European Fisheries and Aquaculture Research Organisations

EFARO

A vision on the future of European Aquaculture

Where will European aquaculture be in 2030, 2050 and beyond, outlining the main drivers and game changers.





In order to deal with the diversity of questions in a growing aquaculture sector, EFARO established an Aquaculture Working Group. The Working Group represents the European Fisheries and Aquaculture Research Organisations with a focus on applied research. It thereby represents an important bridge between knowledge of more basic science and its application within the industry. The thoughts forwarded in this paper represent a longer time horizon than normally used in industry investments, but with a clear focus on innovations, issues to be addressed and game changers.

The Working Group recognized the importance of linking relevant organizations through a dedicated network in order to make available scientific research to support policy makers. A first step in this process was to reinforce an interactive dialogue with EATIP, the European Aquaculture Technology and Innovation Platform, on e.g. environmental issues, future food and industry development and the role of aquaculture in building a circular economy.

The second step was the initiation and formulation of this strategy and position document you have in your hands now. This document presents a science based view of aquaculture's future, not limited to today's economic situation and legislation. It seeks to function as start of a much needed discussion on the scientifically based input to policy makers and industry in the field of aquaculture development.

The members of the Working Group unanimously agree that the future success of European aquaculture depends on its ability to continue the process of knowledge based development. A close collaboration between organisations as EFARO and EATIP is a prerequisite in such process. The intent is therefore to help manage the scientific advisory processes throughout Europe by integrating science and industry and work together with stakeholders and policy makers in identifying and prioritising areas where research co-operation would be most effective and beneficial.

This vision document presents the following three components:

1. In European aquaculture, where do we want to be in 2030, 2050 and beyond?
2. What are the main drivers we have to reckon with moving towards 2030, 2050 and beyond?
3. What are the game changers we would need in order to attain our goals for 2030, 2050 and beyond?

On behalf of the Aquaculture Working Group of EFARO,

Dr. Tammo Bult
President EFARO




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Challenges in aquaculture

The long term challenges in European aquaculture

1. To give the present and future extractive aquaculture sector, reaching from completely closed bio generators to open sea algae and bivalve farming, both a food-, feed- production and environmental service status.

2. To adopt biological and physical limiting drivers in the present open cage production system.

3. Create a combined CAP and CFP policy instrument in support of a diverse EU aquaculture development.

4. To form a critical mass through regional collaboration based on physical and biological conditions.

5. To create economic incentives by adopting “green” technology in commercial large scale production.

6. To complement the system of open cage farming with a diverse freshwater aquaculture industry as a part of the agro system, i.e. a multi-faceted integrated aqua-agro system with inspiration from traditional South East Asia systems, upgraded with modern bio- and engineering- technology.

Background and rationale

Based on modern science we must accept that our climate is changing, we are approaching the resilient limits of our land and sea ecosystems, there are defined limits to natural resources and we will be 9-10 billion people before 2050, with 80% of the population living in cities. On the positive side is an overwhelming amount of evidence that the ecosystem will recover, given the chance, provided that its resilient limits are not violated.

Combining these insights with the fact that world poverty is rapidly declining, that worldwide access to information makes ordinary people more prone to migrate than ever before in world history and that the increasing middle class of growing economies shows a growing interest and economic power in changing their eating habits, in all indicating that the present systems of our food markets will change dramatically over the next 15-100 years. I.e. the present system of enormous centralization of production and extensive global transport of food items must, at least in part, be substituted for circular food production systems, which by necessity must include more local production in order to be able to physically close the loop. Such change will have positive effects on local food security of our cities, work opportunities, and local economic growth.

One could summarize that a combination of limited natural resources, a growing population, an increasing buying power of growing economies and a "connected" world will change present trade patterns into a more diverse one. In all, strong local markets will emerge independent if in either an established or growing economy; i.e. the present import based food market of Europe will be challenged, especially with regards to sea food. Furthermore, limited resources of a closed system, independent if local or global, will by default demand circular production and thereby a geographic connection between use and reuse, including recapture of resources also from the aquatic environment.

Europe with its strength in organization, collaboration, science, technology and its economy has an excellent chance to be well positioned and prepared in applying drivers based on local markets and circular production systems. This insight is already well reflected in a number of documents and reports including research strategies. However, few of these documents have made an unconditional and systematic investment into which game changers must be introduced before 2030, 2050 and beyond in order to realize Europe's huge potential in aquaculture over a longer term perspective. In fact, most of the present work is limited to the time frame of 2020, and therefore naturally also by the present economic, industrial and societal situation.

Aquaculture

Aquaculture represents enormous potential in the future development of European food production, and is recognised as an essential pillar of ensuring food security for Europe.
Aquaculture also represents an opportunity for providing environmental services via cleaner technologies such as the use of nutrient wastes as a resource. Aquaculture is composed of an enormously diverse field of production, with opportunities ranging from the open sea, to completely closed bio reactors, intermediate forms of open freshwater such as ponds and race-ways and closed farming systems like RAS, integrated multi-trophic aquaculture, aquaponics and emerging high intensity closed bio-floc systems which can be located close to the centres of population and cities. Aquaculture also represents possibilities to produce healthy and tasty food without antibiotics in an ethical way, without depending on large areas of arable land and irrigation.

However, aquaculture presently constitutes an oxymoron with regards to dependence on large areas of arable land and fresh water resources. By applying marine and more closed systems, aquaculture is already an efficient user of land and freshwater, but due to its dependence on plant products as soy in the feed, aquaculture has similar footprints with regards to these limited resources as any terrestrial animal. Therefore, exploring new or alternative feed resources along with the necessary technology and delivery systems are urgently needed. However, feed based on recaptured nutrients demands an increased research focus on food safety hazards that will accompany circular systems. This research should also focus on the possibility of complementing present hygiene systems by using insect composts and microbial bioreactors as biological barriers for hazardous pathogens.
In order to successfully formulate functional drivers within our EU system one needs to understand the history of

aquaculture. Aquaculture could grossly be divided into two main origins. The one presently dominating European aquaculture is a high technology and intensification line initiated through salmonid sport fishing during the nineteen hundred century. This development was firstly manifested as flow through raceway-, pond- and tank- systems, and was during the second half of the twenties century integrated with modern fisheries technology and knowhow, resulting in today's cage farming. The third generation of this development is now on its way, manifested as a resources efficient and high intensity land or water based closed or semi closed (e.g. RAS) systems, using advanced control, monitoring and water treatment technologies, but with low biological understanding. One could say that it follows the same development as seen in modern precision farming, a parallel also valid in its use of external feed resources.

The second development line has its origin in tropical and agricultural integrated low intensity freshwater systems, developed through thousands of years. These systems are not characterised by engineering but rather by biological technology, including multi trophic combinations of different animal, microbial and plant species, creating food webs and circular flows of nutrients both within the production system itself and between land and water. Historically these systems thereby constituted an integrated part of the agro system, capturing nutrients from the agricultural system otherwise lost to the water recipient. These systems thereby depend on a combination of external and internally produced nutrients by heterotrophic and phototrophic microbes, but in some cases also through plants and zooplankton, crustaceans and bivalves as well as insects.

At present we see a rapid intensification in these extensive systems by applying modern engineering and chemotherapeutic technologies. A development recognised from the last 100 years of agriculture development, with an increased dependence on external resources and thereby the global trade of artificial fertilizers and feed commodities, by default causing depletion at one locality and accumulation at another.

A key to success in EU aquaculture development therefore lies in understanding that aquaculture cannot be defined by either the fisheries or agriculture policies alone, but must be included in both as well as recognise that a novel line of development lies in a bridge between them. Furthermore, one needs to recognise different applications at different regions of Europe, at different scales of production and a production aimed at different markets. I.e. it is of fundamental importance not to arrange these development lines in competition but as complementing activities with possible synergies, but different knowledge base.

1 A Vision for European Aquaculture (blue growth) achievable in 2030, 2050 and beyond

1.1 Social and Economic

By 2030

- Suitable zones have been allocated to aquaculture, so that coastal and rural communities benefit socially and economically of the production activity and have access to the space they require
- Economics and market information are well understood and supply is matched to market demand.
- An efficient knowledge management within the European Aquaculture sector allows for efficient training activity and consequently a strong innovation sector well recognized all around the world.
- Both CFP and CAP recognizes aquaculture as a part of their domain and both has specific chapters handling not only their specific interest in aquaculture but also how its integration between fisheries and agriculture should be handled to support development of novel and world leading production systems.
- Specific efforts are made to stimulate development of novel aqua systems integrating high technology and biological function in order to form high productive, ethical acceptable and environmentally friendly systems, forming the cutting edge of advancement within the global aquaculture industry.

By 2050

- Public perception is no longer a major issue: the quality of aquaculture products has been recognized and the negative impacts on the environment are largely compensated by positive social impact and ecosystems services provided by the activity
- Barriers between commercial capture fisheries and aquaculture no longer exist and have been replaced by integrated systems of aquatic food production.
- Aquaculture is accepted and recognized as a productive and efficient means of protein production when compared to terrestrial production
- Aqua-feed availability is secured by the successful production of novel feed ingredients through innovative research and development, including use of nutrient wastes as a resource and feed costs have reduced in relation to final product price.

Beyond 2050

- A true circular economy is in place for a high percentage of European aquaculture

1.2 Environmental

By 2030

- Systems for environmental monitoring and environmental indicators have been standardized and are now widely accepted across Europe by aquatic producers, environmental groups and regulators.
- Feed ingredients originate from sustainable sources (both terrestrial and marine).
- Quality of water for the aquaculture industry has been assured by compliance to and enforcement of the water directives WFD & MSFD.
- CFP and CAP formulate joint chapters focusing the role of aquaculture in environmental mitigation as catch crop and provider of environmentally friendly feed sources based on recaptured nutrients from the water by microbial, algae and bivalves aimed both for aquatic and terrestrial animal farming.
- Nutrients, in the form of microbes (microalgae, micro fungi and bacteria) and insects, constitute a significant part of the feed commodity market for farmed fish and shrimp.
- Intensive biofloc systems as well as combination between biofloc and RAS technology have developed into economically feasible and competitive alternatives.

By 2050

- The carrying capacity of zones where aquaculture is the first priority are well assessed and farms/IMTA have been developed or upgraded without detrimental impact on the ecosystem, by the use of best available technology and knowledge.
- Integrated multitrophic systems best adapted to the local conditions allow an optimal use of all rearing inputs while preserving water quality and providing a variety of high quality products and a wide range of eco-services .
- Microbial and insect based feed commodities are based on recaptured nutrients utilising waste and by-products from the food, forestry, agro and aquaculture production systems.

1.3 Biological

By 2030

- European aquaculture products have been cultured and harvested in systems and production regimes maintaining high welfare standards from hatchery to harvest.
- Implementation of regulations and industry best practices have meant no effect of invasive/alien species on either the environment or the Industry itself.

By 2050

- The industry benefits from strains of highly robust juveniles protected by vaccination to minimize pathology risks all along the on-growing the periods in all types of systems.
- Disease issues are minimal due to development of new vaccines and treatments, the use of better technology, better biosecurity and adaptation of the systems/ species to the local environment.
- Designing of production systems has its base in the biological function, i.e. potential of the animal, rather what is technical possible, making antibiotic and use of other chemotherapeutics an obsolete technology.

1.4 Regulatory

By 2030

- Regulation of aquaculture is implemented smoothly and efficiently across a level playing field allowing existing businesses to operate sustainably and facilitating a fast settling of new farms.
- Legislation and food safety assessments of both feed and product have kept pace with the development of the sectors securing consumer confidence (2030).
- Legislation with regard to resource allocation and localisation of different aquaculture systems are based on system analysis at both regional and Pan EU level and is thereby predictable and transparent both for the industry and the EU citizen.

By 2050

- EU regulation and procedures are harmonized and allow harmonious and concerted development of the activity among the countries in Europe.
- Regulation is such that unlocks the potential of growth but within a sustainable way.

1.5 Technological Innovation & Research

By 2030
- Engineering standards and bio-technical innovations have reduced the risk of escapees to very low levels. Any escapees are unable to breed with wild stocks.
- Technological innovation has both allowed the development of aquaculture in offshore exposed areas and reduced the length of the crop-cycle in near shore sites.
- Technological innovation allows the reduction of energy needs per kg product and most energy consumed is renewable.

By 2050
- Feed ingredients (algae, seaweeds, insects) are mostly from culture productions reusing the waste of aquaculture and other human activities (organic wastes, industrial carbon dioxide, urban wastewaters).
- A diverse and varied research base exists addressing and further improving the environmental and economic performance of European aquaculture.
- Stakeholders across Europe collaborate and communicate effectively in order to boost innovation

1.6 Product quality

European aquaculture products are globally recognized for their high food safety and ethical production standards and consistent quality of product, having benefitted from research into the feeds, livestock management and harvesting processes whilst respecting the living organisms' welfare and efficient processing and packaging.

2 Drivers in European Aquaculture

The emerging drivers of society and its economics in the area of food production in favour of aquaculture are:

2.1 Social drivers

- Food security based on local production and markets: the producers are known by the consumers, who can visit the farms and create a kind of personal confidence relationship with the producers; circular economy.
- Food production respecting the welfare of the reared organisms and the environment: the consumer can visit the farm and see by themselves (1) the livestock welfare condition (2) the natural environment quality and they can enjoy the other eco-services provided by the farming activity (as aquatic life around a cage farm, fauna in wetlands treating the final wastewater of a land based IMTA system).
- Regional clustering to form critical mass based on a clustering of various production systems and farmed species, ranging from open sea to closed inland systems.
- Regeneration of coastal and rural communities and traditions (locally produced food festivals) connected to clusters of complementary efficient mass production systems.
- Space optimal use: development of integrated complementary multi- activities optimizing the space use while respecting the environment: energy production coupled with aquaculture, marine protected areas coupled with fishery and aquaculture and touristic activities.
- Further minimisation of the use of anti-biotics and chemicals to strengthen claims that aquaculture uses less antibiotics/chemicals per kg of production and prevent potential future problems with antimicrobial resistance (AMR).

2.2 Environmental drivers

- Circular economy concepts with transparent nutrient budget independent of short or long loops
- Climate secured food production (variety of species with various optimal temperature) and contribution to the reduction of greenhouse gas release (bio-remediation of carbon dioxide by algae cultures)
- Climate change affecting the availability of existing stocks and the ability to culture species within their optimal range.
- Food production independent of large volumes of the fresh water which is necessary for human uses and agriculture.
- Recognition that aquaculture zones can be integrated with protected areas and fishing zones.
- Recapture based fish feed ingredients transformed through open or closed bio generators (microbes), composts (insects) and filtration (micro and macro algae and bivalves).

2.3 Economic drivers

- A balanced global trade and harmonized regulations and controls across Europe.
- The exploitation of the possible synergies between the marine and terrestrial aquaculture activities and other activities (agricultural, fisheries, touristic and industrial) will contribute to maintenance of positive economic activity and growth for social stability
- Increasing affluence and increasing demand/ competition, for high protein meat products and high value food products that are safe and ethically produced.

3 Game changers enabling a European aquaculture vision to happen

Listed below are some of the potential game-changers that will enable growth of European aquaculture.

3.1 Social

- Outreach campaigns to angling groups, fishermen, sailing communities, consumers and tourists to promote aquaculture activities, the high quality products and the services (including the Eco services) they provide.
- Regional clusters. Learn from the Baltic Seas Region experience and initiate new regions and secure synergies between present and new ones; Promote initiatives for the various marine development activities and formulate support for maximizing interactions between platforms/activities in order to secure synergies and optimize space use.
- Socio-Economic Impacts of Blue Growth: With an ambitious strategy of Blue Growth more changes in aquatic production are envisaged. More needs to be known of the processes of reliance and resilience of coastal communities and the social and economic impacts of this development and innovation of novel production sectors using the seas and ocean.

3.2 Environmental

- Demonstration of the production of a wide range of environmental services linked to all types of integrated aquaculture.
- Competitiveness of the sector is likely to require difficult trade-offs against precautionary environmental regulatory regimes; failure to address this challenge is only likely to increase policy incoherence.
- Demonstration of the potential to exploit the immense areas offshore by fish, bivalve and seaweed farming (70% of global surface is mostly unexploited up to now).
- Building with Nature: Innovation of integrated multi-use of seas and oceans and 'building with nature' for Blue Growth. Examples include multi-use of offshore/inshore windmill and other platforms parks including high seas and deep oceans, for food and feed production and harvesting and innovative coastal defence systems that allow for food/feed production beyond safety from flooding alone.

3.3 Economic

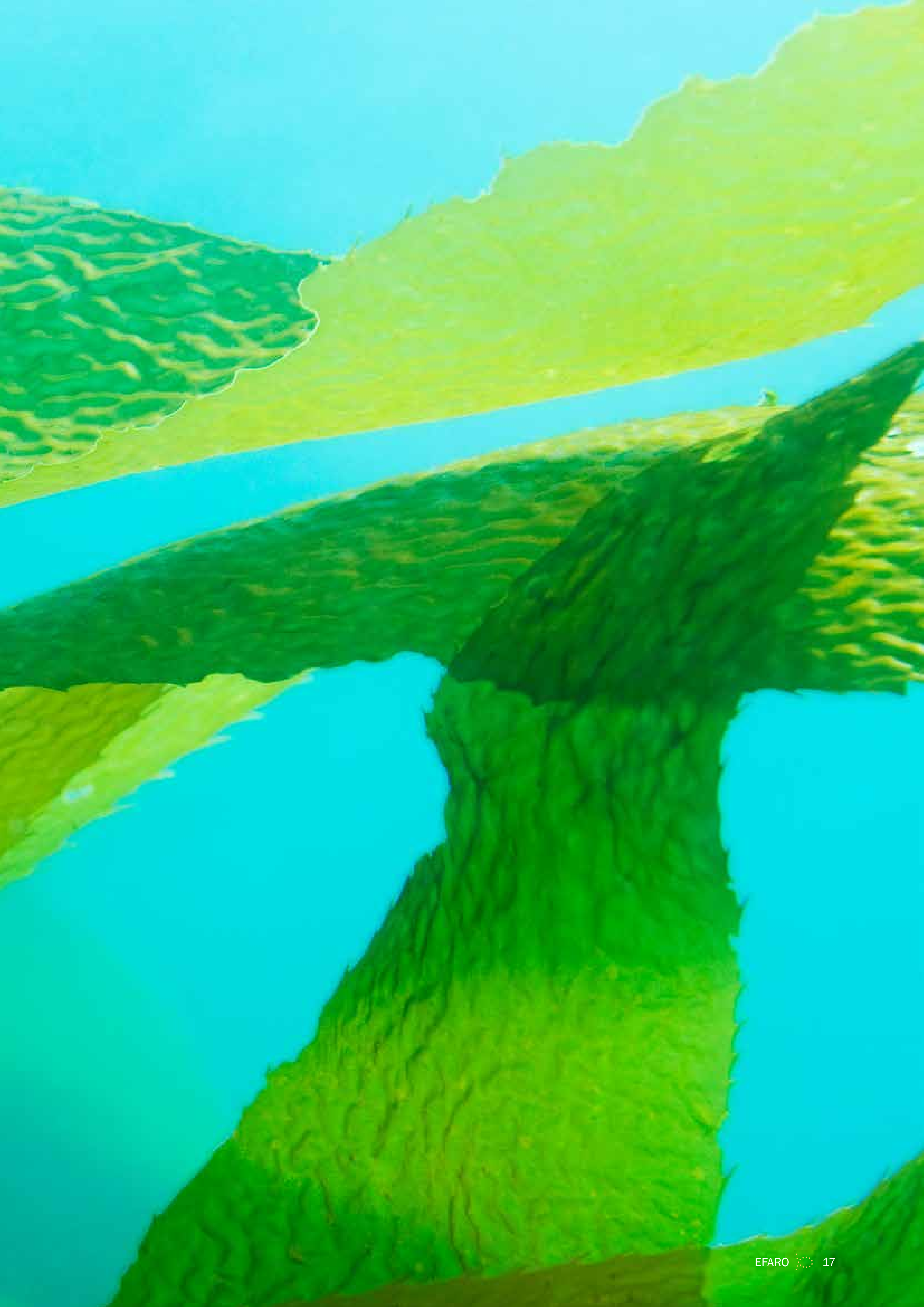
- Promote "green" technology. Formulate an economic system allowing application of "green" technology not yet required as a part of the ordinary production and therefore constituting an extra cost compared to the competition, e.g. by tax exemption, tax breaks but not by subsidies Links with alternative energy, hubs and parks.
- Demonstration of economic viability and the added value of clean green, integrated and combined systems.
- Can aquaculture benefit from some of the previous initiatives that agriculture has benefitted such as permitted developments, fuel tax breaks (Set aside = fallowing).
- Analysis of the economic added value of combining the activities of capture fisheries, aquaculture and tourism linked to protected zones.
- Assess the economic value of the large variety of services provided by aquaculture activities.

3.4 Technical / Scientific

- Develop sustainable fish feeds based on aquaculture ingredients that make aquaculture the most efficient food producer.
- Diversification. Research calls allowing small and diverse applications per call, in order to increase the scientific cluster mobility.
- Breeding: Development of breeding programmes for the production of robust animals.
- Seaweed Production and Value Chains: Innovation and optimization of seaweed products and processes towards economic viable business cases, with a focus on breeding & selection, cultivation in seaworthy installations, harvesting, processing and marketing.
- Develop research on aquaculture productions associations and the integration of aquaculture productions with other productions or service productions.
- Bivalve production: Innovation and optimization of shellfish products with a focus on culture optimization, cultivation in seaworthy installations, management of biohazards, and environmental services.

3.5 Regulatory

- Explore the growing interest of certified eco-produced food. Change the regulation of European authorized eco labelling from a mix of objective and believe based to 100% objective, scientific and experience functional based, in parity with medicine or food safety regulations.
- Feed sources. Facilitate use of new feed sources by a new regulation frame work and ensure food safety aspects of using these is considered a priority.
- Develop understanding of what is aquaculture with planning bodies (terrestrial and marine) and why it is important for food security.
- A level playing field for industry subsidies, environmental controls, food safety, animal welfare and other ethical considerations would create a stronger foundation for investment and give greater transparency for informed consumer choice.
- Harmonise all regulations and controls at the European level (EIA, HRA etc.) in such a way as to keep the European aquaculture potential competitive with the non-European one.



Definitions

A **vision** is an aspirational description of what an organization would like to achieve or accomplish in the mid-term or long-term future. It is intended to serve as a clear guide for choosing current and future courses of action

A **driver** is a force resulting in either conservation or change of present structure. Two main types of drivers behind social development are described by Marx and Voltair, respectively. Marx stated that a driving force of social development attributed to a natural necessity, i.e. the surrounding system sets the limits of human activities. Voltaire, on the other hand, argued that human nature reveals the motive force of social development, i.e. that nature will adopt to human activity. In modern society the view that nature should adopt has until now dominated. However, an accumulating amount of scientifically derived evidence indicates that we've now reached a stage where a community could prosper and gain significant long term advantages by adhering to the limits of our surrounding system, i.e. values badly handled in our present economic system but absolutely fundamental for sustainable economic growth.

A **game changer** makes change possible. A game changer is "a newly introduced element or factor that changes an existing situation or activity in a significant way". I.e. a game changer makes a change in drivers possible. In the present document, aimed at long term changes, identified game changers are separated into realization of visions of year 2030, 2050 and beyond.

The word **local** is a very diffuse term and may describe a defined area as in "the Farmers Market" of a radius of 250 km, nations, regions or even the whole of Europe. The term local is also used in the sense of "traceable" independent of geographic distance, or even as synonymous to small scale. Similarly, the term "circular production" could include everything from the whole global ecosystem to immediate reuse of a by-product by its producer. In this document "local" and "circular" are used in the sense of traceable, possible to define its origin and transparent, i.e. possible to do a material budget or a LCA analysis, but limited to the geographic region of European aquaculture.

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Colophon

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