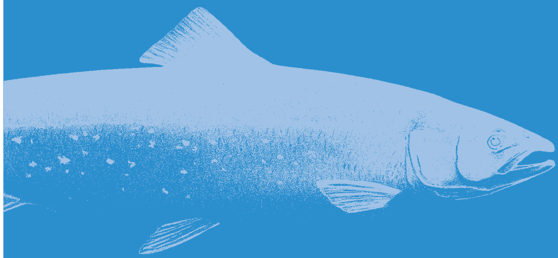
Aquaculture Forum
BREMERHAVEN



Bremerhaven Declaration
on the Future of Fish Nutrition and Aquaculture Technology

3

Part II

Recommendations and Justifications

Workshop III — **February 18–19, 2013**

FINFISH NUTRITION AND AQUACULTURE TECHNOLOGY AT THE CROSSROADS

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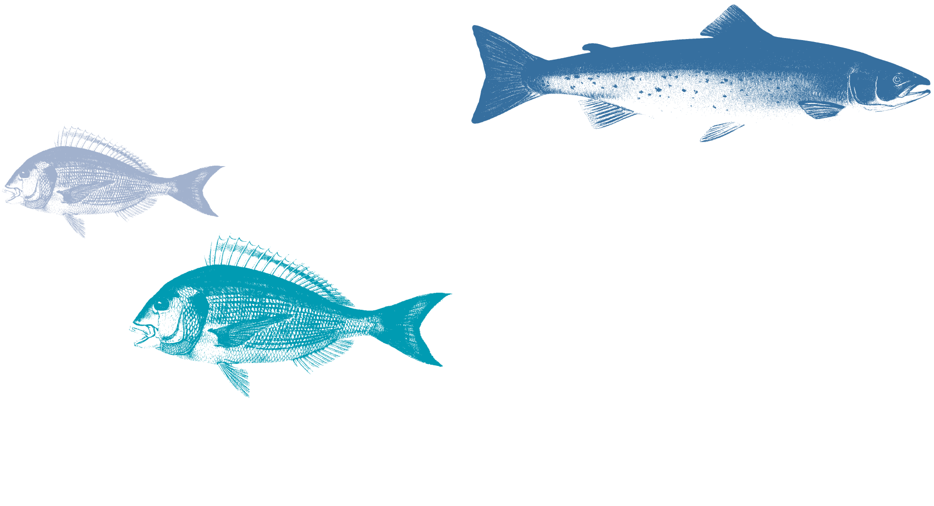

BREMERHAVEN DECLARATION Part II
on the Future of Fish Nutrition and Aquaculture Technology

Aquaculture – an equal right food production sector

Recommendation 1

The aquaculture industry should be seen as an equal right resource user that also needs protection from the externalities of other aquatic and land-based resource users and industries competing for the same resources. In this context there is also an urgent need to simplify regulatory frameworks for aquaculture systems, which are presently highly regulated in many countries within the EU. This can be done without compromising environmental objectives and targets while removing unnecessary bureaucratic barriers that distort the competitiveness of European aquaculture.
Aquaculture system planning should from the start define the externalities and explore their internalization. There is a need to enhance the flow of information on developments in aquaculture systems and production to increase transparency and gain public and consumer acceptance.

Justification

Although an ancient business using conventional farming systems, modern aquaculture developed in many European jurisdictions within the past few decades, other food production sectors (agriculture and animal husbandry) were fully established and guarded by adequate rules and regulations. Aquaculture, however, has still to find its niche within existing food management systems with no clearly defined lead agency governing its development in most European countries. Aquaculture producers are in need of being treated equally to its terrestrial counterpart (agriculture) and should receive common governance rules to maintain competitiveness at a local, regional and EU-wide scale. In several countries (such as Germany) local regulatory conditions differ widely between states ("Länder") and more so in relation to other EU countries, distorting competitiveness and chances for development. Within Europe, aquaculture uses production forms that are more similar to agriculture rather than fisheries. Nevertheless, this food production sector is still administered under the Common Fisheries Policy and only recently it has been recognized that new approaches are needed if the industry is not to fall behind its global competitors in a very globalized market. The aquaculture sector is tightly controlled in Europe, guaranteeing food safety, environmental protection and sustainable production systems. There is a need, however, for aquaculture to be protected from other aquatic resource users in the same way as these businesses are protected from the ill-effect of other industries. Aquaculture systems depend on the quality of the aquatic resources potentially polluted by wastes from industrial and agricultural activities, thus water quality control need to be tightened near aquaculture facilities to allow their safe operation.
Furthermore, we recommend that Aquaculture systems should from the start internalize the externalities. However, this can lead to a distortion of business conditions as most agro-industries are heavily subsidized and are explicitly or implicitly excempt from externalities. Aquaculture, however, can – by doing so - take the lead to become an environmental friendly industry and should more aggressive promote this principle through public awareness campaigns to gain public and consumer acceptance.

Aquafeeds and Nutrition

Recommendation 2

There is an urgent need to invest in research and development of alternatives for fish-meal and fish-oil resources, incorporated with appropriate quality control measures to maintain the quality level of the final products.

Justification

The present growth rate of aquaculture can only be maintained if alternative resources for fish meal and fish oils as key ingredients can be identified and cost-effectively produced. It must be realized that serious competition for these bio-resources exist from other food production sectors. Alternative natural resources are available. However, it has been shown that their use may compromise final product quality. Marine aquaculture products are especially considered healthy food items because of their high content of highly unsaturated fatty acids. As quality considerations can

become a major problem also affecting the image of the industry, further intensive research is required to maintain the high nutritive value of aquatic products.
There is also the problem of resource competition with other industries and these may have serious cost implications. The search for alternatives must be considered as a conceptual part to the solution while market interactions need to be more intensively considered in the future. The feed industry is increasingly faced with trade and price instabilities in markets that require strategic considerations when assessing future competition for bio-resources.

Recommendation 3

Specific research being undertaken when exploring alternatives for fish meal and fish oils in feeds with a primary focus on

- suitability of alternatives to meet species-specific requirements
- the assessment of ecological implications of increasing zooplankton fisheries producing fish oil supplements or replacements,
- the development of oil-seed crops and single-celled micro-organisms to produce n-3 higly unsaturated fatty acids (n-3 HUFA)
- cost-effective production of fish oil substitutes by bio-technological processes
- to improve the intrinsic fatty acid metabolism of fish through breeding programmes to confer a trait of increased n-3HUFA content in aquaculture products

Justification

The growth of and product diversification in the aquaculture sector requires to develop new basic resources to meet the demand for quality feeds designed for a number of specific applications. The limits of using fishmeal as a lipid and protein resource for feed are obvious and extensive efforts are needed to meet the demands for broodstock management, hatchery operation and grow-out facilities. Here fish-oil substitutes obtained from upstream and downstream processing of microalgae (especially when produced in closed production systems) provides one option that needs to be explored further.
Increasing extraction of HUFAs from marine resources other than fish to be used for direct human consumption is another issue when arguing for the need of a high quality lipid composition in cultured fish. Meeting human nutritional needs by including extracted HUFA-PUFA in aquaculture diets allows a high quality product to be produced and sold provided there is an adequate market. However, extracted HUFA-PUFA concentrates from marine resources other than fish (e.g. micro-algae, zooplankton) directly destined for human nutritional demands, may affect the promotion of health food production through aquaculture. Maintaining product quality under changing availability of feed resources will also require a new strategy for monitoring the entire production system. There is an urgent need to incorporate cost-effective methods and logistics to meet these requirements. Finally, when producing fish oil from marine wild resources other than fish (plankton), early environmental impact assessment studies need to be undertaken to assure a sustainable resource use.

Gamete handling and larval rearing

Recommendation 4

There is an urgent need to plan for the comprehensive development of land- and water-based infrastructures needed for the technical and logistical support and supply of Open Ocean Aquaculture that incorporates the multi-dimensional interacting factors for successful operations.

Justification

Omnia ex Ovum (everything comes out of the egg!) – Life starts anew for every generation with the fertilization of gametes. While we are constantly improving the science-based procedures for rearing juveniles, fattening and grow-out of adults to derive at standard quality products (a necessity for continued and reliable market supplies), the need for standardization processes of gamete handling has been largely ignored. This is despite the general recognition that any variability in conditions occurring at the early life cycle stages will have an effect on the performance of the organisms at the individual level with subsequent consequences on the entire cohort or even on the fate of the entire cultured strain within one industry. Today and even more so in the future, the industry will depend on large-scale hatchery supplies of juveniles. The quality and physiological performance capacity of the stocking material will be an important determinant for the performance of the industry. Even more so, we need to develop an aquaculture industry that must be completely independent from natural stocks through proper domestication programmes.
There is an urgent need to harmonize and standardize procedures and protocols in handling aquatic gametes of the key species under mass cultivation to guarantee product quality. The recently established COST Action on the subject is highly welcomed and should be greatly supported in order to involve major players of the industry and the research community beyond the EU borders. This would allow much needed improvements for reliable and efficient seed production while also better securing the selective breeding of strains with target properties. The provision of standardized methodologies for gamete supplies would be an important step in quality assurance of aquaculture production for species for which domestication is a prerequisite for the future development of the industry.

Recommendation 5

There is an urgent need for more predictable and cost-effective production of high-quality larvae, fry and fingerlings for stocking aquaculture grow-out facilities, through a better understanding of
(a) the environmental conditions in the larviculture tanks as well as in the live food production units,
(b) the response of the immune systems of aquaculture species under specific treatments (e.g. application of prebiotics and probiotics) and,
(c) the requirements for a greatly improved microbial management within hatcheries (i.e. use of innovative strategies for manipulation of microbial composition and/or reducing microbial virulence, e.g. interaction with microbial quorum sensing, role of heat shock proteins in disease control).

Justification

Aside from the highly controlled hygienic conditions in most hatcheries, there are still fundamental needs to fully understand the interactions between selected and domesticated stocks within the specific aquaculture environment and the key conditions to be achieved for cost-effective production. Even today, in many established commercial hatcheries for marine and freshwater fish we are regularly confronted with low average survival of fry and juveniles, often accompanied by fish deformities. This critical bottleneck needs to be overcome for future cost efficiency and sustainable development of the industry, and requires many small and detailed improvements in nutrition, zootechniques and microbial control.

In many production systems we still depend on live food in larviculture of fish and shellfish species. Present applications are mainly based on trial and error approaches with a limited base for standardised procedures on quality control. Therefore, there is plenty of room for optimisation of procedures. There are new developments under consideration for the green water techniques:
(a) introducing high quality algal substitutes that may reduce work load,
(b) producing ready-to-use pre-prepared and stored food resources at any time, and
(c) employing selected microbial mixtures for better growth and increased stress resistance in fish larvae. Substantial changes may occur in bacterial communities during the culture process (e.g. within days) and these host-microbial interactions need to be understood and controlled much better to serve the target purpose, and
(d) exploring the application of immune-modulating processes such as quorum sensing interference and heat shock proteins (Hsps) as potential means to control critical diseases, specifically in hatchery systems.

Culture for release (ranching, restocking, species conservation)

Recommendation 6

Hatchery rearing strategies are urgently needed for endangered species to produce progeny with the fitness for survival in a highly competitive and harsh outside environment. Such methods and strategies must be designed to avoid outbreeding depression (maintaining the natural genetic integrity of the species of concern)

Justification

Aquaculture for production and culture for stocking natural waters are two objectives requiring totally different methodologies to meet the specific goals of each. Presently, most of the technical approaches for both purposes are similar. **This is a mistake.** While **aquaculture production systems select for** (a) best survival, (b) high food conversion via feeds designed for best biomass gain, (c) fast growth rates to shorten grow-out time (d) disease resistance, (e) cost-effective production and finally (f) for high quality end products, the **culturing for restocking** needs to provide progeny with the ability to (a) rapidly respond to changing environmental cues, (b) adjust to behavioural traits (diurnal/nocturnal rhythms), (c) recognise predators to avoid them, (d) display robustness to abruptly changes in water quality (e.g. thermoclines; oxygen depletion; high turbidity and changing micro-light climate and wind/wave action), (e)

resist challenges by pathogens/parasites, and (f) finally to effectively interact with behavioural traits of con-specifics (perfect intermingling). In short, **culture for release must be designed to allow progeny at the time of release to match the „FITNESS“ required for survival in the receiving habitat** while also „MATCHING“ the characteristics in all traits of the con-specifics in natural populations. Although this is logical, most stocking and rehabilitation programmes lack a cohesive concept and systematic approach to meet these requirements. A framework based on recently developed strategies for sturgeons (species of high longevity, low residual population size and specific habitat-dependent traits) needs to be developed to meet future demands on species conservation [4]. The conventional hatchery systems offer largely monotonous life conditions of little use to prepare the progeny for the harsh and challenging environmental conditions which they are facing in nature after release. Step by step adaptation to these challenges in a standardized format can help improving performance, including the transition to natural foods, exposure to predators, as well as acclimation to diurnal rhythmic cues (lunar cycles, tidal currents, wind and wave action, etc.).

Recirculating Aquaculture Systems (RAS)

Recommendation 7

The potential to apply modern approaches in recirculating aquaculture systems should be greatly enhanced with due consideration to the economy of the scale.

Justification

Recirculating aquaculture systems are not a new development. Over half a century ago, the first commercial recirculating carp farm has been shown to operate reliably in Japan. However, functionality in terms of system design and performance is no longer applicable because of drastically changing cost structures for both the construction and operation of such system. The earlier trial and error approaches has to be replaced by more professionalism in bio-economics. The use of partial or full recirculation of water resources has advanced during the last few decades, specifically improving our knowledge base on the various treatment processes and their interactions. Certainly, most of the knowledge focusses around the technological and biological performances of system components. However, much more attention has to be paid to the cost-interactions when these components act in concert in order to better evaluate component combinations.

Recommendation 8

Aquaculture Recirculating System (RAS) design must take species-specific requirements into considerations, the design and layout of which must serve the specifically targeted products while increasingly employing process control technology.

Justification

There is no simple solution in system design serving many species equally well. Optimizing system performance will require specific adjustments to species-specific requirements and will have to account for the dynamic state of operation. A steady state performance is mainly a theoretical consideration while system design will have to be planned for flexible, adjustable and modular operational mode, allowing quick adjustments to changing conditions within the system and in the market place. This holds in particular to the design for various life cycle stages (e.g. hatchery operation, grow-out facilities, rearing for release). The so-called “ALL ROUND RAS“ approach is expensive and inefficient while not being sufficiently flexible to react to market demands. Further, modern technological developments in process control should be more readily adapted specifically to improve operational safety and cost effectiveness. The construction of culture units and the operational process technology for RAS must also support behavioural traits of the target species.

4 Chebanov, M., Rosenthal, H., Gessner, J., Van Anrooy, R., Doukakis, P., Pourkazemi, M., Williot, P. 2011. Sturgeon hatchery practices and management for release: Guidelines. FAO Fisheries and Aquaculture Technical Paper No 570, X 110 pp.

Recommendation 9

There is a need to develop technology standards for RAS and its operational components (including materials) while also improving our knowledge base to more accurately predict production capacity (including safety margins) as well as appropriate risk assessment methodologies (including sound contingency planning).

Justification

There are presently no bio-technological standards for recirculating aquaculture systems. These are urgently needed in particular in relation to materials used (in a similar way as available today for the entire food processing industry) but also for minimum performance requirements for system components. While research often needs to be carried out in complex systems to study and understand the dynamic state of the interacting processes involved, the final goal should be more simplified systems with specific performance targets (focussing on single species, or even specific life cycle stages). Design criteria will primarily have to incorporate considerations on temperature, required oxygen supply and species-specific oxygen demands, and other water quality standards needed to determine carrying capacity of the treatment facilities (e.g. biofilters). Additionally, there is a need to design the systems in line with the intended feed, feeding management and planned production cycles. Overall, there is an urgent need to also identify operational safety margins (in terms of reliability of system components and respective backup units and also in terms of safety levels on maximum carrying capacity). Experience shows that many RAS operations are often " under dimensioned" as the initially calculated steady-state load is unrealistic and ambitious while in reality there can be occasionally a high inherent variability to cope with. Without sufficient safety margins these systems are bound to fail. Risk management plans (in particular contingency plans) are urgently needed and must be developed by sound and well-designed accompanying research because presently there seems to be an unacceptable high "on-call" work load for staff, trying to cope with frequent and unexpected break downs. There is a need to employ site-specific risk assessment before the operation starts, including potential hazard identification, mitigation measures and management strategies.

Recommendation 10

There is an urgent need to improve education on principles and on operational practices for all modern aquaculture systems (in particular for RAS) at a multi-disciplinary, trans-disciplinary and a fairly standardized level including appropriate certification.

Justification

Recirculating systems are increasingly used in various forms of aquaculture production. This biotechnology has advanced from trial and error systems to partly complex and highly controlled units. Today the major biological and biochemical processes involved are fairly well understood. However, as more investors are getting involved, adequate and well experienced personnel is not readily available and the complexity of system functions require specific know how while the need for multi-disciplinary experiences are often ignored.

To advance and safeguard this branch of the industry, there is a need of appropriate education and training (with certification: "drivers licence") of managers and operational personnel. Recent studies show that such personnel is rare and lacking among system producers, investors and operators (manager). Often, the claimed expertise is simply assumed, very limited and not complete.

Good management skills of RAS experts should be A MUST in order to avoid system failures and properly manage existing risks. **For large-scale commercial systems, the regulatory authorities should make it mandatory (as part of the license process) that fully educated and certified operators are employed.** Educational programmes through various means (national-, EU-programmes, with industry participation) should be supported including the provision of infrastructure for such educational system that also assist educating small-scale RAS operations.

Educational programmes should include the training on developing Business plans as well as performing market and social studies, covering also a thorough risk assessment approach with special emphasis on operational risks and losses so that planning proceeds by incorporating potential problems from the start. Multidisciplinary team work should be obligatory in such programmes to encompass all

processes involved (system component design, component interactions, operational procedures and final products in relation to markets i.e. from cradle to grave).
•There is also a need for Standardization of the industry through protocols at all stages (e.g. materials, processes; breeding and rearing schedules; health and environmental control).

Integrated Aquaculture Systems, Integrated Multi-Trophic Aquaculture (IMTA) and Aquaponics (Hydroponics/Aeroponics)

Specific recommendation on Integrated Aquaculture

Recommendation 11

Land-based integrated agriculture-aquaculture systems need to be assessed and tested in light of modern biotechnological, socio-economic, and environmental criteria to define practical combinations of various species suited for local markets. The economic scenarios under severe resource competition in various European regions should also be considered.

Justification

Long-term experiences in developing countries indicate that the combination of fish culture with various agricultural crops can add to the economic viability of the entire farming system in freshwater environments. Commonly known are the fish-cum-rice culture systems or those where the (a) aquaculture production is temporarily using waters during the rainy season while during dry season this nutrient-laden water is used for irrigation and (b) were waste from one component of the farm become a new resource for other farm sections. With dwindling energy and natural resources the importance of an intelligent utilization of wastes in modern recycling should not be under-estimated. Examples of such systems are currently in operation and have been so for many years in Hungary (highly effective combined sewage fish ponds), and the traditional Bohemian fish ponds (Czech Republic: combined irrigation- tourist-poultry hunting – using fish ponds as a key component in the managed ecosystem). However, our experience and detailed knowledge on the performance and operational needs of such Integrated Multi-Trophic Aquaculture (IMTA) systems in central and Western Europe is limited. The combined cultivation with species at different trophic levels, besides environmental and economic benefits, may introduce other risks, such as new disease transfer pathways which can have dramatic

negative effects also for human health. For example, the „Influenza Pandemic" in the middle of the last century produced very negative outcomes as certain species combinations (e.g. pigs, poultry and fish) promoted the proliferation of a specific influenza virus through gene recombination for which humans have had no antigen.
Nevertheless, we have learned that certain species combinations can have highly beneficial effects on ecosystem integrity and stability as well as on the economic viability of the farm through product diversification. **It is recommended that an ecosystem approach be taken that includes studies on the dynamic responses of various trophic levels induced by enhanced productivity without supporting disease transfer risks.**
There is also a need to overcome behavioural practices and regulatory barriers that allow a paradigm change to accept that each component of such agri-aqua-system may in itself not be economically viable while the combined production results in sustainable operations serving highly fluctuating product demands and price structures, thereby stabilizing income.
Also, considering the anticipated climate changes in many parts of the world (in developed as well as in developing countries) it is expected that a re-assessment of the options of intelligent water resource partitioning in a multi-stage farming approach will be necessary. Industrialised (high-tech) countries could explore the potential of various scenarios and derive at science-based recommendations for species and system combinations not only at regional but also local level.
Land-based aquaculture systems may also comprise brack-

ish-water and marine culture systems, such as extensive farming systems in combination with wetlands or lagoon fishery but also those producing seeds and weeds in back-waters while supporting artisanal fisheries and eco-tourism (e.g. the Italian valli-coltura lagoon systems). Such integrated systems are in similar needs for research to safeguard their development.

Specific recommendation on Integrated Marine Aquaculture Systems (need for area specific licences)

Recommendation 12

The development of integrated farming systems that employ a mix of species of various trophic levels, thereby enhancing environmental compatibility of aquaculture, should be promoted in suitable coastal areas. New and extended criteria for area licences are needed to accommodate various system components to better utilize natural resources and to protect the environment. The combined cultivation of organisms of different trophic levels confers environmental and economic benefits, but may introduce risks, such as new disease transfer pathways or issues concerning fish and plant hygiene and taste. This field is currently widely underrepresented in aquaculture research and specific recommendations are presented below.

Justification

Aquaculture in integrated systems is not a new idea and has traditionally been practiced in various regions of the world for centuries. Such systems include the Italian "valli coltura" (e.g. combining intensive hatcheries and overwintering ponds with stocking the Venice Lagoons). While stocking of lakes and reservoir is a common practice, integration of aquaculture and fisheries in coastal and marine systems has so far only been practiced successfully in Japan and options of enhanced production through aquaculture supported fisheries in coastal environments should be explored further. Here, new approaches should be explored that incorporate our improved knowledge base and local and regional infrastructure options and requirements.

Specific recommendations on IMTAs (Integrated Marine Trophic Aquaculture)

Recommendation 13

As new Integrated Multi-Trophic Aquaculture (IMTA) systems are designed, there is an urgent need to develop carrying capacity models based on mass balance models for such systems while also the ecology of diseases in these simple ecosystems must be fully investigated to avoid unforeseen impacts of disease outbreaks that limit the development of this technology and jeopardize economic benefits.

Justification

Increasing the complexity of aquaculture production systems from relatively simple monoculture systems to include extractive as well as fed species increases the potential interactions of a pathogen with the environment. Each interaction that occurs may increase or decrease the risk of a disease transmission event occurring. Although many of these interactions will be passive, some may cause the bioaccumulation and biomagnification of a pathogen within any component of an IMTA system. When this occurs the potential for a catastrophic disease outbreak will increase. The recommendation asks for research thatidentifies mitigation strategies to minimize these risks by incorporating appropriate carrying capacity and mass balance models.

Recommendation 14

If protein and lipid sources from IMTA systems are to be used in aquaculture production a framework must be developed to ensure that these products are free of aquatic pathogens with a view to avoiding biomagnification of pathogens within the food chain.

Justification

One of the most exciting areas of IMTA is the ability to produce high quality marine proteins and lipids for use in the production of more valuable aquatic crops (for example the use of farmed blue mussel meal in fish feed to replace wild caught fish meals). However, one concern is the ability of bivalves such as blue mussels to bioaccumulation and biomagnification many pathogenic and non-pathogenic microbes. If these microorganisms survive processing into the diet formulation there is the risk that diseases could be transmitted to the more valuable crop. Thus it is essential that processes are developed to ensure that animal feeds developed from IMTA produced material are pathogen free.
Integrated Pest Management systems are now common tools in disease control. IMTA systems have the potential to act as ablative species protecting the main crop, be it fish bivalves etc., from disease outbreaks. **This can be achieved by strategically locating filter feeding, extractive species,**

such as blue mussels around the fish farm. This provides protection for the farm fish from wild diseases, as the infectious pressure is reduced as certain pathogens such as sea lice (L. salmonis) and ISAV are taken up by the filter feeding animals and inactivated and vice versa. However, this is **not true for all** pathogens and a word of warning for pathogens like Vibrio angullarium where the bivalve will concentrate the bacteria from the water and excrete it in high levels in their faeces. Infectious particles made of this material will increase the infective pressure of V. angullarium increasing the risk of a disease outbreak under certain conditions and these issues need to be properly addressed to minimize risks.

Recommendation 15

It is strongly recommended to support research and development projects on the potential of greenhouse crop production with aquaculture production (e.g. hydroponics / aeroponics) to elucidate mass flows between the compartments of such systems as well as to enhance bio-economic resource use, particularly when contributing to rural economy.

Justification

Combining greenhouse agriculture with aquaculture production under the same roof offers opportunities to employ a multi-resource-use concept (using water twice, transferring nutrients between system components, saving energy and labour by combining units), particularly when aquaculture is using RAS systems. There are several examples worldwide that use such systems, providing a proof of principle while demonstrating that these can function, allowing also a significant reduction in emissions and creating synergies. However, there are huge regional and even local differences in resource availability and climatic conditions that determine success or failure. Up-scaling tests to commercial scale are still lacking but desperately needed. There is still a lack of understanding the various interactions between the sub-systems in terms of energy and nutrient flows as well as potential benefits due to savings of energy and water resources. At present, green-house technology advances quickly and there is an urgent need that aquaculture is incorporated as integral part of the development. There is also a lack of proper understanding on how to combine the various processes involved under given local environmental and economic conditions to obtain optimum output at minimum inputs.

Aquaponics need to target ideal growing conditions in either subsystem in order to create a win-win situation in terms of resource use and product diversification. Both are critical issues determining the acceptance of such systems by fish farmers and horticulturists, particularly when targeting at the minimization of emissions (e.g. N, CO_2, and P).

Therefore, nutrient and mineral flows need to be controlled allowing directed process optimization (feeding regimes, diets use, cost efficiency, etc.).

Potential for increasing economic feasibility will also be gained once reliable data become available on the performance and on the bio-efficiency so that the merits of bio-certification may become a reality (e.g. drastic reduction of emissions).

It has also to be realized that at present greenhouse technology advances rapidly offering new opportunities to improve operational efficiencies.

Although there are some limited on-going small-scale projects on the feasibility of such systems in temperate regions: upscaling is urgently needed to support the development on a commercial scale. Legislation should – in a timely fashion – reflect the development and accompany the ongoing progress by amending adequate legislation in a timely fashion (including appropriate licenses guidance for prototype testing).

The further development of aquaponic systems requires specific education. Therefore, theoretical and hands-on training to manage and optimize the output of the highly complex combination of fish and plant production system is essential. This is the only way to integrate aquaculture systems into already existing agriculture businesses in the future.

Similar to the recommendations made under IMTAs, the development of aquaponic systems will also have to include elements to consider interactions of disease agents from either system while also addressing issues by proper integrated management.

Bremerhaven, April 30th, 2013

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Contributions to the Bremerhaven Declaration on **"the Future of Fish Nutrition and Aquaculture Technology"** were received from Members of the Programme Committee, Session Chairs and speakers while participants presented their views during the Panel discussion on day two of the workshop.
These views were accommodated as much as possible by the Editorial Committee (Rosenthal, Buck, Koch) Those participants who offered support to the views expressed in this Declaration are listed as follows:

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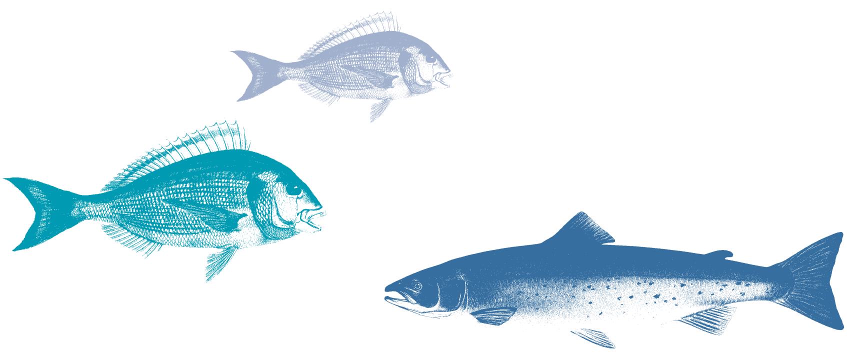

2012 – 2013

Business and science for a sustainable European aquaculture

Aquaculture Forum
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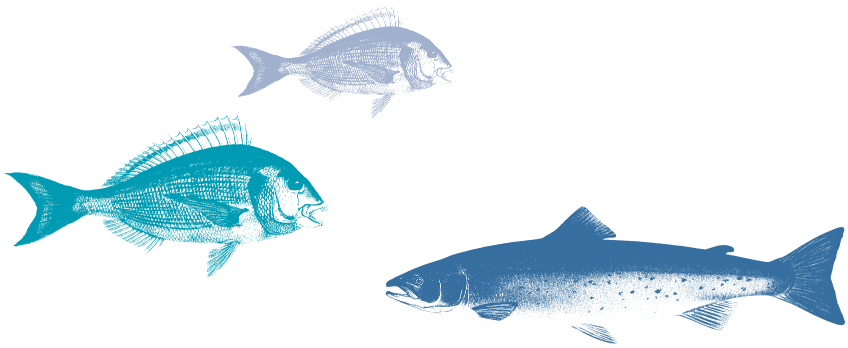

Workshop IV September 23–24, 2013

DEVELOPMENTAL TRENDS AND DIVERSIFICATION IN EUROPEAN AQUACULTURE

4

New species and/or new products from established aquaculture species?

The rapid growth of the industry in several parts of the world has been based on a limited number of species. Several new species are now in production, the names of which were largely unknown by the consumers 10 years ago. Can we expect this trend to continue? Should we try to investigate in option to diversify aquaculture through the development of culture know-how for new species?

Alternatively, should we diversify products derived from a limited number of species for which our knowledge on reproduction, growth, nutrition, and health is well established? Does future aquaculture produce only for the food market or will aquaculture species become increasingly the bioreactors to extract additionally high-prized substances needed by others than the food markets? Will freshwater or marine species dominate the future mass production systems?

The workshop will focus on these and related issues.