H), Sogn and Fjordane (SF), Møre and Romsdal (MR), Sør-Trøndelag (ST), Nord-Trøndelag (NT), Nordland (N), Troms (T) and Finnmark (F). Darker circles indicate several cultivation sites close to each other. Data from the Directorate of Fisheries (2016a)

farming wastes by utilising excess nutrients as a valuable resource for marine plant production. Seaweeds in such integrated cultivation systems, e.g. in proximity to fish farms, function as extractive components within a cultivation food web. In addition to reducing the environmental impact of intensive fish aquaculture, IMTA systems add value to the investment in finfish aquaculture by increasing the yield of total biomass produced on a single site (Chopin et al., 2012).

Commercial dried *Laminaria digitata* for human consumption *(Pierrick Stévant)*

For more than five decades, seaweeds have been the subject of considerable industrial utilization in Norway based on harvesting of natural biomass. Harvested wild seaweed biomass of primarily *Laminaria hyperborea* (commonly known as 'forest kelp', Northern kelp' or 'cuvie') but also *Ascophyllum nodosum* (knotted wrack) amounted to over 154,000 t fresh weight in 2014 (FAO, 2016b). Harvesting of wild *L. hyperborea*, using specifically designed trawling equipment, remains somewhat controversial as the removal of and interference with natural habitats (specifically kelp forests) has the potential to affect local biodiversity and ecosystem integrity, and may contribute to coastal erosion. Although Norwegian management regimes for seaweed harvesting are considered to be among the best in the world, regional conflicts persist between the seaweed trawling industry and other coastal zone users (representing for instance coastal fisheries, marine conservation groups and ornithologists). Even with positive developments in knowledge-based integrated coastal zone management with broad stakeholder involvement, and the consideration of a prospective geographic expansion of kelp trawling areas northward, it is not foreseen that future harvesting of wild kelp biomass will be able to meet the growing demands of an industry that is mainly producing alginate from *L. hyperborea*.

Norway's long and complex coastline extending over 100,000 km and characterized by fjords, islands and skerries is highly suited for aquaculture. The cold temperate waters of the Northeast Atlantic are home to more than 400 species of brown, red and green seaweeds, many of which have recognized commercial value. Norway is the world's second largest exporter of seafood and has natural advantages which create opportunities to increase seafood production through aquaculture. In 2015, 1.38 million t of salmon and trout were farmed in Norway. As salmon and trout production in Norway is predicted to increase by approximately 3 to 5% per year over the coming decades, measures must be taken to limit the negative effects of excess nutrient discharge, especially environmental eutrophication and resulting ecological degradation and biodiversity loss. In addition, finite global phosphorus resources provide a powerful argument for recovering excess nutrients, specifically phosphorus, from all sources including aquaculture and in view of their high value. The benefit of employing IMTA in this context, i.e. recovering organic and inorganic nutrients discharged from fish farms, is emphasized in a study by Wang et al. (2012) which highlights the potential for seaweed production in Norway, based on the estimated total amount of dissolved inorganic nutrients released by salmon farms. In this context, the development of seaweed aquaculture in Norway is supported the European strategy driving "Blue Growth" initiatives.

Status of seaweed aquaculture in Norway

Experimental cultivation of kelps (Laminariales) at sea in Norway started around 2005 following successful trials conducted in France, Germany, Ireland and

Table 1: Statistics from seaweed cultivation in Norway between 2014 and 2016. Source: Directorate of Fisheries (2016a; 2016b). Production data for 2016 have not yet been registered (as per January 2017).

	2014	2015	2016
Total seaweed cultivation sites at sea	8	24	36
Total surface area for seaweed cultivation at sea (ha)	76	194	277
Seaweed production output (t wet weight)	na	51	na
Commercial value (USD) [a]	na	21 760	na
Number of companies involved in seaweed cultivation	6	16	20

a Values initially expressed in Norwegian krone (NOK). The exchange rate of 1NOK= 0.1221USD was used.

Scotland. Joint efforts of key actors from both research and private sectors primarily focused on developing cultivation technology in order to upscale the biomass production. Current efforts regarding the industrial scale production of seaweeds, mainly sugar kelp (*Saccharina latissima*), are now being directed at developing efficient farming strategies that reduce the need for technical maintenance, along with marine technology, including mechanisation of seedling deployment, biomass harvest and crop handling logistics (MACROSEA, www.sintef.no/projectweb/macrosea/). Efficient cultivation technology along with access to sufficient area at sea is a prerequisite for the sustainable development of an industry based on the utilization of seaweed biomass. Although activities to date have been characterised by research and pilot scale production, the first commercial permits for cultivation of seaweeds were granted in 2014 following the creation of a specific - interim - licensing system for macroalgae by public authorities. The Ministry of Trade, Industry and Fisheries coordinates the processing of seaweed farming applications and considers them according to the Aquaculture Act. The evaluation of applications involves several authorities, including the Directorate of Fisheries, The Norwegian Coastal Administration, the Norwegian Food Safety Authority, The County Governor's Environmental Department and The Norwegian Water Resources and Energy Directorate, each one considering potential conflicts of the application within their area of responsibility. Whether the seaweed farm is in concordance with coastal zone spatial plans, is considered by the concerned municipal authorities, as coastal zone management lies within the municipalities' responsibility.

Since 2014, several permits for sea cultivation of seaweeds, including in IMTA systems, have been granted following the rapid increase in the number of private actors involved in this activity (table 1). The surface allocated to seaweed cultivation has more than tripled between 2014 and 2016, currently reaching a total of ca. 277 ha along the entire Norwegian coast, and corresponding to a production potential of approximately 16,000 t (as estimated from the total maximum production by applicants on each cultivation sites). However, this potential by far exceeds the real production output, given that most companies involved in this activity are at a start-up phase characterized by experimental production. In fact, only 10 of 16 companies holding a cultivation permit were operating in 2015 (Directorate of Fisheries, 2016a; 2016b). In Norway as in the rest of Europe, efforts for large-scale cultivation of seaweed biomass has been focussing largely on kelp species, particularly *S. latissima*, because of the species' potential for high biomass yields and valuable nutritional content. The cultivation of *S. latissima* represented 96% (49 t wet weight) of the total production output, while cultivation of winged kelp (*Alaria esculenta*) represented the remaining 4% (2 t wet weight). Although licences for cultivation of a wide range of species (e.g. *Palmaria palmata, Ulva* spp., *Laminaria digitata, Porphyra* spp.) were granted, none of these are currently cultivated at sea. Given the data reported by the Directorate of Fisheries (2016b) for the year 2015, the retail value of *S. latissima* and *A. esculenta* was 399 USD t^{-1} and 1099 USD t^{-1}, respectively. Although no information is available regarding the retail markets of the produced biomass, *A. esculenta* is often sold in dried or fresh form as a high value food ingredient or sea vegetable whereas *S. latissima* has a broader range of market outputs, e.g. dried for human consumption or as meal in animal feed, which may explain the difference in market value. A higher value for *A. esculenta* may also simply result from a lower biomass availability on the market. As a comparison, retail value of the global seaweed production output is estimated to 206 USD t^{-1} in 2014 based on figures mentioned earlier (FAO, 2016b).

Despite a long coastline and an increase in the number of permits at sea, seaweed cultivation sites are still scarce and not evenly distributed along the Norwegian coast (fig. 1). A very large part of the allocated surface area (87%) shared by 28 cultivation sites is concentrated on ten municipalities, localized in few counties, namely Hordaland and Sogn and Fjordane in the west, Sør- and Nord-Trøndelag in the mid-part and Nordland in the northern part of the country. Hence, there is a large potential to establish seaweed cultivation in other areas, especially the Møre and Romsdal county in the west, as well as Troms and Finnmark counties in the north, both of which are characterized by extensive areas and the presence of salmon aquaculture (see possibilities for integration of seaweed and salmon farming above). At present, only a few of the existing cultivation sites are in the vicinity of fish farms, hence characterized as IMTA. Most of the so-called IMTA sites were developed as "add-on" to a pre-existing fish farm and to date, few have been fully designed for the purpose of fish and seaweed co-culture. However, many sites of seaweed monoculture are located in areas of intense salmon production (Directorate of Fisheries' interactive map:

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IMTA site in Oldervika, Nordland *(Céline Rebours)*

Harvesting *Alaria esculenta* from the IMTA in Oldervika, Nordland *(Céline Rebours)*

http://kart.fiskeridir.no/default.aspx?gui=1&lang=2) thus, are likely to directly benefit from nutrient releases originating from fish farming activities.

The cultivation cycle of the kelp species is based on their life cycle. Sporelings are grown from microscopic stages i.e.zoospores or gametophytes (derived from zoospores) under controlled conditions and directly seeded onto appropriate substrata (e.g. twine, nets, ribbons, sheets) which are later on deployed at sea for further growth under natural conditions. Although the production of spores in natural kelp populations is seasonal and species-specific, sorus (reproductive structure) formation can be induced artificially by, for example, controlling the light regimes provided to adult sporophytes. In this way, viable sporelings can be produced at all seasons. However, biofouling of the biomass from epiphytic organisms limits the cultivation period at sea from autumn to spring (see Risk assessment 1 – epiphytes and diseases).

Product applications - industrial perspectives

Seaweed cultivation has been subject to increasing interest in Europe over the past decades, and activities have benefited from recent trends towards a bio-economy based on natural, and especially marine, biological resources. In Norway, research efforts to develop seaweed cultivation and processing technology were driven initially by the interest for producing bioenergy from seaweed´s carbohydrates. However, the production of biofuel and biogas on commercial scales is impaired by the difficulties associated with producing large biomass volumes, since neither cultivation technology nor access to aquaculture sites at sea have yet been sufficiently developed for large-scale production. In addition, the market value for seaweed biomass as biofuel is low compared with other product types (Skjermo et al., 2014). Seaweed biomass is a rich source of a wide range of bioactive products of potentially high market value. Relevant applications include (i) human food, (ii) domestic animal and fish feed products, (iii) fertiliser, (iv) prebiotics, (v) cosmetics, (vi) bioactive peptides and (vii) pharmaceuticals and nutraceuticals, and these are predicted to play an important role in the emerging Norwegian bio-economy based on seaweed cultivation.

In the past, mainly brown algae have been utilised in Norway. Primary applications have been alginate (used as food additives, health products and bio-medicinal ingredients, to name just a few), or agricultural products (i.e. animal feed supplement and soil enhancers/fertilizers). In most cases, the seaweeds have been used for the functional properties of their polysaccharides or their mineral content. Although the seaweed chemical composition is variable depending on species, collection time and habitat, the nutritional value of several species is well characterized. Most species share a low lipid content on the one hand, while being rich in polysaccharides (both structural and storage) and minerals on the other. Other nutritional properties, such as a relatively high protein content and high quality profiles of amino-acids, lipids and minerals are highly relevant towards food and feed applications. Positive effects of

including seaweeds in feed meals have been reported for both, marine and terrestrial organisms, and several feed products based on powdered dried seaweed are commercially available.

Seaweeds have traditionally been a major element of the diet in Asian countries and are used extensively as food in China, Japan, Korea and the Philippines where they are recognized for their nutritional value as well as for rich and unique flavours. In Europe, traditions of eating seaweeds have been limited to coastal communities, and over the past centuries, few regions have had an explicit culture for utilising seaweeds as a significant component of the people's diet. The use of seaweeds as food in Norway goes back to the Vikings who likely brought dried dulse on long expeditions at sea for its virtues in protecting against scurvy, following its high content of vitamins. In recent decades, Asian dishes such as sushi, have enjoyed increasing popularity and contributed to introducing seaweeds to European palates. In Scandinavia, the renewal of the Nordic cuisine initiated by high-end restaurants and based on locally available natural ingredients has aroused interest for including seaweeds in the gastronomy. Previous studies have revealed the potential of seaweed species native to the Atlantic coast of Europe (e.g. the red algae *P. palmata* and the kelps *S. latissima* and *A. esculenta*) to be used as food ingredients in a wide range of foodstuffs both as vegetables and flavour enhancers. In Western Europe, i.e. France, Ireland, Spain and U.K., a number of small and medium-sized enterprises are using wild or cultivated seaweeds in food products. This new type of businesses has developed in recent years following the rising demand from European consumers (NETALGAE, 2012). In France, edible seaweeds e.g. S. latissima, P. palmata, Undaria pinnatifida and Himanthalia elongata are sold in fresh or dried form, as "sea vegetable" or condiment, or are incorporated in various product types (e.g. spreads, dressings, soups). The retail price of these products, mainly sold in organic or health food shops, varies greatly with product category, seaweed species and the amount of seaweed used, but the identified market value is generally high i.e. over 100 € kg^{-1} (ca. 105 USD kg^{-1}) on average for dried and flaked seaweeds. Although there is no data available regarding seaweed consumption in Norway, it is truly marginal and few Nordic seaweed food products are currently available. The development of such "niche" food products, based on market and consumer insight, can contribute to creating value from Norwegian produced seaweed biomass on a relative short-term. Thoroughly investigating the food safety of commercialized edible seaweeds (see Risk assessment 2 – product related) is, however, essential.

Moreover, seaweeds contain a large variety of phytochemical constituents that can be used in the prevention and treatment of health diseases by various mechanisms. Bioactive compounds of interest include polysaccharides (e.g. alginates, fucoidans), polyphenols and pigments, to name just a few. Besides being used mainly in the food industry as thickening or emulsifying agent, alginates are regarded as a source of dietary fiber with beneficial effects both on colonic and cardiovascular health. Alginate polymers can be artificially modified to achieve tailored properties suited in various medical applications including cell micro-encapsulation, tissue engineering and regeneration, and dental impressions. The company leading the alginate production in Norway (FMC BioPolymer) manufactures ultrapure alginate from wild Laminaria hyperborea for research and high-end commercial applications. The same firm recently obtained the authorization to commercialize high purity extracts of fucoidan as a dietary ingredient. Fucoidan represents a group of polysaccharides from brown seaweeds, mainly composed of sulfated fucose with documented bioactivity. Other compounds which are currently not commercially exploited in Norway may offer industrial opportunities in the future. Carotenoid pigments from brown algae, namely fucoxanthin, are recognized for their antioxidant activity as well as positive health effects against obesity and type-2 diabetes, and can be found in dietary supplements and nutraceuticals. Phycoerythrin, a pigment from red algae, is used extensively in fluorescent applications in clinical and immunological analysis as well as natural dye in the food and cosmetic industry. Extraction procedures of this pigment using common species along the Atlantic coast of Europe, e.g. P. palmata, have been suggested together with methodology for industrial upscaling. Polyphenols are secondary metabolites which are abundant in brown seaweeds such as A. nodosum, Fucus spp., and widely recognized for their antioxidant properties. Polyphenol-rich extracts from brown algae have inhibitory effects against lipid oxidation in fish and fish oil. Hence, polyphenols may provide a safer alternative to synthetic commercial antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and tert-butyl hydroxyquinone (TBHQ) which are currently used in the food and feed industry, and criticized for their potential toxicity and carcinogenic effects. The commercial exploitation of such high value-added products will require relatively low biomass volumes in comparison to bulk products (e.g. biofuels), and is predicted to generate economic value from cultivated macroalgal biomass. However, the extraction of these substances is technology demanding thus, associated with high investment costs. More knowledge is also required regarding the market potential of seaweed bioactive compounds to identify commercial opportunities.

In contrast to current processes in the Norwegian alginate industry, in which only a fraction of the harvested biomass is utilized and by-products are discarded, recent trends towards bio-economy favour complete utilization of produced biomass, recycling of nutrients in complete cycles and hence, reducing negative environmental impacts. Integrated processes maximizing biomass utilization by recovering a stream of products from seaweed biomass have been studied with promising results. An increasing number of initiatives involving both research and industrial partners are aiming to develop biorefinery processes of marine macroalgae in Norway, in order to optimize feedstock utilization towards a wide range of products. However, the high water content of seaweeds (70 to 90%) represents a challenge for conserving and transporting large amounts of biomass (as in industrial production) from harvesting to processing sites. Seaweeds are characterized by a rapid microbial decomposition once harvested, and thus require appropriate preservation methods to maintain

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Lumpfish *(Cyclopterus lumpus)* in an IMTA site in Oldervika, Nordland *(Céline Rebours)*

biomass quality and ensure product safety. Primary processes such as drying can effectively stabilize the biomass but require technology and may be difficult to implement close to harvesting sites for large biomass volumes. Drying also affects the chemical content with consequences for the product's nutritional value as well as extraction yields of bioactive compounds during further processing. Post-harvest treatments that will contribute to maintaining biomass quality include seawater storage, cold storage, silage and freezing. A recent study by Broch et al. (2016) stressed that large-scale seaweed cultivation sets standards for efficient logistic strategies and suggests the use of energy surplus from existing industrial facilities along the coast for processing of large biomass volumes. Another national research project investigates the possibilities for using energy surplus from a waste incinerator located on the west coast of Norway for seaweed processing, including its technical, economic and logistic potential (PROMAC, www.promac.no/).

Risk assessment 1 – Managerial tools associated with seaweed cultivation and IMTA

Despite a growing interest for seaweed cultivation in the western world and a wide range of industrial applications globally, the tools and methods for establishing a seaweed industry in Norway - whether they are technical, economic, environmental, social or regulatory - still need to be developed or adapted from Asian models to fit European frameworks. This will help aquaculture enterprises and policy makers gain a better understanding of the risks and benefits associated with seaweed cultivation in both monoculture and IMTA systems, and provide conditions suitable for the development of a sustainable bioeconomy based on macroalgal biomass.

By cultivating extractive species (e.g. seaweeds) near fish farms, IMTA systems increase the biomass production of an aquaculture site associated with a certain area license. Whereas seaweed cultivation integrated with fish farms is currently being viewed as an experimental "add-on" to existing aquaculture sites of salmonid fishes, the potential of seaweed production for improving environmental and economic performance of fish aquaculture and consequently increasing biomass production, is significant. The regulatory frameworks largely differ among species (i.e. fish, seaweed, shellfish) and are non-existent for species combinations (particularly concerning the integration of finfish, shellfish and seaweed production). The current interim regulatory process in use includes seaweed cultivations and IMTA systems, but needs to be specifically adapted for the various seaweed farming scenarios. An adaptation of the legal framework needs to achieve the transition from fed-monoculture (fish or shellfish) to poly- and integrated aquaculture. In addition, the adaptation of existing regulations and policies for IMTA will demand an assessment of the risks and benefits of developing new aquaculture systems or using new aquaculture species.

The "Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry" provides a guideline for current Norwegian aquaculture policies, focusing on five key problem areas, i.e. (i) genetic interaction and escape, (ii) pollution and emissions, (iii) disease, (iv) area utilization and (v) feed and feed resources. Whereas these policies were designed for fish aquaculture, they are equally relevant for seaweed cultivation, and are discussed below in this context.

Genetic interactions

There are several infamous cases of accidental introductions of non-native seaweed species to new coastal environments, e.g. *Undaria pinnatifida* and *Sargassum muticum* to Western Europe and *Caulerpa taxifolia* to the Mediterranean Sea, which have resulted in massive population explosions of the non-native species and consequently significant ecosystem alterations. Because spreading of non-native species can have large environmental and economic impacts, their intentional use in mariculture must be prevented.

Though seaweeds have been exploited in Asia for centuries, selective breeding of crops is a relatively recent practice, carried out for the purpose of increasing yields and/or value by optimizing seaweed growth, improving the biomass' general quality or increasing the content of one or several desirable compounds, as well as improving performance towards pathogens and competitors. Commercial varieties of *Saccharina japonica* as well as eucheumoid species like *Kappaphycus alvarezii* and *Eucheuma denticulatum* illustrate successful efforts towards seaweed crop improvement. However, crop selection and the use of the selected varieties on a large scale may lead to gene swamping, where genetic material from cultivated crops is introduced to wild populations.

The genetic structure and degrees of isolation between populations of species that are relevant for aquaculture in Norway are still poorly understood. Recent studies conducted on kelp species showed increasing genetic isolation correlated with distance among populations. Water current patterns were identified as the primary force responsible for spreading of dispersal stages, resulting in gene flow among populations. High extent of isolation may lead to phenotypic differences among populations, which can be affected by selection. Accordingly, morphological differences between sugar kelps from Northern and Southern Norway were reported, as well as differences in growth under certain conditions. In this regard, the use and spreading of crop material along the coast of Norway must be regulated to limit the effects of "crop-to-wild" gene flows. Hence, using local ecotypes for crop breeding is recommended as well as restricting the produced crops within fjord systems and coastal areas defined by the eco-region based map catalogue from the Norwegian Environment Agency (Miljødirektoratet, https://kartkatalog.miljodirektoratet.no/Dataset/Details/501). Sterilization technologies for cultivated seaweeds have also been suggested as a measure to mitigate gene swamping but examples of supposedly sterile aquaculture organisms adapting over time and eventually being able to reproduce after all, advise caution in such cases.

Impact on ecosystems

As organisms which take up dissolved nutrients from surrounding seawater, seaweeds function as extractive components in culture systems. Thus, they assimilate dissolved inorganic nitrogen and phosphorus, which, in many coastal ecosystems, originate from terrestrial runoffs or from fish farming activities. In this way, seaweed cultivations can mitigate potential eutrophication of coastal environments. In addition to nutrients, seaweeds assimilate dissolved carbon in form of CO_2 as part of the photosynthetic processes. The annual production of a Norwegian kelp forest (*L. hyperborea*) was estimated between 14 and 25 t ha^{-1} dry weight, corresponding to 5.6 to 10 t ha^{-1} of carbon-bound biomass growth, ranking these kelp forests among the most productive vegetation systems on earth. Likewise, the brown alga *Ecklonia cava* cultivated on ropes has the potential to extract approximately 10 t CO_2 ha^{-1} $year^{-1}$. Large-scale seaweed cultivation is justifiably regarded as a potential temporary CO_2 sink and may contribute substantially to the management of human impacts on atmospheric and oceanic carbon cycle interactions.

Seaweed cultivations create a temporary habitat for invertebrates and fishes, increasing habitat complexity, possibly functioning as artificial reefs and contributing to ecological interactions within nearby ecosystems. Although such an effect has not been systematically investigated, seaweed cultivation fields have been observed to house associated biota, i.e. mobile drifting or swimming organisms and attached fauna and flora. These observations indicate an overall positive effect on local biodiversity, but environmental monitoring over time will provide evidence. Similarly, benthic environments associated with seaweed cultivations are bound to be altered, and the effects need to be documented systematically. An ongoing research project in collaboration with Norwegian fish farmers (TARELAKS, contact Céline Rebours) is addressing ecosystem effects of co-cultivation of seaweeds and salmonids at pilot IMTA-sites. In this context, the effects of seaweeds on water quality (e.g. current speed, dissolved nutrient content, chlorophyll *a* content) and fish health parameters, as well as on biological diversity near the seaweed cultivation sites are being assessed. Preliminary observations obtained from a Norwegian farm in a European project (IDREEM, www.idreem.eu/) indicate high abundances of juvenile fishes associated with macroalgae cultivations. Especially lumpfish, *Cyclopterus lumpus,* appear to be common in seaweed farms. This is a potentially valuable association, as lump suckers are being used as cleaning fish in salmon farms to remove parasites (salmon lice) from the farmed fish. Salmon lice infestations represent one of the major challenges facing the salmon aquaculture industry in Norway, and developing biological controls is a priority.

Nutrient transfers form seaweeds and kelp forests to other ecosystems are key processes in nature, increasing food availability to otherwise nutrient-poor environments. However, besides acting as a temporary nutrient sink and having potentially positive effects on surrounding pelagic environments, large-scale seaweed cultivations may also cause high material deposits on

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the seafloor which could have adverse consequences on benthic ecosystems and biodiversity through decomposition processes and associated oxygen depletion. In addition, physical shading of both pelagic and benthic ecosystem by large-scale seaweed cultivation may affect primary production in the case of shallow inshore areas, although these effects have not yet been studied.

Epiphytes and diseases

Problems with pathogens and epiphytes of seaweeds may arise in large-scale and high-density cultivations. In Norway, the presence of epiphytic invertebrates, especially bryozoans (e.g. *Membranipora membranacea* and *Electra pilosa*), but also blue mussels (*Mytilus edulis*), hydroids and fouling macroalgae has been reported for sugar kelp cultivated at sea during summer months. In worst case scenarios, such fouling may lead to extensive blade damage and loss of biomass or considerable quality deterioration. Whereas the diversity of associated organisms in natural kelps beds carries important ecological functions in coastal areas, biofouling by epiphytes is a major constraint for the year-round cultivation of seaweed biomass, forcing producers to harvest in May-June, hence limiting the year-round seaweed cultivation at sea. Outbreaks of encrusting colonies of the bryozoan *M. membranacea* are the result of settlement of cyphonaut larvae, which are present in the water column of coastal area throughout the year with a peak of abundance during the summer. Larval recruitment and the extent of biofouling which may vary among cultivation sites, are linked to zooplankton population dynamics, influenced by a wide range of both biotic and abiotic factors including the temperature history and wave action. Seawater temperature seems to play an important role since the onset of fouling is somewhat delayed at higher latitudes. However, the same time delay is observed for growth of kelps, with growth seasons extended into late summer in Northern Norway, compared to more southern locations. Hence, the growing season for cultivated sugar kelp is limited from October to May in southern Norway, and possibly to August in Northern Norway, and the crops must be harvested before the onset of fouling. In the case of IMTA, the peak nutrient release from fish farms occurs during the summer months, due to high metabolic activity and growth of the fish. Developing crops resistant to fouling or alternative seaweed species as summer crops, is key to increasing the production efficiency in IMTA systems.

Seaweed production in IMTA systems will also alter the surrounding water quality and the fish-rearing environment in general, e.g. by changing the oxygen content resulting from photosynthesis and respiration, as well as hydrographic regimes to the fish cages. Large-scale seaweed cultivation may also influence fish health indirectly either by acting as a physical and/or biological barrier for pathogens, or in the opposite case, as a reservoir for fish disease agents.

Whereas evidence from IMTA sites elsewhere indicates many benefits – both on conceptual, practical, environmental and economic levels, potential risks associated with integrated fish and seaweed production need to be evaluated and assessed in the context of specific geography, production systems (regarding both fish and seaweed), scales of production, and associated technology. Such issues are also addressed in on-going research projects in Norway.

Area utilization

A special commission mandated by the Norwegian Ministry of Trade, Industry and Fisheries stressed that a sufficient number of locations must be assigned to aquaculture with focus on efficient production and minimal environmental impact. An economically viable seaweed aquaculture sector requires large areas for cultivation which may lead to conflicts with other users of the coastal zone. Integrated management tools applied across municipal boundaries are therefore necessary to avoid conflicts between seaweed cultivation on the one hand and other uses, including fisheries, fairways, nature protection, renewable energy production, kelp trawling areas as well as oil and gas installations on the other.

Although the current demand for seaweed biomass can be met by cultivation sites in the Norwegian coastal zone, model simulations including environmental variables critical to seaweed growth (e.g. light intensity, nutrient, temperature and current speed) showed better and more stable conditions off the continental shelf than closer to the coast. The modelling study by Broch et al. (2016) was carried out for the coast of Møre and Romsdal county with an overall conclusion of a prospective upscaling of seaweed biomass production placed offshore.

However, offshore working environments entail technical challenges including mooring of the cultivation structures as well as logistic aspects from deployment of seedlings at sea to harvesting and processing of the biomass. Knowledge and competence transfer from existing maritime industries (e.g. oil and gas) is pointed out by the authors as a key factor for the success of the future offshore seaweed production.

Threats from climate change

Climate change is likely to impose threats to marine ecosystems and consequently aquaculture. Rising sea temperatures could eventually lead to significant changes both in terms of aquaculture species, optimal range for the production and localization patterns. Higher sea temperatures will involve a relocation of the boundaries of the distribution of organisms in the ocean, including seaweeds, and the general northern displacement of farmed organisms. Higher summer sea surface temperatures may be problematic for farmed species that are adapted for life in cold water. As a result, the productivity of aquaculture species can be affected and southern Norway may be less suitable for species such as salmon, with socio-economic impacts. Such climatic changes may eventually entail that northern areas will be better suited for mariculture than southern regions. Assessments of the consequences of climate change on aquaculture species in the UK and Ireland, suggested that elevated sea temperatures and changes in hydrodynamic regimes will impact macroalgal cultivation; however, impacts will likely vary according to species and geographic locations. It is therefore particularly important to investigate the framework conditions

for seaweed monoculture and IMTA along the entire Norwegian coast.

Risk assessment 2 – Product related

In contrast to the many features of seaweeds beneficial for human health and nutrition, seaweeds may also accumulate undesired compounds such as heavy metals (lead, mercury, cadmium, arsenic) as well as minerals and trace elements which may be toxic above a certain limit (iodine, manganese, zinc).

Variations in content and concentrations of undesirable and toxic compounds are dependent on species, seasons and locations, and in general, levels of toxic compounds are often related to the quality of the surrounding environment of harvested or cultivated seaweeds. However, few studies about negative consequences of consuming seaweeds have been carried out, but among the best documented are effects of high iodine content in some brown algae. The potentially mitigating effects of primary processing of edible seaweeds on their content of toxins as well as antinutrients (i.e. compounds reducing digestibility and bio-availability of health-advancing ingredients) and on their microbial stability require further investigation.

Current research efforts in collaboration with the Norwegian Food Safety Authority are addressing these relevant questions in order to establish a regulatory framework for the use of macroalgae as human food and animal feed. Such a regulatory framework is a prerequisite for further industrial development of seaweeds as raw material for human consumption and animal production.

Conclusions

The seaweed industry is a growing economic sector in Norway. Both research communities, public and private stakeholders are collaborating to further the sustainable development of the Norwegian bio-economy based on cultivated seaweed biomass. Although cultivation technology has come a long way, it still requires optimization to upscale the biomass production and reduce the need for technical operators as well as maintenance. Current needs from seaweed producers are directed towards energy efficient processing standards that will maintain or increase product quality, ensure consumer safety and maximize biomass utilization. Integrated models using industrial surplus heat as energy source for seaweed processing are suggested, and their feasibility are currently under study.

Despite a large body of scientific literature reporting on the quality of macroalgal phytochemical constituents, commercial outputs from Norwegian cultivated seaweeds are currently limited. High-value products to be used in food, cosmetics as well as medical and pharmaceutical applications, are predicted to play an important role in creating value from Norwegian cultivated seaweed biomass. Nevertheless, expert knowledge regarding markets and prices for different seaweed products is required in order to establish market strategies. Successful product developments along with efficient logistic solutions throughout the entire value chain will build competitiveness of the Norwegian seaweed sector. The future production of macroalgae on large-scale and at relatively low cost will open perspectives for using the biomass as feedstock for bulk products (high volume and low price) e.g. bio-fuels and -chemical, and animal feed.

Upscaling seaweed cultivation requires specific solutions regarding the technical, spatial and practical integration of the production and will be specific for each production site. Although the current demand for seaweed raw material can be met by cultivating biomass within the coastal zone, large-scale production is foreseen to occur outside the continental shelf of Norway, due to more stable growth conditions and avoidance of conflicts arising with other users of the coastal zone. The Norwegian regulations regarding seaweed cultivation (including monoculture and IMTA) is not yet fully developed. Hence, the cooperation between public authorities, the industry and research institutions is needed in order to develop a knowledge-based legal framework for a sustainable industry based on cultivated seaweed biomass in Norway.

References

Broch OJ, Skjermo J and Handå A (2016). Potensialet for storskala dyrking av makroalger i Møre og Romsdal. SINTEF Fisheries and Aquaculture - Report A27869. https://www.sintef.no/publikasjoner/publikasjon/?pubid=SINTEF+A27869

Chopin T, Cooper JA, Cross S et al (2012). Open-water integrated multi-trophic aquaculture: environmental biomitigation and economic diversification of fed aquaculture by extractive aquaculture. Rev Aquacult 4(4): 209-220.

Directorate of Fisheries (2016a). Akvakulturregisteret. Cited 11 Jan 2017. http://www.fiskeridir.no/Akvakultur/Registre-og-skjema/Akvakulturregisteret

Directorate of Fisheries (2016b). Akvakulturstatistikk (tidsserier)-Alger. Cited 02 Nov 2016. http://www.fiskeridir.no/Akvakultur/Statistikk-akvakultur/Akvakulturstatistikk-tidsserier/Alger

FAO, (2016a). The state of world fisheries and aquaculture: Food and Agriculture Organization of the United Nations (FAO), Fisheries and Aquaculture Department. Rome, 2012. http://www.fao.org/3/a-i5555e.pdf

FAO (2016b). FAO Yearbook - Fishery and Aquaculture Statistics Summary tables. Cited 01 Nov 2016. ftp://ftp.fao.org/FI/STAT/summary/default.htm

NETALGAE, (2012). Overview of the seaweed industry by country: Ireland, France, Norway, Portugal, Spain, United Kingdom. A summary of the initial findings of the Netalgae project regarding the current status of the seaweed industries in the participant countries. Netalgae project financed by the Atlantic Area Operational Programme of the European Union. http://www.netalgae.eu/uploadedfiles/posters_final_UK_1.pdf

Skjermo J, Aasen IM, Arff J et al (2014). A new Norwegian bioeconomy based on cultivation and processing of seaweeds: opportunities and R&D needs. SINTEF Fisheries and Aquaculture - Report A25981. https://www.sintef.no/contentassets/04aa6cd738b245979b334715163c0506/seaweed-bioeconomy-2014-revised-2.pdf

Wang X, Olsen LM, Reitan KI et al (2012). Discharge of nutrient wastes from salmon farms: environmental effects, and potential for integrated multi-trophic aquaculture. Aquac Environ Interact 2(3): 267-283.

COLUMBUS

KNOWLEDGE TRANSFER FOR BLUE GROWTH

"We really are sitting on the crest of a wave and exploring new horizons under the COLUMBUS project. As public spending on research and development continues to grow; funding providers need to see a return on their investment. In COLUMBUS, we use a tried-and-tested methodology to maximise the potential of knowledge to have real, quantifiable impacts on policy, industry, science and society."
~ Georgia Bayliss-Brown, Senior Knowledge Transfer Officer at AquaTT (Dublin, Ireland).

The marine environment offers huge potential for citizens' well-being, with extensive resources that form the basis for many economic activities. The ocean is a source of food, water, energy and raw materials; a medium for tourism, transport and commerce; and, can provide solutions to many societal challenges. Nevertheless, the ocean is neither inexhaustible nor immune to damage. Marine and maritime research has a critical role to play in developing our understanding of the seas and advancing technology so that we can grow their economic potential in a sustainable manner. However, key substantial research results are not always known or exploited when they could be of use to marine and maritime stakeholders (e.g. scientists and policymakers).

Funded under HORIZON 2020, the COLUMBUS Approach is to:

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

To achieve its goals, COLUMBUS has established a "Knowledge Fellowship", a network of nine full-time Knowledge Transfer Fellows within each Competence Node whose role is to carry out Knowledge Transfer using a methodology based on the needs prioritised early in the project. These fellows work across nine Competence Nodes, each with a specific focus area: Aquaculture; Fisheries; Monitoring & Observation; Marine Biological Resources; Maritime Transport & Logistics; Marine Physical Resources; Maritime Tourism; Marine Governance & Management; and Marine Environment & Futures. This combined critical mass provides a multiplier effect to help achieve measurable impacts and to develop a blueprint for future activities in this field of work, thereby contributing to the development of a thriving and sustainable marine and maritime economy.

The COLUMBUS project was designed by AquaTT who are the Strategic and Operational Leader as well as the project manager for the project, and it is coordinated by Bord Iascaigh Mhara (BIM).

In May 2015, the European Commission (EC) launched an Information Sharing Platform on Marine and Maritime Research[1] to support the "Innovation in the Blue Economy" Communication of May 2014, as well as the European Parliament's Resolution of September 2015 on "Untapping the potential of research and innovation in the blue economy to create jobs and growth". The platform, currently in its pilot stage, shares available research data and key results from EU-funded projects related to the marine and maritime research sectors.

In cooperation with the respective Project Coordinators of the 31 FP7 Oceans of Tomorrow projects, the COLUMBUS project collected over 500 Knowledge Outputs, of which 456 exploitable results were extracted to populate this pilot platform. This collection of knowledge from research projects facilitates the uptake of new ideas, research results, data, products and services by industry, policy makers, civil society and other interested parties. This platform is an example of sharing results from European funded projects as soon as possible, thus supporting the concept of Open Science.

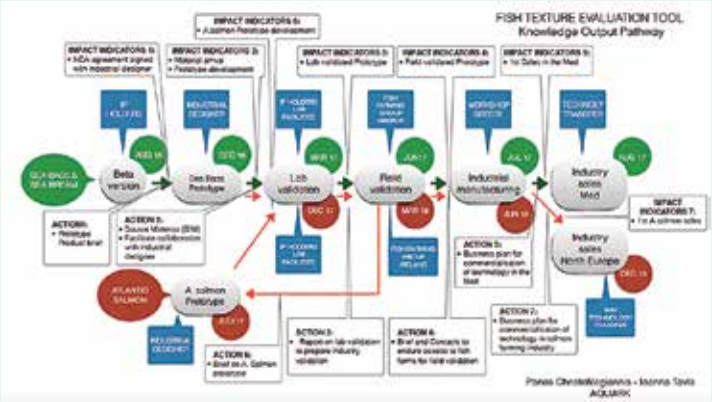
The Greek company AQUARK (represented by Panos Christofilogiannis, Katerina Moutou and Joanna Tavla) is the Competence Node Leader for Aquaculture and has been leading work in this area to identify and extract Knowledge Outputs from many EU projects, and have them validated by the coordinators and 'rated' by independent expert analysis. This has resulted in a list of outputs that will now be put into a 'transfer pathway' to identify end-users of the knowledge and map out how best to transfer it to them.

[1] *http://cordis.europa.eu/packs/marine-information-platform_en.html*

Three examples show more the approach, and are being used as "COLUMBUS CASE STUDIES".

1

The first is a FISH TEXTURE EVALUATION TOOL that provides a non-Destructive Textural Assessment of Fish Freshness. The tool is a prototype device that measures the elasticity and firmness of the fish muscle in cultured fish as indication of freshness and quality that is able to inform on the day of harvest and potentially give indications of the impact of diet on the fish quality. It was developed by Kriton Grigorakis (HCMR) and Dimitrios Dimogiannopoulos (TEI Piraeus) under the FP7 ARRAINA project www.arraina.eu



It was prioritised for transfer as a cost-effective, fast, non-destructive tool to reliably measure (numerical value) physical changes in fish, even in early freshness stages before bacterial spoilage occurs.

Competitor methods (potentiometric measurement of dielectric properties of fish) or sensors measure chemical products during post-mortem storage have the disadvantage of sensitivity for later spoilage stages (and they measure spoilage instead of degree of freshness).

A detailed Knowledge Output Pathway (from prototype, to industrial design, validation, testing and industrial manufacturing) has been created and is currently being enacted. It should see a final product ready for the Mediterranean market (sea bass/sea bream) by August 2017 and another for the salmon market by the end of 2018.

It is projected that the tool could be used at several stages in the fish value chain and especially during processing and at point-of-sale to strengthen buyer and consumer confidence in fish freshness and shelf-life. It could also help to create new market segments of superior (super fresh) fish that could be awarded a premium price (for example, local super fresh produce vs imported fish) or best flesh quality fish for use as sushi and sashimi.

2

The second case study goes "across borders", as it concerns an anti-fouling product that has impacts in most marine and maritime sectors.

Selektope is a raw material (biocide) to develop high efficacy, environmentally friendly anti-fouling coatings for a wide range of use, primarily in the maritime sector. It is free of toxic substances (compared to copper based anti-fouling paints). It does not kill organisms but prevents them from attaching to the ship's hull or other submerged structures including rafts, buoys and aquaculture installations. Selektope (generic name Medetomidine) has a pharmacological mode of action to combat barnacle settlement.

Mussel fouling on measurement device.
Source: Wikipedia.

By temporarily stimulating the octopamine receptor in the barnacle larvae, causing their legs to start kicking, the organisms are repelled from the hull.

This innovative product was prioritized for transfer as environmentally friendly anti-fouling coatings are missing on the market. This product is not yet globally approved due to long-lasting and costly approval procedures and needs to be showcased. It is owned by the Swedish company I-Tech that holds IP and regulatory rights.

It has market potential in many other marine sectors (e.g. aquaculture, marine observation devices, offshore structures) and while the COLUMBUS partner CMT was engaging with the Selektope Project Coordinator, potential target users were identified and contact was initiated with an SME Paint manufacturer. At the same time, COLUMBUS fostered a new collaboration between CETMAR (Vigo) and CMT (Hamburg). CETMAR provides testing facilities/infrastructure to test Selektope in a market different from shipbuilding where there is a great demand for new environmental friendly anti-fouling paints.

This Knowledge Transfer will introduce Selektope to a new market while demonstrating the performance of the product. Hopefully Selektope will turn into an alternative to traditional (toxic) anti-fouling paints.

3

Finally, (and not a Case Study as yet) an FP7 project SEA-on-a-CHIP[2] has developed a miniaturized, autonomous, remote and flexible **immuno-sensor platform** based on a fully integrated array of micro/nano-electrodes and a microfluidic system in a lab-on-a-chip configuration combined with electrochemical detection for **real time analysis of chemical contaminants in marine waters** in multi-stressor conditions. It has obvious applications for fish and especially shellfish farms, but also in other circumstances.

The first SEA-on-a-CHIP prototype with the outer casing on (left) and off (right). The second prototype will be smaller, more energy efficient and more efficient in its use of chemicals.

The prototype device consists of three main parts:

- Sampling device with integrated microfluidics for the controlled sampling and sample handling of seawater.
- Lab-on-a-chip unit for sample preparation and electrochemical detection based on a parallelized competitive immunoassay of up to eight different target contaminants.
- Communication module for secure wireless transmission of SEA-on-a-CHIP sensor data to a monitoring station and then to the cloud for operator analysis.

In the last phase of the SEA-on-a-CHIP project, an Open Technical Meeting and workshop (to be held in Olhão, Portugal May 16-17. Contact Antonio Marques amarques@ipma.pt) aims to increase the international visibility of the project results, coordinate the dissemination and exploitation of results and establish the relationships of the consortium with the end users, authorities and other EU-funded projects in related areas. The event will also focus on analytical methods for the determination of seawater pollutants, microelectronics in biosensing applications, and biosensors for marine environmental applications, notably aquaculture.

[2] www.sea-on-a-chip.eu

For more about the COLUMBUS project, see www.columbusproject.eu or contact its Project Manager, Cliona Ní Cheallacháin cliona@aquatt.ie

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Aquaculture in the German print media

BY YVONNE FEUCHT (YVONNE.FEUCHT@THUENEN.DE) AND KATRIN ZANDER

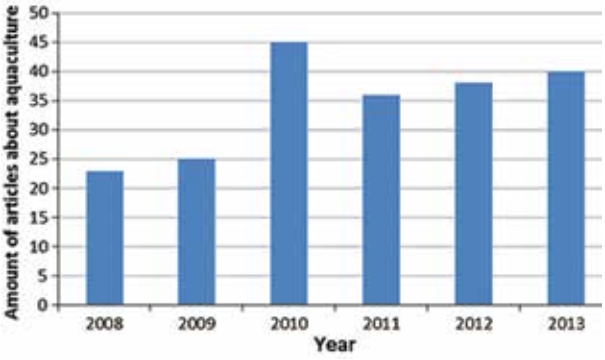
Presented at Aquaculture Europe 2015 and recently published in our Aquaculture International journal (February 2017, Volume 25, Issue 1, pp 177–195), the paper on which this article is based sought to identify media coverage of aquaculture and to determine which aspects of aquaculture were highlighted and how they were discussed. The study also focused on the presentation of recirculating systems and of organic aquaculture.

The public perception of production processes is becoming more and more important for the reputation and economic success of the food sector. Negative attitudes held by the public might be reflected in consumers' purchase behaviour and further development of the aquaculture sector largely depends on consumer demand for its products on the one hand and on favourable legislation which allows for establishing new farms or enlarging existing ones on the other.

One way to approach and to understand public perception is the analysis of media coverage – especially as the press is an important opinion-former in the public debate. Thus, it is essential for the aquaculture industry to be informed about the presentation of aquaculture in the media and to be able to identify potential factors of influence. However, only a few scientific papers have been published on media coverage of aquaculture and their findings point out that media generally transmitted a negative image of the sector. Risks for human health and for the environment were emphasized, whereas the benefits were less frequently considered. Where they were, the benefits were mainly reported with respect to economic features.

This study analysed the aquaculture coverage of three German newspapers - the Süddeutsche Zeitung (SZ), the Frankfurter Allgemeine Zeitung (FAZ) and the Bild - between January 2008 and December 2013. The selected print media cover a spectrum of political orientation from social liberal (SZ) to right-wing populism (Bild). The SZ and the FAZ are the two premium newspapers with the highest circulations in Germany. In contrast, the Bild is a tabloid and the top-selling daily paper in Germany.

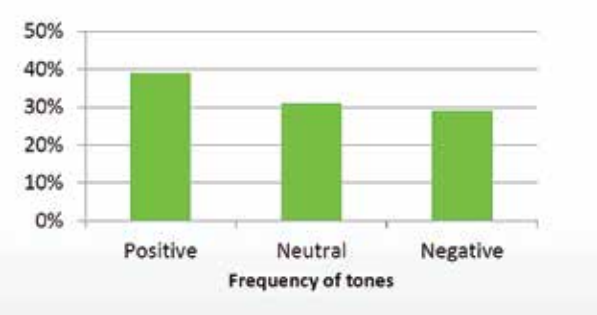
All articles containing the following keywords were collected for the sample: "aquaculture, fish farming, fish farm, aquafarm, fishkeeping, pond-farming, farmed fish, rearing and fish, rearing and algae, rearing and shrimp, rearing and mussel". The articles were obtained from the online archives of the newspapers and imported into the software MAXQDA 11 for further analysis. They were then categorized into tones and text segments were sorted according to different attributes and their aspects. Tones represented the overarching tenor in which an article presented aquaculture. A combination of deductive and inductive category development was used to code the tones, attributes and their aspects.



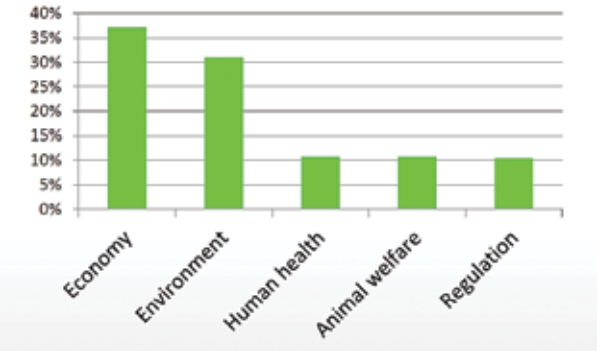
In total 208 aquaculture-related articles were found. Most of the articles (57%) were published by the SZ. The dominance of the SZ could be due to the fact that most of the German fish farms are located in Southern Germany (Bavaria and Baden-Württemberg), the region for which the SZ publishes local sections. The majority of the articles were published in the print editions of the analysed newspapers. Media coverage of aquaculture increased during the analysed time period, with the highest number of articles published in 2010.

continued on page 32

The articles were categorized into three tones: benefit, risk and neutral. Articles coded with the neutral tone presented aquaculture in a balanced manner. Articles that used the benefit tone mainly focused on benefits of aquaculture, while articles coded with the risk tone mostly highlighted the risks of aquaculture. It was very interesting to note that the benefit tone was, with 39%, most prevalent followed by the neutral (31%) and risk tone (29%).



Five attributes were also identified: economy, environment, human health, animal welfare and regulation.



During the time period studied, the media coverage of the analysed newspapers mostly focused on economic and environmental attributes of aquaculture. "Human health", "Animal welfare" and "Regulation"were less frequent. Text segments which reported on the "economy" attribute mostly belonged to the tone "benefit".

The 'economy' attribute

The 'economy' attribute consisted of two aspects: 'prospects of the sector' and 'production description.' The analysed media mostly discussed the economic prospects of the aquaculture sector (61 % of all articles in this attribute) and, to a lesser extent, described production (39 %).

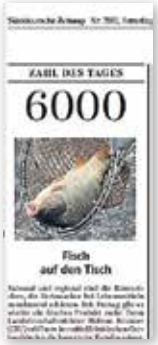
Articles which belonged to the 'prospects of the sector' aspect highlighted the huge economic potential of aquaculture in developed and developing countries. The increasing share of aquaculture products in the worldwide seafood production as well as the high profitability of some segments of aquaculture was pointed out: '*Fish is perceived as the big business opportunity of the future. Experts say that in a few years this food will be sold for prices not yet imaginable' (SZ-Print 2011).*

One example of an aquaculture segment with promising prospects was the farming of species with small population sizes or even endangered populations and thus sometimes protected, such as lobster, sturgeon and tuna. The establishment of aquaculture in other niche markets such as the production of biofuel by algae was also covered by the newspapers. Some articles mentioned the potential of direct selling of aquaculture products to generate additional income particularly in the context of smaller family-owned businesses. They reported that direct selling is appreciated by many consumers.

Articles which focused on the aspect of 'production description' primarily explained production procedures in different systems such as in RAS used for sturgeon and shrimp farming as well as in flow-through systems for trout. It was pointed out that high knowledge intensity was required in order for fish farmers to succeed due to the often very specialized and sometimes highly technical production systems required to cover the complex and strongly varying demands of some of the farmed species. The articles described aquaculture as a sector under high competitive pressure, which is sometimes intensive in cost and human capital and risky due to natural hazards, sophisticated systems, and sensitive as well as demanding and sometimes challenging to raise species.

A main focus of the articles which belonged to the 'economic' attribute was on German aquaculture. Two main themes were addressed by the media: On the one hand, economically well-situated family businesses and part-time farms which often make a living by direct selling were described.

And, on the other hand, some concentration and mechanization trends in German aquaculture which are similar to the changes that had already occurred in agriculture were mentioned. The German aquaculture sector was described as small compared to the production in other European countries and worldwide. The German aquaculture sector was presented as a quality-oriented market primarily dominated by salmonid and carp farming.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Fisch auf den Tisch

According to the articles, organic aquaculture as well as other niche markets such as aquaponics or the farming of highly demanding species such as sturgeon in closed recirculating systems showed particular market potentials. German aquaculture was also reported as an option for farmers who are searching for a second mainstay in addition to their agricultural activity. A side track of German aquaculture as a highly innovative field was the ongoing research focusing on environmental protection and energy supply, e.g., biofuel from algae or carbon reduction through algae farming. Basically, German aquaculture, especially those operations with ponds and flow-through systems and on a low technical level, was described as sustainable, trustworthy, environmentally friendly and practicing good management. Major constraints for the development of the sector were seen in high production costs and regulations (e.g., environmental specifications). Therefore, German aquaculture was not described as a growing sector per se, but rather as a market with a tra-

ditional base which guarantees a living and has a potential for innovation in niche markets (e.g., aquaponics).

The 'environment' attribute

The second most frequently mentioned attribute in the articles was 'environment.' It included four aspects: 'environmental risks' (42 %), 'environmental protection' (37 %), 'use of resources' (18 %) and 'genetic engineering' (4 %).

In the 'environmental risks' attribute, the use of wild fish in fish feed as well as for stocking purposes in aquaculture (in particular in the case of tuna) was a major issue. Aquaculture was considered to enhance the depletion of wild fish stocks by using fish feed made from wild fish: '*Large quantities of wild fish are fed to the "cage fish." This is outrageous since this practice depletes the oceans further.' (SZ-Print 2012)*. However, this information was often outbalanced in the same aspect by mentioning the efforts made by the aquaculture sector to reduce fish meal and oil in fish feed: *'Scientists try to reduce the proportion of fish meal in feed pellets by replacing it with plant-based nutrients.' (SZ-Online 2013)*. The general tone was that fish from aquaculture would be much more acceptable if the fish feed was to be plant based to the greatest possible extent and if the remaining wild fish fraction were to originate from discards and wastes of food fish production.

Many articles also reported on potential contaminations caused by aquaculture production, e.g., fish feces, feed loss, released parasites (e.g., sea lice) and chemical residues. The risks which can result from potential contaminations were sometimes put into perspective by references to innovations which alleviate the negative effects reported on, e.g., new water treatment methods and improved control mechanisms.

Other environmental risks covered by the analysed media were further disturbances and destruction of surrounding ecosystems by aquaculture. For example, articles reported on the competition with wildlife for food, the introduction of invasive species and the potential risks of escapees on wild populations. The destruction of mangroves as well as the salinization of fresh water bodies by shrimp farms was also discussed in the articles. With 408 records, salmon was the predominant fish species reported in the 'environmental risks' aspect, followed by tuna with 164 records.

The analyzed articles under the aspect 'environmental protection' highlighted the diverse ecosystem services provided by aquaculture. Some articles showed that ponds, in particular, are important elements of specific cultural landscapes, e.g., the Aischgrund in Bavaria (traditional landscape characterized by the farming of carp in ponds since the Middle Ages). Aquaculture's contribution to the preservation of biodiversity through rearing aquatic species for the release into the wild as well as providing habitats for wildlife was described. In contrast to the articles which discussed aquaculture's contribution to the depletion of wild stocks, several articles argued that aquaculture takes part in the conservation of wild fish stocks by substituting wild species for farmed ones.


Bild.de

Unterwasserfarmen sollen Ostsee-Wasser verbessern

Dienstag, 05. Januar 2010, 17:43 Uhr

Eine Möwe schaut auf die Ostsee. (Archivbild)
Foto: dpa

It was pointed out that some forms of aquaculture can even help to keep bodies of water clean, e.g., mussels, which feed on soluble nutrients and therefore reduce the nutrient load. Due to the high quantity of carbon stored in their shells, mussels were also presented as contributing to the mitigation of climate change. Local fish farms were also described as generally reducing the impact of climate change because of the reduction in carbon emissions resulting from shorter transport distances.

The 'use of resources' aspect focused on the use of energy and water. The high energy demand especially of RAS was discussed. The articles mentioned various eco-efficient ways for dealing with the high energy consumption of these systems (e.g., use of solar power or waste heat from biogas production). The use of water in aquaculture was mainly discussed in the context of policies which are intended to regulate water usage (e.g., number of net cages allowed in a fjord or the usage right of a water source). The articles also reported on the efforts made by the aquaculture sector to reduce water use and to improve the wastewater treatment in different production systems (e.g., in organic pond aquaculture or in recirculating systems).

A few articles (3 %) reported on the application of 'genetic engineering' in aquaculture. Half of the articles addressed the authorization of a genetically modified salmon for the US market. The potential endangerment of the wild salmon population due to possible mating with escaped, genetically modified fish as well as potential health risks for consumers (e.g., higher risk of cancer and allergic reactions) were discussed. Simultaneously, it was pointed out that no genetically modified fish has been approved in Europe thus far. Hence, European consumers are protected from the potential health risks resulting from genetically modified fish to date. The other half of the articles concentrated on the fact that genetically modified feed is used in conventional aquaculture, whereas it is not allowed in organic aquaculture. Therefore, organic aquaculture would avoid risks for the environment and human health which might potentially arise from genetically modified feed.

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The 'human health' attribute

The 'human health' attribute was much less frequently mentioned than 'economy' and 'environment.' It consisted of two aspects which highlighted contradicting points of view: 'good for human health' and 'risk for human health.'

The majority of the articles (79 %) emphasized potential direct and indirect health risks for humans. The aspect 'risk for human health' reported on the use of colorants and other chemical additives in fish feed and on the application of chemicals against parasites as well as the use of growth-promoting hormones and antibiotics.


Süddeutsche.de Wirtschaft
16. Dezember 2008 19:05 Bio-Fisch
Garnelen ohne Antibiotika
Von Robert Lücke

The articles pointed out that these chemicals are potentially carcinogenic. Some articles also reflected upon the concentration of noxious substances such as polychlorinated dibenzo-p-dioxins in farmed seafood. The most controversial subject in this aspect was the use of drugs and in particular of antibiotics in aquaculture: '*Onshore as well as in water-industrial animal production forces the perversion of nature and thus finds itself confronted with a massive image problem. A problem which was also fostered by Asian fish farmers, who stuffed shrimps and other seafood with antibiotics until the EU stopped the import in 2002.' (SZ-Online 2010).* Some articles compared aquaculture to mass animal husbandry and inferred from this an excessive use of antibiotics. Articles also criticized the preventive application of antibiotics.

Other arguments discussed in this aspect pointed out the decreasing use of antibiotics and stated that the use of antibiotics was no longer a concern in aquaculture: Improved farm management, innovations (e.g., use of cleaner fish) and more rigid controls would prevent the improper use of drugs, especially antibiotics: '*Compared to the year 1987, when Norway fed one kilogram of antibiotics per metric ton of farmed salmon, the amount of antibiotics has decreased to a minimum today.' (SZ-Online 2010).* With regard to the use of antibiotics, German aquaculture was presented favourably. Some articles stated that German aquacultures rarely employed antibiotics and other kinds of drugs also due to the rigid regulations in place.

Only a minority of articles (21 %) in this attribute highlighted seafood as healthy food for human beings. These articles argued that seafood is high in omega-3 fatty acids as well as in iodine, vitamins and micronutrients. The preventive effect of seafood on cardiovascular diseases was also mentioned. Some articles referred to the German Food Association (DGE, Deutsche Gesellschaft für Ernährung), which recommends the consumption of seafood once to twice a week.

As in the 'environment' attribute, with 374 records salmon was the fish species most often referred to in this attribute, followed by sturgeon (86 mentions) and trout (68 mentions).

The 'animal welfare' attribute

The 'animal welfare' attribute was addressed as often as the 'human health' attribute. It included two aspects: 'appropriate husbandry' (64 %) and 'animal health' (36 %), which indicates that the appropriate culturing of farmed aquatic species was more at the focus. The articles in this aspect, most frequently discussed questions related to the stocking density. It was stressed that high stocking densities are common in some forms of aquaculture (salmon and shrimp). Articles related high stocking densities with a low freedom of movement, which would result in a potentially high stress level for the fish. Consequently, the possibilities of species-appropriate behaviour and thus animal welfare were questioned in some forms of aquaculture. It was concluded that the high stocking densities in aquaculture might imply animal welfare problems similar to those in intensive pig and poultry farming: '*Aquaculture is the pig fattening of the sea, the animal welfare problems are comparable to those of intensive livestock farming' (SZ-Online 2012).* In contrast, other articles argued that some species (e.g., trout) need a certain stocking density in order to meet the requirements of animal welfare.

Articles focusing on 'animal health' argued that the rearing of aquaculture species in intensive production systems enhances stress levels and as such reduces resistance to environmental challenges including pathogens. A decreased fitness in aquaculture was also linked to antibiotic resistance originating from a high use of antibiotics in highly stocked farms. Salmon aquaculture in Chile was presented as particularly vulnerable for epidemics due to low animal welfare and environmental standards. The composition of fish feed was another topic in this aspect. Some articles reported on the difficulties in producing species-appropriate plant-based fish feed.

The 'regulation' attribute

The 'regulation' attribute was the least frequently considered attribute. We divided the 'regulation' attribute in the three aspects 'regulation and control on national level' (50 %), 'impact of the EU' (42 %) and 'conflict of interest' (8 %).

In the 'regulation and control on national level' aspect, existing controls were criticized. Part of the articles doubted that controls are sufficient with respect to environment and food safety. Some articles reported on incidents of misdeclaration of species in Europe and worldwide.

Other articles focused on the regulation of aquaculture production, which was described as being rather strict in European countries. In contrast, the regulations in Chile, the USA and Canada were described as less rigid and in case of Chile as particularly inefficient. The articles highlighted the schemes of Norway and UK as European examples for well implemented regulations. In general, the European aquaculture sector was described as safe for the consumer and the environment.


DEUTSCHLAND UND DIE WELT

Für Karlsruhe ist ein Auto keine Waffe

Miese Muschelgeschäfte

The 'impact of the EU' aspect referred to the positive and negative impact of the EU as a regulatory body in the aquaculture sector. On the one hand, some articles described the EU regulations as an additional burden to national laws for the economic development of the sector. On the other hand, the EU was presented as a supporter of the European aquaculture industry because of its efforts in setting standards and labelling, such as indications of origin (PDO, protected designation of origin) and organic production. Other articles also mentioned some strategies developed on the EU level to foster the development of the EU aquaculture sector. Some articles pointed to the subsidies issued for the aquaculture sector by the EU.

All the articles which reported on the 'conflict of interest' aspect belonged to the negative tone. The articles described situations in which an excessively close relationship between politicians or NGOs and the aquaculture industry had been observed. Some articles suggested that the aquaculture industry uses these connections to hush up critical incidents: '*For years, the salary of a salmon expert of the WWF Norway was completely paid by Marine Harvest, the biggest player in the sector*' *(FAZ-Online 2012)*.

In conclusion, aquaculture was generally presented as a dynamic economic sector with clear potential for innovation and one that is able to connect environmentally friendly practices with local production and quality.

The analysis revealed that the German media mainly described aquaculture in a positive to neutral manner. This is encouraging for the aquaculture sector – especially for organic fish farming and RAS which were described as eco-friendly and representing a healthy alternative.

In order to (further) improve its reputation, the aquaculture sector should continue to focus on the performance of its production systems with regard to environmental and health effects and animal welfare aspects.

REPORT OF THE AQUACULTURE EUROPE ONLINE SURVEY

In 2007, the Board of EAS approved a new strategy to develop our Aquaculture Europe (AE) events from a 300-person conference to THE European Aquaculture Forum, with a conference, trade show industry-focussed events and EU project sessions/events and with a target of 1000+ participants. The bi-annual agreement with Nor Fishing to hold the AE event with Aqua Nor was stopped in 2013 to further pursue this strategy.

An online survey was made in December 2016 and received the input of 599 attendees of AE events held since 2011 and thus providing a solid basis for further development of the event.

WHO REPLIED?

An invitation to take part in the survey was sent to 2806 participants at our Aquaculture Europe events held over the past five years. Invitees included full conference delegates, exhibitors and trade show or industry forum visitors. Of these, 599 persons completed the survey representing a response rate of 21%. This is very good for online surveys and EAS sincerely thanks those that took the time (average completion time was 8 minutes) to reply.

Of the total respondents, 41% registered to the latest event that they attended as EAS member, 41% as non-member, 7% as member of WAS and 6% as trade show visitor. Total student responses were 21% of the total, so 126 students.

Respondents age data is as follows, with more than half being between 31 and 50.

AGE	% of people	%
less than 30		17
31 to 40		29
41 to 50		25
51 to 60		19
more than 60		11

1. Which of these recent AE events have you attended? (you may check more than one)

Response	Total	% of responses	%
AE2016 (Edinburgh, Scotland)	368		61%
AE2014 (San Sebastian, Spain)	264		44%
AE2015 (Rotterdam, The Netherlands)	240		40%
AQUA2012 (Prague, Czech Republic)	150		25%
AE2011 (Rhodes, Greece)	135		23%
AE2013 (Trondheim, Norway)	63		11%
Total respondents: 599 Skipped question: 0			

ATTENDANCE AT AE EVENTS?

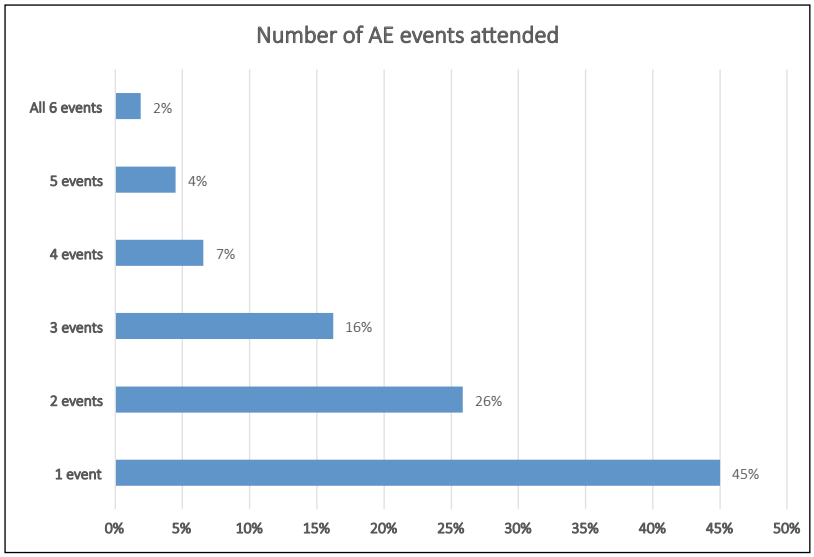
A big majority of those that replied were present at AE2016 in Edinburgh, with high numbers also present at AE2014 in San Sebastian and AE2015 in Rotterdam. The survey tried to address management issues of the AE events without this being affected by the site location and size of the meeting. AE2016 was our biggest event to date (1700 participants) and held in a 5-floor congress centre with many parallel and industry sessions. It is therefore clear that much of the feedback in this report is related to the experience of attending the AE2016 event and not necessarily on attendance of several EAS AE events.

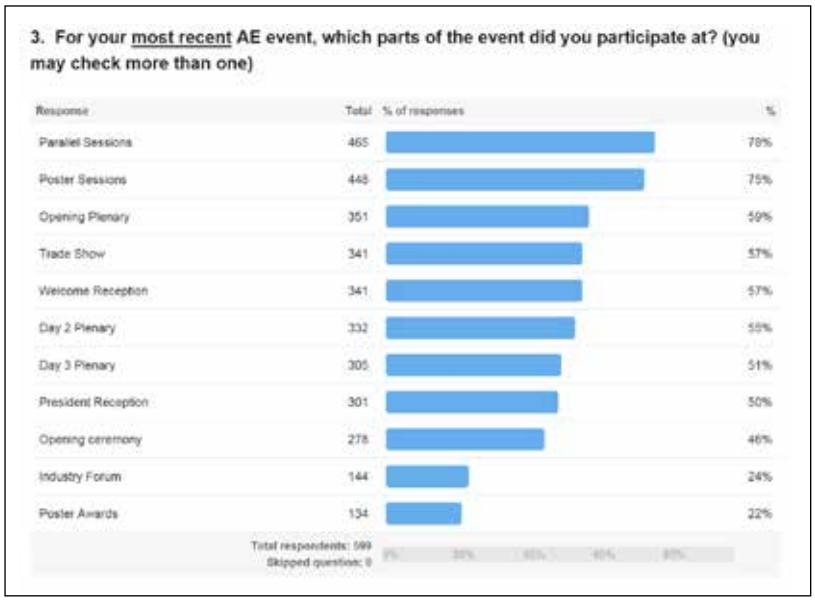
The data used for the above chart was used to compile the following figure that shows the percentage of respondents that have attended one or more of the AE events listed above.

As can be seen, 45% of respondents only attended one of the events and just over a quarter of people attended two events. 11 respondents attended all six of the AE events that made up the basis of the survey.

More than three quarters of the people that replied to the survey took part in the parallel and poster sessions of the most recent AE event that they attended. Around half also participated at the opening plenary, trade show, welcome reception, plenaries on Days 2 and 3 and the President's reception. Less than a quarter took part in the poster awards (despite them being done at the President reception at AE2016, but as a part of the Day 3 plenary in AE2015 and AE2014).

Most people use the theme/programme of the event as their principal criteria to decide to attend. It is also interesting that around half of them come 'because it is the annual





3. For your most recent AE event, which parts of the event did you participate at? (you may check more than one)

Response	Total	% of responses	%
Parallel Sessions	465		78%
Poster Sessions	448		75%
Opening Plenary	351		59%
Trade Show	341		57%
Welcome Reception	341		57%
Day 2 Plenary	332		55%
Day 3 Plenary	305		51%
President Reception	301		50%
Opening ceremony	278		46%
Industry Forum	144		24%
Poster Awards	134		22%

Total respondents: 599
Skipped question: 0

VISITOR EXPERIENCE

EAS uses various channels to advertise and promote our AE events. Participants were asked to rate these on a scale of 1-5, where 1 (shown in dark red) is "not at all useful" and 5 (shown in dark green) is "extremely useful".

The event brochure (online and the PDF version) are considered useful, as are the EAS web page and EAS mail shots. Advertising – whether in our own publications, in other publications or on social media - is considered as being less useful as a promotional channel. Other sources include promotion through other meetings and workshops, university mail and verbal communication with colleagues and friends.

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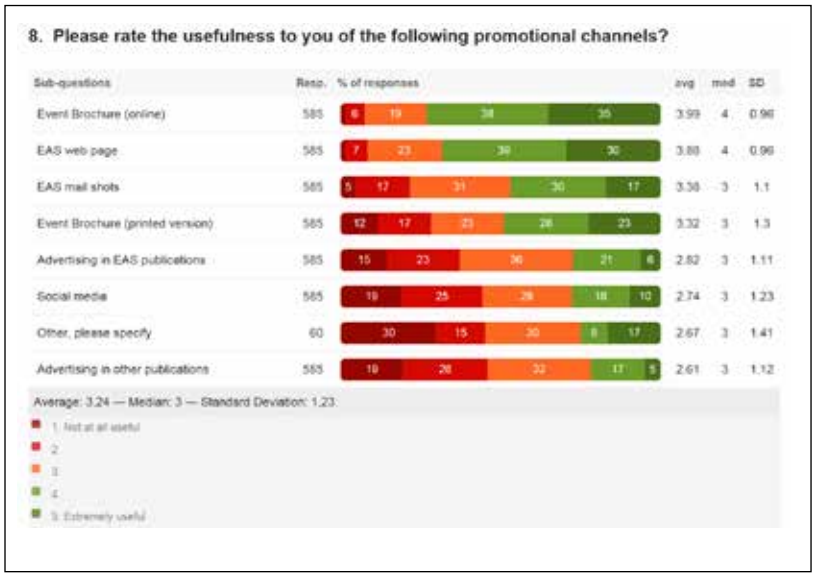


8. Please rate the usefulness to you of the following promotional channels?

Sub-questions	Resp.	% of responses	avg	med	SD
Event Brochure (online)	585	6 19 38 35	3.99	4	0.96
EAS web page	585	7 23 39 30	3.88	4	0.96
EAS mail shots	585	5 17 31 30 17	3.38	3	1.1
Event Brochure (printed version)	585	12 17 23 28 23	3.32	3	1.3
Advertising in EAS publications	585	15 23 36 21 6	2.82	3	1.11
Social media	585	19 25 28 18 10	2.74	3	1.23
Other, please specify	60	30 15 30 8 17	2.67	3	1.41
Advertising in other publications	585	19 28 32 17 5	2.61	3	1.12

Average: 3.24 — Median: 3 — Standard Deviation: 1.23

1. Not at all useful
2
3
4
5. Extremely useful

EAS event', 44% base their decision on the location, whereas only 14% come in function of the importance of aquaculture in that country and 12% based on the proximity of the location to aquaculture production.

Other (free comments) reasons include the person's availability and place of residence, the willingness of the institute or company to pay for it, potential business opportunities, attendance at other, satellite meetings organised around the event, the invited speakers and, above all, the chance to meet people and – as several commented - the fun!

The majority of participants plan their week using the online programme (the overview grid and later the detailed programme). As they arrive at the event location, 52% use the printed programme book and 32% use the event app.

Almost exactly half of the respondents read the AE Summary Report that is a compilation of the reports of the parallel sessions, notes on the plenaries and details of the poster awards. Of the half that read it, 56% find it useful or extremely useful and 37% are neutral.

Using the same scale as above (but from 1 as "very poor" to 5 as "excellent") visitors were asked to rate the AE services, before and during the event. The grey areas in the figure below show those services that are not applicable to (i.e. not used by) participants. Most services are seen as being very good or excellent.

PRESENTER EXPERIENCE

74% of respondents have given presentations (in oral, poster, plenary or industry sessions). They were asked to rate the presenter services - communication with the organisers, with the poster desk and with their session chair (where relevant).

Pretty well all of the presenter services were rated as very good or better.

FUTURE AE EVENTS

Total participation at recent AE events has been more than 1000. AE2016 attracted 1700 persons. Increasing numbers also imply various compromises - including event importance, quality of the science, trade show attendance, networking opportunities and general intimacy.

People were asked what they consider to be a good 'size' for our AE events and the clear majority (a combined total of 77%) put this figure as being between 1000 and 2000.

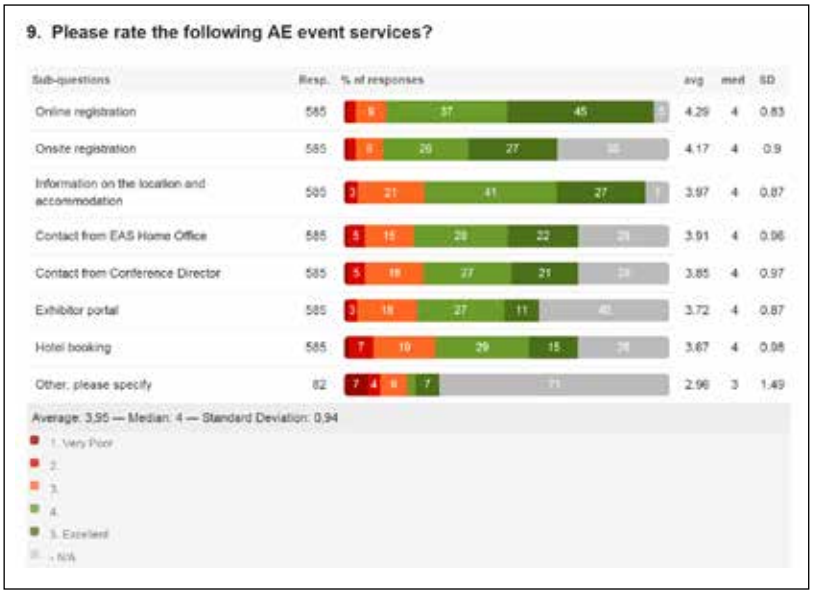
When asked what they would like to see in future AE events, there was a wide variety of responses.

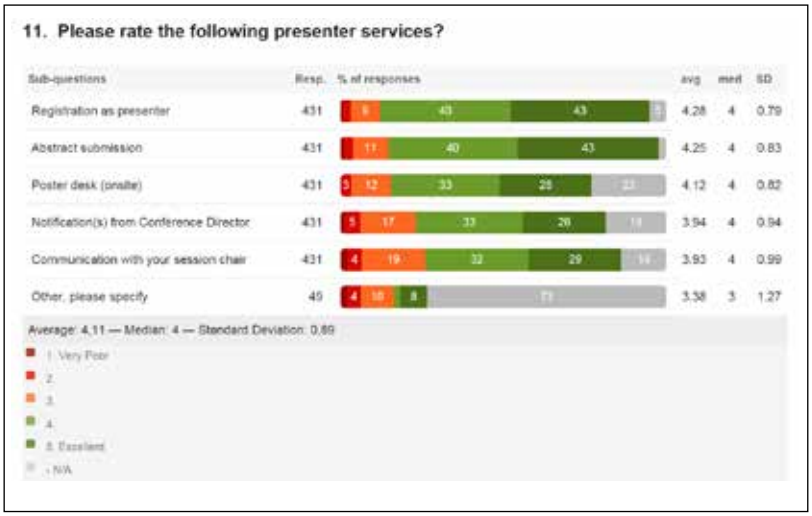
In general terms, participants are fine with the plenary, parallel and poster sessions as they are currently organised. However, there was an equal proportion that would like to see either fewer parallel sessions or more industry forums. It is not easy to interpret this outcome on the full data, but when filtered, a higher percentage of those attending AE2016 in Edinburgh favoured fewer parallel sessions compared with AE2015 in Rotterdam or AE2014 in San Sebastian, were there actually were fewer parallel sessions.

E-posters and poster pitches are less popular for the majority of participants and the message is clear that people like to see a plenary on each conference day. This was even more strongly the case for those that had previously indicated their attendance at one or more plenary sessions during the most recent event that they came to.

Other suggestions included round tables, more involvement of trade show participants, more sessions/activities on education and training, including job opportunities and fewer parallel sessions by extending the number of conference days.

Respondents said that they would recommend Aquaculture Europe events to colleagues or friends. They were asked to assign this to a 10-point scale, using the Net Promotor Score (Explanation of NPS at https://www.checkmarket.com/blog/net-promoter-score/), where those that rated 0-6 are "Detractors" those rating 7-8 "Passives" and only those rating 9-10 "Promotors".



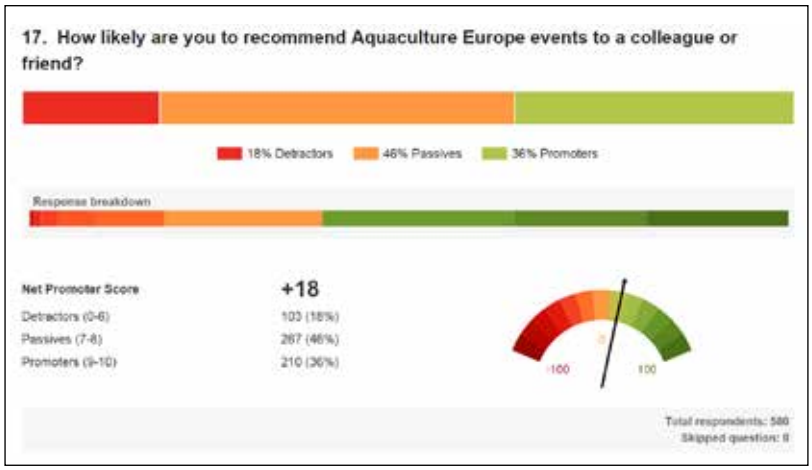


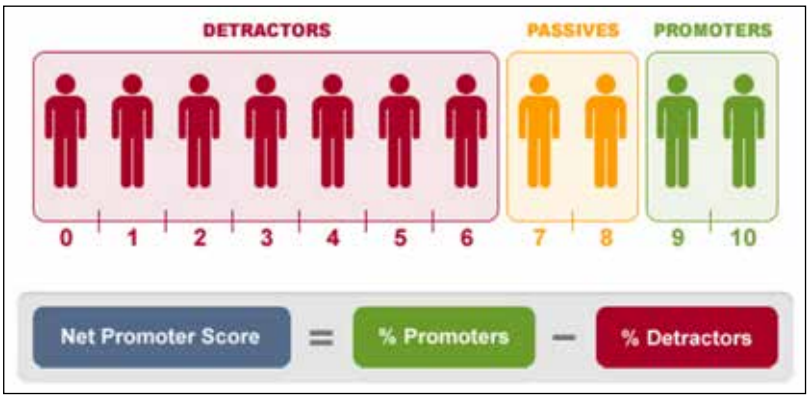
	Total	% of responses	%
less than 1000	70		12
1000	108		19
1500	201		35
2000	136		23
2500	24		4
more than 2500	41		7

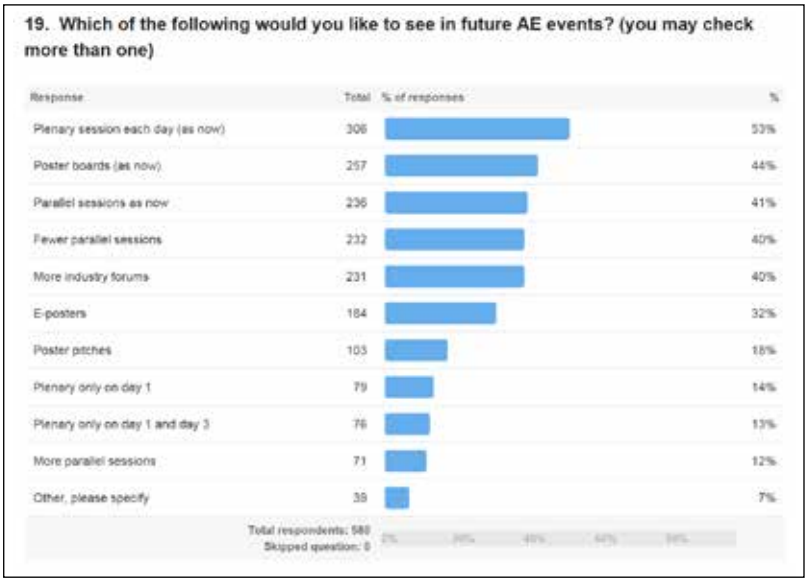
This is displayed as a gauge, with an overall NPS of +18. The three groups are shown on the top bar and the bottom bar shows the detailed response breakdown.

We received 118 free text comments on ideas for future opening plenary sessions and these will be reviewed by the EAS Board and by the Programme Co-chairs of our planned future events.

186 persons also gave us ideas on what we could do better, and the list was very wide ranging. This will provide useful feedback to the EAS Board, as well as to the Steering Committees of AE2017, AQUA 2018 and AE2019.







Finally, it is encouraging to see that 343 people are planning to attend the AE2017 "Co-operation for growth" meeting in Dubrovnik, Croatia; 191 the AQUA 2018 event in Montpellier, France and 150 the AE2019 event in Berlin, Germany. EAS looks forward to welcoming you there!

http://www.easonline.org/36-news/news/363-ae2017

SUNDERLAND MARINE MARKS THREE DECADES OF AQUACULTURE INSURANCE

Sunderland Marine marks 30 years of insuring fish farms this year, significantly longer than any other global insurer in this sector. The company, which is also a major fishing vessel insurer, is consistently the largest underwriter in the aquaculture sector worldwide.

Sunderland Marine chief executive officer Tom Rutter says, 'We believe our position in the market reflects our clients' confidence in the quality and security of the cover we provide. Since we wrote our first policy for Pairc Salmon fish farm off the north-west coast of Scotland in 1986, the global aquaculture industry has grown from 10 million to 75 million tonnes a year, now representing approximately 50% of all fish supplied for direct human consumption.'

He says over the past 30 years fish farming has progressed through many cycles. 'In the early years, the industry consisted of mainly small owner-operated units. Today, the industry is consolidated under a relatively small number of major companies controlling many sites and has led to the introduction of stringent technical standards.'

Aquaculture insurance is a high-risk and specialist business he says. 'In the last 30 years many competing insurers have come and gone in the wake of heavy losses. The largest aquaculture companies produce millions of fish a year and ensuring they are raised in optimum growing conditions, including protecting them from predators and natural perils, is no mean feat. Insuring them is just as challenging.'

Sunderland Marine's underwriting team includes five former fish farmers, who provide a unique risk management service to operators as an integral part of their all-risks cover.

Rutter has been with Sunderland Marine for 37 years and was managing director of the aquaculture division until being promoted to chief executive officer last September. He concludes, 'Over the past 30 years we have continually adapted to the changing profile of the aquaculture sector, but we still deliver the same high quality service and security as we did back in 1986. The experience, resilience and technical expertise gained over this period is second to none and positions us well for the next 30 years.'

Sunderland Marine chief executive officer Tom Rutter

….AND CONSOLIDATES ITS POSITION IN NORTH AMERICA

Sunderland Marine has completed the consolidation of its operations in North America with the sale of its Seattle branch.

A management buy-out was agreed to take effect from 1 November 2016. The new owner, former Seattle office underwriting manager Chris Elliot, will take the brokerage forward under the new name of ARES Insurance Managers. The sale is the final step in parent company North Group's plans to drive operational efficiency and strengthen Sunderland Marine's global operations following its acquisition in 2014. Former Seattle office claims manager Mark McDermott will remain with Sunderland Marine to continue the high service levels currently provided to the North American market.

North's joint managing director Alan Wilson noted, 'We are confident that this reorganisation and restructuring of Sunderland Marine in North America will further streamline the business, reduce costs and improve overall efficiency.'

ALLER AQUA GROUP moves quickly in Sub-Saharan Africa!

In Aller Aqua Zambia the factory is now under construction. The first board meeting has been held – and staff members have started onboarding! At the same time, the company is entering the African market from several strategic positions.

Photo from the first board meeting of Aller Aqua Zambia Limited. The meeting took place at IFU's (Investment Fund for Developing Countries) headquarters. From left to right: Adam Taylor (CEO of Oakfield Holdings Limited), Henrik T. Halken (Group Vice President, Aller Aqua Group), Johnny Hansen (IFU Regional director, Africa) and Carsten Jørgensen (Group Vice President, Aller Aqua Group). *© Aller Aqua Group A/S*

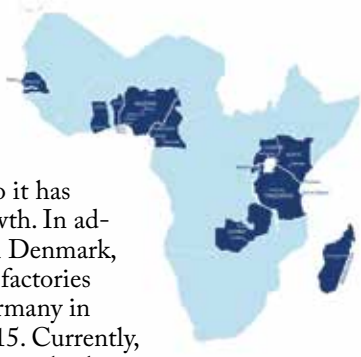
Adam Taylor, Henrik T. Halken, Johnny Hansen and Carsten Jørgensen met in IFU's headquarters in Copenhagen for the company's first board meeting. The meeting was initiated to ensure the best possible start for Aller Aqua Zambia Limited. The current outlook is very positive. The first big client is secured and the first employees, including the managing director, have been recruited. Now the building of the factory needs to keep its pace and the company should be ready for production of high quality extruded fish feed for aquaculture by September 2017.

Whilst the new factory is under construction in Siavonga, Aller Aqua Zambia has made the first sales agreement with one of the largest Tilapia producers in the World – Yalelo Limited. Yalelo has plans to grow the production of Tilapia to 30.000 tonnes in Zambia within the next few years. This rapid expansion will help secure Aller Aqua Zambia Limited's success in the African country. The new factory will have a production capacity of 50.000 tonnes of fish feed per year and will be the most technically advanced fish feed factory in Southern Africa.

Henrik T. Halken and Carsten Jørgensen have both been a part of Aller Aqua Group for many years and are appointed to lead the Zambian company from the Danish side. Henrik Halken is in charge of Aller Aqua's factories on the African continent, whereas Carsten Jørgensen is Chief Financial Officer and handles the finances.

Aller Aqua Zambia Limited is owned by Aller Aqua Group A/S and Oakfield Holdings Limited, represented by Adam Taylor who will be chairman of the company. Henrik Halken will take the position as vice chairman and other board members are Carsten Jørgensen and Bryan McCoy.

Aller Aqua Group has a clear and expansive strategy for Africa.



"Aller Aqua Group is in rapid expansion. Since the company began producing fish feed for aquaculture more than 50 years ago it has achieved constant growth. In addition to the factory in Denmark, the company has built factories in Poland in 2001, Germany in 2007 and Egypt in 2015. Currently, the company is building in both Zambia and China as well as extending the capacity in Egypt with a third production line. This will increase the capacity in Egypt substantially. Both of the new factories as well as the third production line in Egypt are expected to be inaugurated in 2017.

In Zambia we are investing a total of 10 million USD, as well as a significant amount in Egypt" Henrik Halken informs.

"With the investment in Zambia, we will be the market leader in Africa in terms of modern and environmentally friendly fish feeds for aquaculture. This will enable us to expand our sales not only in Zambia but also the surrounding countries. During recent years Aller Aqua Group has started sales companies in both Nigeria, Ghana and Kenya.

The African market will, without a doubt, grow significantly in the coming years. The number of inhabitants is rising quickly and the population will need healthy food which is high in protein. Fish farming and locally produced fish is part of the solution for this, and fish farming can further help people get a livelihood and get out of poverty. In Zambia approx. 95% of the raw materials we will use comes from the local market, which is a great advantage.

The Zambian factory under construction, February 2017
© Aller Aqua Group A/S

The build of the factory is Zambia is ongoing and on schedule. Obviously, there are many challenges when building in Zambia compared to Denmark. But we have a fantastic team and management whom will ensure that we succeed and overcome these challenges." Finishes Henrik T. Halken.

In January 2016 Aller Aqua took the consequence of the increased activity in the African countries and appointed Niels Lundgaard Commercial Director of Africa. Niels focuses entirely on expanding the business in the Sub-Saharan countries.

"With the subsidiaries in Nigeria, Kenya and Ghana we have strong bases for the rest of the region. From Nigeria, we sell feed to Benin. Recently a distributor agreement was signed in Rwanda, and there are Aller Aqua agents in both Cameroon and Senegal. To countries such as Uganda, Tanzania and Madagascar, Aller Aqua sells feed directly from its German factory. This gives us a wide reach in the area. We have highly skilled teams in place, and enter the markets with our usual approach; We want to grow with the customers

R&D Manager Dr Hanno Slawski, a customer, Commercial Director of Africa Niels Lundgaard and Country Manager for Nigeria, Lasisi Nurudeen talk aquaculture - © *Aller Aqua Group A/S*

and help them increase the output on their fish farms. We do this by providing extruded fish feed, advice and training. We further hold seminars and participate in local events and exhibitions." Niels explains.

As a result of Aller Aqua's growth in the markets in Sub-Sahara, the company will participate in World Aquaculture 2017, which takes place in Cape Town in South Africa, June 26th-30th

A fresh view on aquaculture

The BioMar Group has just launched a new website framing its ambitions for innovating aquaculture. The new website gives all users access to a significant knowledge base and makes it clear that the future of the aquaculture depends upon cooperation, innovation, performance and sustainability.

BioMar Group is now inviting all stakeholders to explore the new company website. While building it one of the most important aspirations has been to enhance collaboration and partnership with stakeholders, sharing information and promoting long-term thinking. The new format gives easy access to a significant knowledge base on farming and feeding in aquaculture while telling the story about how BioMar for more than 50 years has been a significant player in building sustainable and efficient aquaculture.

Sif Rishøj, Corporate Communication Director of the BioMar Group, looks forward to giving new insights into BioMar and its activities: "At BioMar we are committed to innovating aquaculture. The website has been designed to ease communication and cooperation with our stakeholders. Actually we have designed and build a website that is extremely user friendly. I believe that it is very easy to find the right information despite the extensive volume of material available".

BioMar launched last year the company purpose statement carrying the tagline "Let´s Innovate Aquaculture" and a new ambitious strategy "Shaping the Future". The guiding principles of the strategic initiatives - as well as the daily work in the company – are described by the four core notions: Innovation, Sustainability, Cooperation and Performance. These guiding principles are unfolded and described in depth on the new website.

"Our marketing and technical departments have worked hard in order to make a comprehensive webpage with the ambition of creating a truly interesting source of information. It will be constantly updated and developed with the aim of interacting with the aquaculture community being a proactive contributor to the development of a sustainable and efficient industry."

The website is of course compatible with today's browsers and mobile devices. No matter the media the web page will open up for a user-friendly experience with easy navigation. It is available in fourteen languages allowing the users to easily access detailed information on products and product utilisation.

For further information please contact:

Sif Rishoej, Director, Global HR & Corporate Communication, BioMar Group, sri@biomar.com

Carlos Diaz, CEO, BioMar Group, cdiaz@biomar.com

ISS 8
Vienna 2017
8th International Symposium on Sturgeon

THE 8TH INTERNATIONAL SYMPOSIUM ON STURGEONS IS COMING UP!

SEPTEMBER 11 - 17, 2017

The International Symposia on Sturgeons (ISS) are governed by the World Sturgeon Conservation Society (WSCS). They take place in a four year cycle in varying countries in alternating regions with major importance for sturgeons and sturgeon biology. Sturgeons were among the first species that suffered from the increasing industrialization and human population development in Europe. The series of ISSs revealed the involvement of an increasing number of experts dealing with this ancient group of fishes and the associated issues concerning their decline, recovery options and production. Increasingly, the conference has developed from the classical presentation of scientific results to a forum for management issues.

The upcoming venue is taking place in Vienna, Austria from September 11th to 17th 2017 as an all-European effort to bring together the sturgeon experts worldwide to draw the international attention to the pressing issue of sturgeon conservation in a densely populated region that reveals the most intense conflicts between economic development and nature conservation. Furthermore, the location draws the attention to the necessity of a transboundary approach since the Danube River - the last resort of functional sturgeon populations in Europe - is the system shared by the largest number of countries worldwide is highly threatened by economic development.

The 8th ISS is to focus on the analysis of the dynamics of the decline and its drivers while transferring the lessons to be learnt from successful conservation attempts to further improve the measures taken to render the investment in conservation successful.

For this purpose, the ISS8 will bring together sturgeon experts from all over the world to discuss and share their concepts and experiences to further improve the management of sturgeons along with their essential habitats.

The second stronghold of the conference will be the aquaculture sector. Europe has a large share in sturgeon farming and caviar production. Traditionally, European traders have been the dominating distributors in caviar trade. Therefore, the European focus on caviar and caviar trade will provide a vital input for the conference topics. Quality control, alternative production methods, market trends and collaborative approaches in production and marketing of caviar and meat, as well as control and enforcement are among the key issues to be addressed to meet the future challenges in this sector.

The ISS8 will be organised in close cooperation between the University of Natural Resources and Life Sciences, Vienna (BOKU) and the Leibniz- Institute for Freshwater Ecology and Inland Fisheries (IGB- Berlin). Both Institutes have a long tradition in research and restoration of freshwater ecosystems and are involved in programmes for the protection and rehabilitation of sturgeon stocks in Europe.

The symposium will be hosted in the facilities of BOKU in Vienna beginning September 10th with the registration and a social in the evening and lasting until the 17th with excursions and side events closing the meeting. It includes oral presentations, posters and workshops on a wide variety of sturgeon related topics that take plpace between September 11th and 15th. Student presentations will be evaluated and thus have the chance to be awarded with one of several prizes.

As an add on to the conference itself, excursions will take place nationally to restoration programmes of habitats and sturgeon stocks as well as to fish farms. Furthermore, satellite events will give further insight into the European connections of sturgeon conservation and farming, with restoration programmes and aquaculture enterprises in Germany, Italy, France, Poland and the Danube Delta in Romania, among other from a sturgeons point of view interesting sites, are to be visited in several post conference tours.

To render the ISS8 a memorable event, traditional Danube Fish Barbecues, an Conference Dinner in the impressive Natural History Museum in Vienna and a various evening venues to clear your head for the next day of sessions are part of the program.

For more information please check the website under
http://www.iss8.info/index.php/iss8home.html

or register online at
http://www.iss8.info/index.php/Registration1.html

If you are interested in becoming more than a participant but to actively support this venue, either through sponsorship, becoming an exhibitor on the trade show or taking the role as a partner of the conference. For further Information please contact the conference bureau.

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 2017

International Conference Maritime Spatial Planning, Ecosystem Approach and Supporting Information Systems
(MaPSIS) - ***Maritime spatial planning is now***
Las Palmas de Gran Canaria, April 24-28, 2017
To find and apply sustainable development solutions, it is necessary to manage information on maritime activities and environmental data. Present-day data and information systems provide user friendly solutions for development of data infrastructures that can manage, integrate, analyze and finally expose marine & maritime data.
European seas have legal instruments that provide the framework for maritime spatial planning (MSP 2014/59/EU), framework on marine strategies (MSFD 2008/56/EC), framework on marine and maritime information management and open data access (INSPIRE 2007/2/EC within SEIS; Marine Knowledge 2020 within Integrated Maritime Policy). This conference aims to bring together professionals, policy & decision makers, researchers and other stakeholders that are included in legal frameworks, to discuss issues, methodologies, best practices and finally integrate maritime with environmental planning using open data Infrastructures.
Contact: Parque Científico Tecnológico Marino - Universidad de Las Palmas de Gran Canaria - Ctra. Taliarte s/n, 35200 Telde. Spain.
Email: gcourtois@fpct.ulpgc.es

Aquaculture Extrusion Technology short course
Ås, Norway, April 24 to 26, 2017
DescriptionThis 3-day course, offered annually in Norway since 2015, 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

Seafood Expo Global
Brussels, Belgium, April 25-27, 2017
Seafood Expo Global/Seafood Processing Global is the world's largest seafood trade fair. The fair features more than 1,700 exhibiting companies from over 75 countries. Info: http://www.seafoodexpo.com/global/

Food & Feed Drying Technology short course
Ås, Norway, April 27 & 28, 2017
Drying is an essential operation in aquafeed production, and it is one of the most energy-intensive process operations. Yet it is often poorly understood and inefficient. 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

MAY 2017

11th International Conference on Molluscan Shellfish Safety: Protecting consumers, assuring supply, growing confidence
Galway, Ireland May 14 - 18, 2017
ICMSS2017 is the 11th conference in this series and offers an important multidisciplinary interface between

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regulatory, scientific and industrial representatives of the international molluscan food safety community. It is a biannual forum where unusual, emerging and novel shellfish risk factors are discussed, offering new information and solutions.
Info: http://www.conference.ie

JUNE 2017

Aquaculture UK
Stirling, Scotland, June 14-15, 2017
The Aquaculture UK Conference 2017 takes a refreshing and exciting look at the issues to be addressed in the further development of the UK aquaculture industry. The conference offers a valuable opportunity to network, meet decision makers and plan the future of the industry. Contact: Benchmark House, 8 Smithy Wood Drive, Sheffield, S35 1QN, England; Tel. Matt Colvan +44 (0)114 2464799;
Email: info@aquacultureuk.com.
Web: https://aquacultureuk.com

6th Congress of the International Society for Applied Phycology
Nantes, France, June 18-23, 2017
The scope of the 6th edition of ISAP congress is to appreciate the huge phycological biodiversity and the diversity of its biotechnological applications through the prism of a new and promising industrial sector in full development. The Congress will include speakers and posters presentations, exhibitors and for the first time a BtoB session to meet the right partners.
Email: isap2017@sciencesconf.org;
Url: https://isap2017.sciencesconf.org/

AUGUST 2017

Aqua Nor
Trondheim, Norway, August 15-18, 2017
Since 1979, Aqua Nor has been an important international meeting place for the aquaculture industry, and it is today the world's largest aquaculture technology exhibition. Contact: Klostergata 90, 7030 Trondheim; Tel. +47 73 56 86 40; E-mail: mailbox@nor-fishing.no. Web: http://www.aqua-nor.no

SEPTEMBER 2017

Larvi 2017 - 7th Fish and Shellfish Larviculture Symposium
Ghent, Belgium, September 4-7, 2017
Capitalising on the previous "larvi" symposia (in '91, '95, '01, '05, '09, '13), the Aquaculture R&D Consortium of Ghent University and the Norwegian University of Science and Technology (NTNU) have joined again in organizing "larvi'17" and are inviting the academic as well as the private sector to attend the 7th Fish and Shellfish Larviculture Symposium. Bringing together European and non-European stakeholders, the latest progress in academic research and in the sector will be reviewed, problems identified and avenues for future collaboration explored.
Contact: Laboratory of Aquaculture & Artemia Reference Center, Ghent University, Campus Coupure F, Coupure Links, 653, B-9000 Gent, Belgium.
Tel: +32-9-264 37 54; Fax: +32-9-264 41 93;
E-mail: larvi@UGent.be.
Web: http://www.aquaculture.UGent.be

18th International Conference on Disease of Fish and Shellfish
Belfast, Northern Ireland, September 4-7, 2017
Organised by The European Association of Fish Pathologists. Info: www.eafp2017.com

8th International Symposium on Sturgeons
Vienna, Austria, September 11-17, 2017
The upcoming venue will be an all-European effort to bring together the sturgeon experts worldwide.
For more information see
http://www.iss8.info/index.php/iss8home.html

12th Icelandic Fisheries Exhibition
Smárinn, Kópavogur, Iceland, September 13-15, 2017
A must for all commercial fisheries organisations and associated businesses, the three year cycle of the show is a direct response to the wishes of the exhibiting companies. This ensures that they have new products on display at each event, and as a result the exhibition has constantly grown since its inception in 1984.
Contact: Marianne Rasmussen-Coulling, Events Director, Mercator Media Ltd, UK. Tel: +44 1329 825335; Fax: +44 1329 550192;
Email: mrasmussen@mercatormedia.com.
Url: http://www.icefish.is

OCTOBER 2017

Aquaculture Europe 2017 - Cooperation for Growth
Dubrovnik, Croatia. October 16-20, 2017
Contact for abstracts and registration: EAS Conference Organiser, John Cooksey, MF Cooksey Conference Management, AE2015 Conference, P.O. Box 2302, Valley Center, CA 92082, USA.
Tel: +1 760 751 5005; Fax +1 760 751 5003;
E-mail: worldaqua@aol.com
Contact for industry and media sponsorship opportunities: Mario Stael, MAREVENT, Begijnengracht 40, 9000 Gent, Belgium.
Tel/Fax: +32 9 2334912;
E-mail: mario@marevent.com;
Web: www.marevent.com
General information: European Aquaculture Society, Slijkensesteenweg 4, 8400 Oostende, Belgium.
Tel. +32 59 32 38 59
Email: ae2017@aquaeas.eu
Url: www.aquaeas.eu

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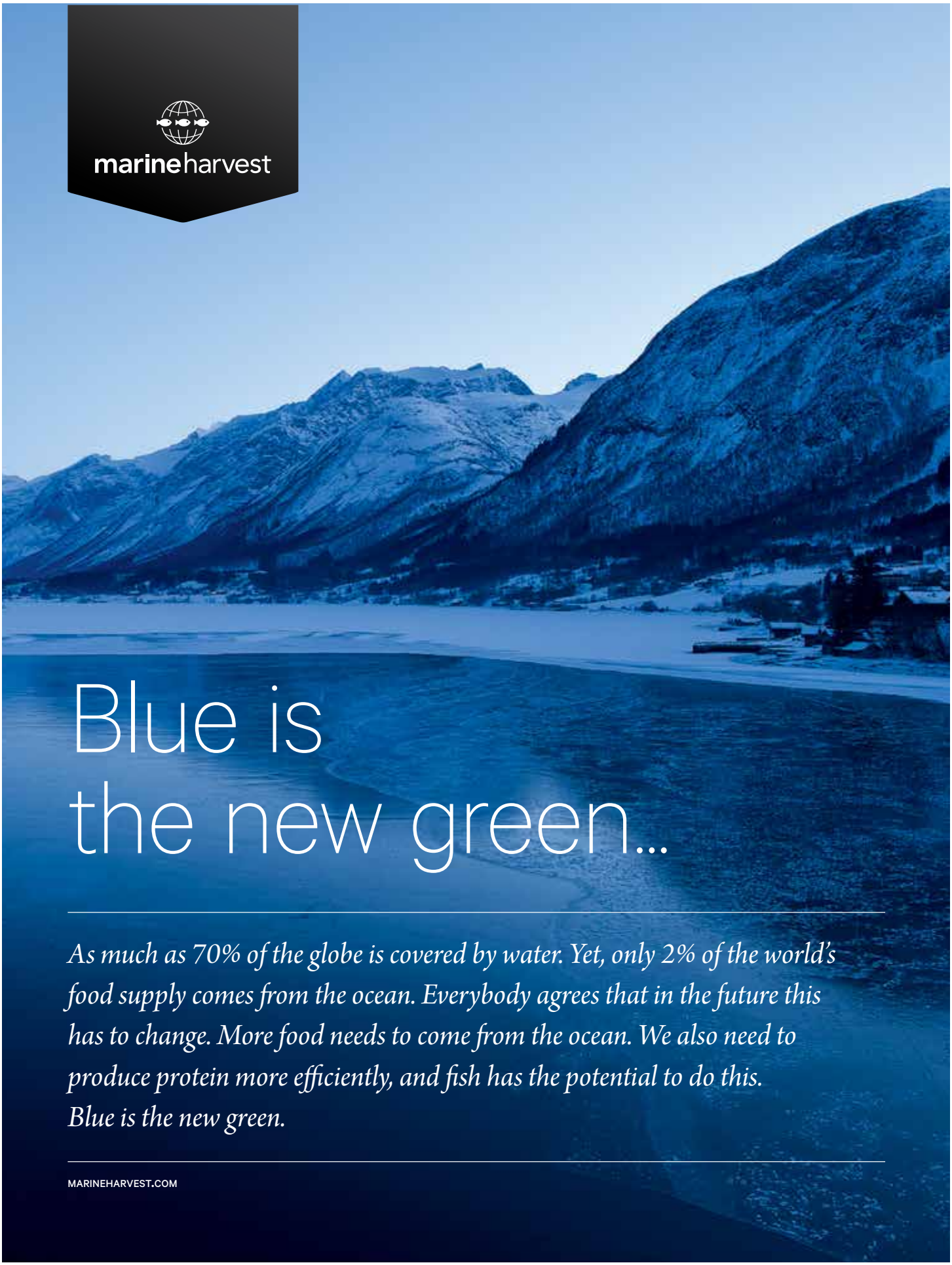
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