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Integrate Aquaculture:
an eco-innovative solution to foster
sustainability in the Atlantic Area

INTERREG Atlantic Area 2014-2020 Project EAPA_232/2016

WP6 – Defining a network for IMTA development

Action 4 report: Drafting a strategic plan to develop IMTA in the Atlantic Area

DELIVERABLE 6.4

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Finally, a special thank you goes to the reviewers of the various reports published in the context of this Work Package n°6. They have helped render the results of this work more intelligible and enabled us to extract the greatest amount of information, making these reports as coherent and relevant as possible.

1 Context and methods

1.1 The INTEGRATE project

The objective of the INTEGRATE project is to promote Integrated Multi-Trophic Aquaculture (IMTA). These systems are based on the cultivation of multiple species belonging to different trophic levels and interacting on the same site. The project is also an opportunity to enhance the cooperation between the research sector and industries in the innovating aquaculture sector while supporting technology transfer to professionals and educational institutions.

One phase of the project, Work Package N°6, "Defining a Framework for IMTA development: Action Plans for the Atlantic Area" is split into four actions:

- identification of barriers to the implementation of IMTA throughout the Atlantic Area;
- stakeholders' position on IMTA in Europe;
- regulatory analysis of IMTA in the Atlantic Area;
- how to develop an action plan: from diagnosis to action (drafting an action plan for the development of IMTA in the Atlantic Area).

Agrocampus Ouest is in charge of managing this Work Package, and designed the method to conduct the survey and achieve the different actions. The method was then applied by the different partners in their own countries to obtain as much data as possible about the IMTA sector in the Atlantic Area.

The action plan proposed in this document aims to give the work carried out since September 2017 tangible form. Firstly, a review of the major issues for IMTA development in the Atlantic Area is presented. A brief summary of the results from work carried out within the framework of Work Package N°6 will also help contextualise the recommendations developed in the rest of the document.

1.2 Defining a framework for the development of IMTA

Stagnating aquaculture production in Europe, combined with increasing environmental and societal pressures, calls for an evolution in aquaculture practices. IMTA and its various systems may provide a solution to these sustainability issues. But these new practices are also hard to impose. The objective of the work carried out by Agrocampus Ouest is to study the IMTA sector across the Atlantic Area in order to draw up an overview and propose recommendations to create a favourable context for the development of IMTA.

Identifying the obstacles

The first step in this work was to identify the existing IMTA sites and project holders. The aim was to inventory the sector's facilities by meeting its main players. A survey was conducted using interviews with the producers concerned, as well as administrations, technical institutes, research centres and training institutions to highlight the main barriers to and levers for the development of the sector (Eyrolles et al., 2018a).

Stakeholders' positions

Following this initial work, the most successful IMTA sites were analysed as case studies. New interviews were conducted with a wider panel of stakeholders (local residents, environmental associations, scientists and administrations directly related to the creation of the site studied, etc.). This second survey aimed to understand the position of each of these stakeholders during the process of creating an IMTA site, i.e. to identify their motivations or their apprehensions regarding an IMTA production site being set up (Eyrolles et al., 2018b).

Analysis and diagnosis

Based on the results of previous surveys, a diagnosis of the sector was conducted. SWOT (Strengths, Weaknesses, Opportunities, Threats) matrix analyses were conducted at a national level for each of the following themes: Technical, Social, Environmental and Economic. The regulations governing aquaculture practices were also studied in greater depth in order to highlight certain recurrent issues and facilitate setting up IMTA sites in Atlantic Area countries (Eyrolles et al., 2019).

Drafting an action plan

The work achieved in the previous steps was used as a basis for drawing up the recommendations presented in another section below. These surveys and analyses results were complemented by other work carried out in parallel within the INTEGRATE project. Several workshops brought together different stakeholders to discuss technical, social, environmental and economic issues, and to identify good practices to implement in IMTA. The discussions and reflections initiated during these workshops confirmed and completed the surveys conducted (Ratcliff et al., 2019).

This document presents the recommendations stemming from the results of previous work. Many solutions were identified by the stakeholders interviewed during the surveys. Concrete implementation actions have been proposed, showing the involvement of these players in developing the sector and their willingness to help aquaculture evolve. These proposals will be presented following an overview of the Integrated Multi-Trophic Aquaculture sector in the Atlantic Area.

2 The challenges of IMTA development

Aquaculture has been viewed for many years as a means of producing high-quality protein at low cost in terms of resources, compared to the production of land animals (Food and Agriculture Organization of the United Nations, 2014a, 2014b). In light of stagnating fisheries catches in recent years, aquaculture must also be ready to respond to the increasing demand for seafood. However, while some Asian countries, such as China, Indonesia or Vietnam, are still experiencing positive aquaculture production growth rates, the situation in Europe is very different. Production has stagnated for several years and some sectors, notably marine fish farming, are in decline (European Commission, 2012). Several reasons can explain this evolution.

From the point of view of the international market, countries like France and Portugal are no longer competitive in the intensive fish farming sectors for sea bass or sea bream. Other countries have more favourable environmental and socio-economic conditions for low-cost production (Gerard et al., 2006). However, the limited production of marine fish in Atlantic Area countries cannot be explained by this market aspect alone. Aquaculture's potential impacts on the environment raise environmental and societal issues that no longer allow new aquaculture sites to be created at sea (Barrington et al., 2010; Callier et al., 2009; Kaiser and Stead, 2002; Katranidis et al., 2003; Lazard et al., 2010). This analysis also holds true for shellfish and algae production under pressure from other activities on the coast and at sea (touristic, recreational, residential activities, and so on).

In light of these challenges, the concept of Integrated Multi-Trophic Aquaculture (IMTA) is attracting more and more interest. It combines numerous practices involving the cultivation of different species depending on the location of the production site (land-based, on the foreshore or in the open sea) (Bushmann et al., 2001; Granada et al., 2016; Neori et al., 2004). The concept is usually presented with 3 compartments (fish, shellfish and seaweed). The fed species (fish) releases dissolved and particulate nutrients. These waste products are used as "resources" by the other species: the algae will use dissolved nitrogen and phosphorus compounds, while the molluscs will be able to filter the particles (Figure 1). These interactions based on the use of waste from the fed species are called "trophic relations". However, other very different systems based on other types of interactions have been developed, such as the co-cultivation of shellfish and seaweed, or shrimp and oysters.

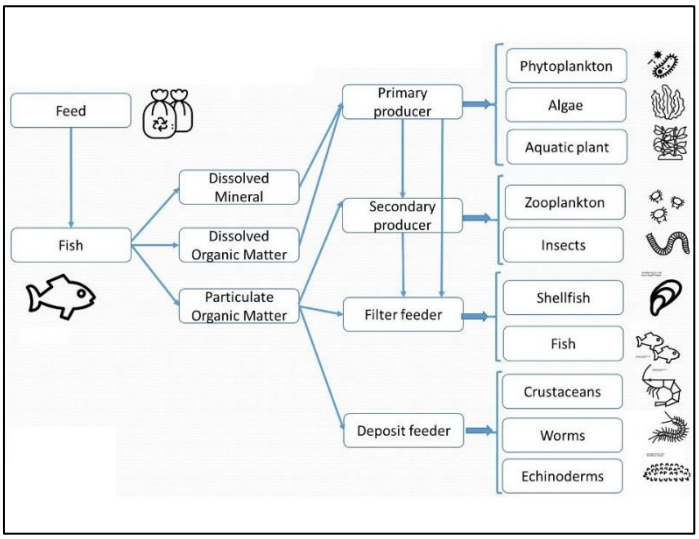

Figure 1: Simplified network of species of interest in IMTA (from Aubin, 2019, pers. obs.)

The IMTA concept covers numerous practices involving the cultivation of different species depending on the location of the production site (in land, in the open sea, on the foreshore) (Bushmann et al., 2001; Granada et al., 2016; Neori et al., 2004). These systems can offer various benefits such as reduced nutrient emissions (through the absorption of nutrients by algae) and increased production per unit area (Hughes et al., 2016). These systems also enable diversification of production and thus improve economic resilience for producers (Kleitou et al., 2018).

The possibility of optimising the resources needed for aquaculture while enabling producers to diversify their production activities are the two major advantages of these practices. IMTA also appears to be able to respond to current concerns about preserving environmental quality and reducing resource consumption.

While these issues are common to the different countries in the Atlantic Area region, each of them has its own aquaculture development strategy. This document presents an action plan that proposes concrete solutions to facilitate the development of IMTA, while remaining relevant for all the countries of the European Atlantic Area.

Note: the INTEGRATE project is limited to the study of marine IMTA, whether based at sea or on land.

3 Overview of the IMTA sector in the Atlantic Area

The inventory proposed here is a summary of the results of the various work mentioned above. For further information, the following documents are available on the INTEGRATE project's website: integrate-imta.eu

- Deliverable 6.1: Status of development opportunities for the IMTA sector in the Atlantic Arc (Eyrolles et al., 2018a)
- Deliverable 6.2: Examples of implementation of IMTA systems in the Atlantic Arc (Eyrolles et al., 2018b)
- Deliverable 6.3: Diagnosis of the IMTA sector in the Atlantic Arc (Eyrolles et al., 2019)

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3.1.1 A sector in the making

The number of IMTA initiatives identified in the Atlantic area of each country varies greatly (Table 1). It should be noted that in each country, experimental IMTA systems have been developed within research projects. However, the number of IMTA sites used for commercial purposes remains very limited, with only a dozen in all the countries of the Atlantic Area in 2018 and a few companies located on the French coast, in Brittany and Vendée and Charente Maritime departments. France is the country with the largest number of commercial systems, with 5 sites identified in 2018 (Figure 2). However, these are traditional systems that have been developed over several decades and for which producers do not generally claim any link to the IMTA concept.

	United Kingdom	Ireland	France	Portugal	Spain
Experiments	2	5	3	6	2
Commercial sites	1	1	5 and more*	2	2
Total	3	6	8 and more*	8	4

Table 1: Number of IMTA initiatives identified in each of the countries of the Atlantic Arc in 2018

* two sectors including several companies whose practices can be assimilated to IMTA have been identified in France in northern Brittany and in Charente Maritime.

At present, very few systems have been developed in the Atlantic Area with the objective of implementing IMTA practices. These facilities are generally small and represent only a small part of total business activity.

While a real interest in these practices is observed throughout the Atlantic Area, but progress towards actual implementation remains slow. Companies are setting up new experimental projects, but they are having difficulties in obtaining authorisations.

These observations highlight the real interest in IMTA practices and a desire to continue developing the sector. However, the small number of successful initiatives is a reminder of the need to change the regulatory and socio-economic context, in order to truly boost the development of IMTA.

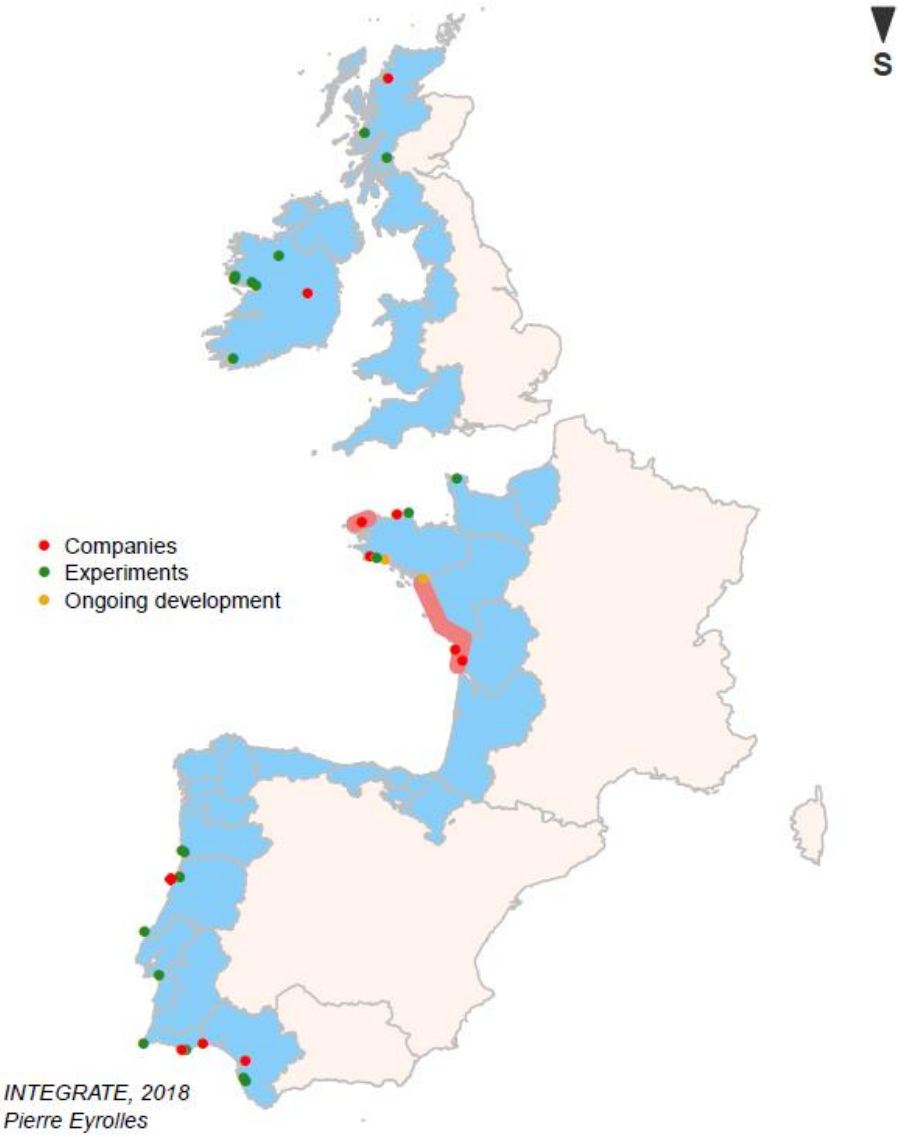

Figure 2: location of IMTA facilities in the Atlantic Area in 2018

3.1.2 A wide range of systems

The diversity of aquaculture practices

The first finding is the multitude of practices and systems that can be grouped under the term IMTA. An example of system diversity in the Atlantic Area is that of open-sea cages used for salmonid farming. This type of system combines seaweed culture near fish cages to limit dissolved nutrients being released into the environment. Its particularity is to be located in an open environment and therefore subjected to environmental uncertainties (physical-chemical parameters of water, bad weather, etc.). Aquaculture in inland saline lagoons is also widely represented with the oyster and shrimp co-cultivation sector, found in the Vendée and the Charente Maritime departments in France, or the co-cultivation of seaweed, shellfish and fish in Portugal. These semi-open systems are of particular interest in terms of improving both farm productivity and shellfish quality. These associations also make it possible to optimise the exploited surface areas by cultivating several species in the same space, without competition for food resources, and to diversify productions, thus improving economic resilience for producers. From an environmental point of view, cultivating seaweed in basins enables a significant part of dissolved nutrients to be absorbed, thus preventing eutrophication of the waters.

The various IMTA initiatives identified in the Atlantic Area also differ in terms of the size of companies, the number of associated species and the design of the IMTA system. Very small IMTA structures producing a few tonnes of fish, shellfish and seaweed have recently been established in France or Portugal, while owners of large salmonid farming structures are considering setting up IMTA systems combining algae cultivation in France and the United Kingdom. IMTA can also be thought of as the evolution of a monoculture system for diversification purposes. In this case, the IMTA system will consist of different production modules that are added to each other and combined to utilise the resources and waste of each species. However, the most recent systems have been designed from the outset to breed or grow multiple species. These two approaches to IMTA system design are not particularly contradictory, but they can differ from a purely administrative or regulatory point of view for project holders.

Different interactions depending on the systems

Each of the systems mentioned above can have specific interactions with the environment. Cages at sea are sometimes singled out because fish discharges can impact benthic habitats. On-shore farming systems are carefully monitored to avoid eutrophication of the environment. Interactions within systems also depend on the species farmed and the production sites (hydro morphology). This means that resulting benefits vary greatly from one system to another.

Due to the multitude of practices covered by these terms, it is hard to base thought and reflection on sustainability. Each IMTA system brings benefits from an environmental or socio-economic point of view. However, it is not possible to communicate generally about sustainability, since it depends on the local context.

Difficult appropriation due to the complexity of IMTA

In light of such diversity in systems and business models, it is difficult to develop and promote each of these practices under the same term of IMTA as they generate different environmental benefits and do not have the same technical characteristics. Some players do not appropriate this term and do not consider their practices as part of an IMTA process. All this diversity makes proposing a global strategy to promote the sector even more difficult.

The complexity of the term IMTA for "integrated multi-trophic aquaculture" has also repercussions from a commercial point of view as it makes it harder for the consumer to appropriate these aquaculture practices.

3.1.3 Specific expectations regarding each country

Although the INTEGRATE project is based on a common desire to develop the IMTA sector in the Atlantic Area, the particularities of each country's aquaculture sector impose significant constraints. On the one hand, the production systems and therefore the majority of species cultivated are very different. The United Kingdom's production is mainly focused on salmon farming while France mainly produces shellfish. So both the technical challenges and the means invested in converting monoculture systems into IMTA systems are quite different.

In addition, the national socio-economic contexts do not allow for homogeneous development of the IMTA sector. Opportunities for installing new aquaculture systems can vary greatly depending on the importance of landscapes, recreational, touristic, residential or other economic activities. Depending on the local, regional and national context, expectations for the development of IMTA are not the same.

The regulatory context also differs greatly from one country to another, as do governance and procedures for obtaining production authorisations. Regulatory constraints concerning the environment are not homogeneous either, since each country translates European directives in its own way.

For each country, IMTA development priorities are characterised by:

- **Different interests in IMTA:** IMTA systems can present particular advantages (reduction of eutrophication, enhanced utilisation of space, optimisation of resources) whose interest depends on the social and environmental context specific to each country or region;
- **Different systems considered or favoured:** Since the national aquaculture sectors already developed can vary greatly, the IMTA systems considered can also be very different;
- **Different challenges to take up from a governance or regulatory point of view:** Each country has its own regulations and processes in terms of the licensing process for creating aquaculture sites. The particular advantages and constraints of these different processes lead to different recommendations.

Requirements in terms of communication, awareness, technical progress or changes in regulations depend on the specific context of each country, or even each region. Nevertheless, the case studies, cross-analysis tools and consultation with a wide range of stakeholders helped us to assess priorities and draft recommendations applicable to all partners. And despite the difficulties mentioned above, an action plan at the scale of the Atlantic Area to promote and develop the IMTA sector is proposed thereafter.

4 Recommendations for the development of IMTA

These recommendations have been the subject of consultation by multiple stakeholders in the aquaculture sector and therefore reflect their concerns and expectations regarding the development of IMTA. This document supplements the list of reports on aquaculture development issues. It is intended for decision-makers and administrations, but also for all stakeholders in the aquaculture sector and in coastal areas. The stated ambition of this publication is to raise awareness of the importance of the aquaculture sector and its evolution towards ever more sustainable practices.

Note: the INTEGRATE project is limited to the study of marine IMTA, whether based at sea or on land.

4.1 Support research and development needed for IMTA

Finding: The lack of knowledge about how IMTA systems function makes it impossible to propose robust and economically viable models to all aquaculturists today.

A gap between IMTA models and current aquaculture practices

IMTA systems are not suitable for current aquaculture production scales or equipment. In Scotland, the salmon farming industry is so important from an economic point of view that there are no incentives to jointly grow algae and shellfish.

On the contrary, in Portugal and France, aquaculture relies on shellfish production and there is very little fish farming. Introducing fish farming equipment requires investments that are too high and would be difficult to implement. New IMTA systems still need to be designed for the industry to adopt these practices.

A lack of knowledge

There are currently few reliable IMTA models with proven environmental benefits. Many questions remain unresolved with respect to offshore systems in terms of their operation, interactions between species or actual impacts on the environment.

A need to guarantee economic sustainability

While IMTA is seen as a good way to diversify aquaculture activities, aquaculturists are primarily concerned about the economic sustainability of these systems. Current systems are barely reaching commercial scale and there is no real evidence of economic sustainability. Despite the different modelling studies comparing salmon monoculture and salmon-seaweed IMTA, new technical-economic studies need to be implemented with true IMTA facilities. Labour and additional investments need to be taken into account in order for the comparison to be consistent, along with a market study for algae and other additional productions.

Developing new species

Domestication of new species could be a solution to solve some of the environmental problems of aquaculture, as well as to access new markets and improve the economic sustainability of IMTA systems. Current seaweed markets in the Atlantic Area are not fully developed and this sector suffers from low price and profitability issues.

Education and training

IMTA requires real upgrading of employee skills. Managing the interactions of different species in the same area and ensuring the system's equilibrium are demanding tasks. New curricula and training programmes are needed, as well as pilot and educational farms. According to some partners, the creation of new IMTA curricula could encourage innovation and strengthen the development of IMTA.

4.1.1 Intensify research about interactions within the systems and with the environment

Knowledge about how IMTA systems function is still too partial. Research on interactions must first and foremost help us better understand the exchanges between the different compartments of an IMTA system. This must also lead to studying their interest in terms of environmental sustainability.

Environmental sustainability is a key element of IMTA. Advances in knowledge must make it possible to determine the potential environmental benefits attributed to certain associations of species, in particular algae and fish in an open environment. In this respect, monitoring techniques must evolve (monitoring physical-chemical parameters) in order to be able to confirm that nutrient exchanges do indeed take place, and therefore provide bioremediation at the scale of a bay or in an open environment system. Once these monitoring tools have been adjusted, it will be possible to develop models to predict the impacts of an IMTA system on its environment, or to quantify the exchanges between the compartments. Setting up case studies or pilot projects, over the long term and in partnership with professionals, would make it possible to study the real effects on the system's productivity, the health and equilibrium of the different species, and the impacts, whether positive or negative, on the environment.

New environmental or socio-economic indicators could then be proposed to better assess the overall sustainability of IMTA systems. Funding for these research projects could come from public actors such as local authorities, or from Europe via Structural Funds like the EMFF. Experimental applications for the production of additional species should also be facilitated through exemptions, particularly for fish farming and for the introduction of new species, such as sea cucumbers that require further research.

4.1.2 Find new species that meet economic and environmental challenges

The IMTA systems developed to date only partially address certain environmental issues in aquaculture. For land-based systems, the problems associated with eutrophication, for example, are particularly important. In open sea systems, the impact on the benthic environment is a major environmental issue. Thus, mastering the life cycle of new species, such as sea cucumbers or other echinoderms, and their adaptation within an IMTA system is essential.

The system profitability is another key point to factor in when designing new IMTA systems. This means that a market study for the identified species is needed, as is an appropriate analysis of marketing opportunities.

Finding candidates (models, species) could be done by producers and researchers working together to identify the biological and technical obstacles to be overcome. The advantages and disadvantages of each species must be characterised for each of the IMTA systems, systematically in relation to the production environment (in the open sea, inland, in recirculating systems). The bioremediation made possible by combining the culturing of algae along with fish or shellfish farming is a good example of the beneficial interaction that may take place within an onshore IMTA system. On the other hand, sedimentation of the wastes under fish cages in an open environment remains an issue. The IMTA models developed to date have not been able to solve this problem, although new avenues are being investigated in connection with breeding detritivore species. Market demand can also be used to target certain species of interest, especially for growing macroalgae.

In response to this recommendation, some stakeholders consider that finding new species is not necessary and that efforts should rather focus on understanding established systems with already domesticated species. Conversely, other players suggest moving away from existing monoculture models so as not to limit innovation and to test new species associations by imitating existing aquatic ecosystems. Following this second point of view would require new investments to imagine new production methods, but this approach could also lead to the invention of new, more optimised and more sustainable IMTA systems. Research projects aimed at breeding or cultivating new species are already underway, initially to master their life cycle. A second step will be necessary to check whether integrating these species in an IMTA system is of interest.

4.1.3 Improve collaboration between scientists and the industry

By industry, we mean the first players involved in developing IMTA / aquaculture. Although the sector is still in its early stages of development, some operators remain open to the idea of diversifying their production. However, they need specific support and working in collaboration with research bodies would be a good start.

Professional organisations can also act to connect industry and research, facilitating the understanding of each other's working constraints and making results accessible to the industry. Researchers need support from producers as well as their advice and vision of their activity to guide and plan their studies. Collaborative projects supported by professional structures can only take place if their objectives meet the producers' demands. It is important to emphasise that the aquaculture sector remains highly competitive. Technological advances and projects between technical institutes and companies are jealously guarded, and do not benefit all stakeholders, except in the case of public funding. Creating advanced workshops and technical forums open to everyone could be a good opportunity for producers to discover IMTA practices and grow their knowledge in this field. These workshops could be held at shellfish trade fairs. In addition, there is a growing need to finance long-term projects, especially in IMTA, given the lack of experience and feedback available on this breeding technique, in order to understand how these systems function and respond over time. Open-sea systems in particular must be given priority and their interactions with the environment must be investigated.

4.1.4 Find solutions for the industry to diversify and ways to convert current aquaculture systems

Each country has its own specificities in terms of aquaculture system, and the theoretical IMTA models (fish, molluscs, algae) are not generally well suited to these realities. It seems necessary to work on the transition from existing monoculture systems to IMTA systems, rather than trying to implement generic systems that do not correspond to the specific aquaculture context of each country.

Training and awareness-raising work is needed to help professionals take up the challenge of making aquaculture evolve towards ever more sustainable practices. Creating a technical guide and organising participatory workshops or "living labs" would be a good way to improve the industry's knowledge and obtain relevant information about how to manage these systems. If producers are working on optimised systems (especially for intensive salmon farms), adding a compartment to develop an IMTA system can lead to completely rethinking how the farm operates. However, some production systems, such as offshore or inland saline lagoons, allow for diversification and the development of a relatively simple IMTA system. It must be emphasised, however, that it is difficult to obtain approval for some requests to diversify concessions, especially when systems include fish farming. Administrative or regulatory aspects are sometimes considered to hinder setting up experiments or innovative approaches. Other blockages by local stakeholders may reflect certain concerns about developing the aquaculture sector or IMTA, as well as a lack of knowledge about practices. Requests to produce additional species as an experiment could be facilitated by means of dispensations. These experiments could be supervised with mandatory (environmental, technical-economic, etc.) monitoring and reporting to State services in order to guarantee the absence of environmental degradation and the relevance of the systems tested.

4.2 Support IMTA projects upstream

Finding: At the European level, there is no major obstacle to establishing a multi-species production system. All countries are subject to the same European texts and directives and the European Union has expressed the desire to develop sustainable aquaculture and better management of marine areas. There are no regulations prohibiting the exploitation of several species on the same concession in the Atlantic area. However, it was pointed out that producers had difficulties in obtaining production sites, for various reasons presented in detail below.

A very complex and time-consuming licensing process

It now seems necessary to simplify licensing. Project sponsors are wary of this complex process and are reluctant to set up projects. Various partners in the project shared the accounts by producers for whom it took several months or even years to obtain a license, whether to create a new aquaculture site or diversify their production.

Social acceptability and territorial development

Some projects have been restricted or even stopped following legal proceedings related to environmental issues. Aquaculture suffers from poor social acceptance, which is why the development of new aquaculture sites requires using participatory tools or public consultation, but also giving fundamental thought about how to integrate the activity in a given area. The presentation of the IMTA farm development project can be supported by local stakeholders if they see it as a good opportunity for local development.

However, in some cases, local stakeholders will never agree with the development of aquaculture because it does not correspond to their vision of their area or because it is not adapted to or compatible with residential or recreational activities. In this case, the local authorities must decide whether to impose the creation of aquaculture sites or to placate the opponents despite the aquaculture development.

4.2.1 Increase awareness and develop training courses to enhance innovation and develop new IMTA systems

One major challenge concerns raising awareness of the importance of diversifying production among new generations of aquaculturists. Promoting IMTA practices as part of aquaculture training courses would help to encourage experimental initiatives in training centres and by young farmers and would lead to new ideas for associations of species or optimising existing systems. In addition, many professionals perceive IMTA systems as being complex to control, which does not encourage them to diversify their farm through IMTA. This obstacle could be overcome by training producers so that they understand how these systems work and how to control them.

Greater awareness of IMTA practices could lead to greater innovation and new aquaculture practices. The target audience would be producers attending new continuing education offers, provided the means are found to finance these courses and make them particularly attractive and "profitable" for the producers in question. The main challenge would then be to propose robust IMTA models that have been technically and economically validated. Organising "living labs" could also be an opportunity to propose concrete solutions for operators' existing systems to evolve. An IMTA installation or conversion guide would also allow producers to think about potential ways of diversifying their system. Creating new initial training courses could help support the implementation of new IMTA initiatives for future operators.

Although some applications may be inherently incompatible with the regulatory framework, blocked application files are sometimes perceived as a lack of knowledge about new aquaculture practices by the competent authorities or the public. Raising awareness of the challenges of aquaculture's evolution would lead to better knowledge and acceptance of these farms and farming practices using new equipment. While it may seem difficult to market new aquaculture practices to the general public, targeting local stakeholders when a project is implemented remains feasible for project holders. Training courses could give them "turnkey" tools or methods to carry their project forward in their area, knowing the administration will generally relay any useful information.

4.2.2 Change licensing procedures

According to accounts from several professionals at the European level, applications for diversification are cumbersome and do not always succeed, or only after long delays. Although it is true that applications by shellfish farmers to diversify with algae production are now better taken into account and dealt with quickly, it remains urgent to facilitate experiments or diversification in concessions, especially for algae-fish combinations. A faster response from the competent authority is also essential, so that the project sponsors can understand the reasons for refusal and improve their application file.

Aquaculture license applications generally involve a complex process and are not very clear to the industry. Furthermore, often very few resources are put in place to help applicants and it can become a long and costly process. A simplification of the whole process, with an online system that would show the application's status and at which step it may be held up, would be seen as an improvement by the industry.

4.2.3 Synthesise marine planning documents and texts related to the protection of the environment

Obtaining site licenses to produce several species is particularly delicate. Although no regulation currently prohibits the cultivation of several species in the same area, the combination of regulations specific to each species can significantly restrict the geographical possibilities of installation.

IMTA should be given its rightful place and the overlapping of different regulations should not block these practices. The State, the industry and the administrative services involved in transposing European directives into national law must work together to simplify these regulations. A clear and exhaustive synthesis of these texts will provide new possibilities concerning potential sites for implementing IMTA. An example of work currently carried out by the French Office for Biodiversity is to produce a summary of aquaculture activity regulations, called the "technical-economic reference document" for marine culture. This will be a very large, comprehensive document covering all applicable regulations, but it will have the advantage of grouping all legal texts together. It is imperative that all professionals take part in these discussions.

4.2.4 Standardise environmental surveys to homogenise licensing

Proposing an environmental impact study template could help streamline licensing processes. However, small project sponsors also want more homogeneous environmental studies so they can consolidate their application file and be able to deal with legal appeals or challenges.

Homogenisation and simplification of environmental and impact studies on a limited number of criteria adapted to the local context would avoid the systematic challenge of producing long and costly studies. Standardising environmental studies should also make it easier to investigate cases by comparing different systems and their interactions with the environment. In some countries, such as the United Kingdom (specifically in Scotland), official mathematical models of faeces deposition for cage culture are used to identify the potential impact of a system on its environment. Such initiatives would standardise and give credibility to environmental studies. French producers have asked for the development of an assessment model of the impacts of their activity that is acceptable to everyone (scientists, administrations, producers and environmental associations). Joint work in this direction will have to be carried out with the environmental authority, scientists and ministries on the adoption of indicators or standards. Tools such as Life Cycle Assessments are very effective in estimating the characteristics of a system in terms of global impact on the environment according to various criteria (eutrophication, acidification, CO_2 emissions among others), but they remain very expensive to implement and are not suitable for a preliminary study of a system at a local scale.

4.3 Give IMTA visibility

Finding: In addition to the lack of knowledge about IMTA operations, at present only a handful of experts truly understand this type of aquaculture. Although these practices have existed for several centuries, the term IMTA and its interpretation by professionals is recent. IMTA suffers from a lack of visibility at different scales.

A lack of visibility for the regulators

Regulators lack visibility on the impacts of IMTA and it is difficult for them to process application files because they do not have a reference model. However, a recent meeting with the authorities made it possible to communicate about the benefits of IMTA and could bolster its development in protected areas in Portugal. In Ireland, there are some examples of IMTA Files receiving good feedback from the regulators. IMTA is gaining in visibility. However, the competition for land areas (salt marshes in France and Portugal) and the prolonged abandonment of these salt marshes make regulators less inclined to accept their conversion into productive aquaculture sites.

A lack of visibility for local stakeholders

This point concerns not only IMTA, but the aquaculture sector on the whole. The benefits of this activity in terms of local and regional development, as well as ecosystem services or heritage and cultural value are consistent. Aquaculture needs to be re-evaluated and integrated into spatial development plans. Communication about aquaculture products, but also and especially about the aquaculture trade appears essential. However, it will be meaningless to develop and seek acceptance of these activities without proper consultation and co-construction of projects.

A lack of point of reference for the consumer

IMTA suffers from a lack of visibility and concerns are emerging about how its products might be perceived by potential consumers. In commercialising these products, the aim may be a better environmental footprint, but the term IMTA sounds technocratic and remains difficult to grasp. People might not understand the term or, worse yet, be wary of these production practices.

4.3.1 Set up participatory tools to integrate IMTA projects in local area development plans

The idea is to rely on a participatory tool that brings together all local stakeholders. Many of them do not feel sufficiently involved in the decision-making process for the development of certain sectors. This is particularly true for aquaculture, which has many interactions with the environment and other marine activities.

This tool could take the form of a commission or a marine park, or other organisations deemed objective in examining application files. Their role would be to inform local stakeholders about IMTA project applications and to give advice. This approach would involve a wider range of stakeholders in the decision-making process and compensate for the lack of transparency with regard to the implementation of these projects. The competitive aspect of the sector may push some professionals to oppose the development of new aquaculture sites and the development of new practices. It is however essential that all stakeholders are given equal weight in such a commission, as failure to do so would generate distrust and a loss of credibility in its opinion.

4.3.2 Communicate on IMTA ecosystem services

Definition of these ecosystem services

In the Common International Classification of Ecosystem Services (CICES) V5.1 (2018), Haines-Young and Potschin define these as "the contributions that ecosystems (i.e. living systems) make to human well-being. These services are final in that they are the outputs of ecosystems (whether natural, semi-natural or highly modified) that most directly affect the well-being of people".

Table 2 presents some examples of ecosystem services as defined by Haines-Young and Potschin the CICES V5.1 (2018) .

CICES V5.1 Section	Group (examples)
Provisioning (Biotic & Abiotic)	Cultivated terrestrial plants, and wild plants (terrestrial and aquatic) for nutrition, materials or energy; Reared animals for nutrition, materials or energy; Genetic material from plants, algae or fungi, and animals
Regulation & Maintenance (Biotic & Abiotic)	Regulation of baseline flows and extreme events; Lifecycle maintenance, habitat and gene pool protection; Pest and disease control; Water conditions
Cultural (Biotic & Abiotic)	Physical and experiential interactions with natural environment; Intellectual and representative interactions with natural environment; Spiritual, symbolic and other interactions with natural environment (and abiotic component thereof)

Table 2: examples of ecosystem services as defined by Haines-Young and Potschin (2018).

IMTA and aquaculture more generally can contribute to the development of local areas, both in the maritime domain and on land. It is part of the economic activity of many localities and helps maintain, structure and develop a web of services for the local population. In addition, maintaining these activities may, in some cases, contribute to the conservation of biodiversity and specific and traditional landscapes. Communication focused on these aspects would raise awareness about the importance of these activities for rural coastal areas.

This awareness should target, as a priority, local stakeholders who could oppose the development of the IMTA or aquaculture sector. Local elected representatives could also be specifically informed of the evolution of changing aquaculture practices and the issues related to their positive impact on territorial development. Communication focused on the value of maintaining a less seasonal economic activity than tourism is a priority. Regarding biodiversity, landscapes and heritage, awareness raising can be carried out through tourist activities to reach a wider audience. Tours or explanatory panels describing growing methods, their evolution and the social and cultural importance of this sector of activity can be effective means of communication. Other links between training institutions, schools and aquaculture or tourism professionals can be created to raise awareness among consumers and stakeholders in a given area. The role played by professionals in promoting their activity is also very important. Tools such as educational farms or "aqua tourism" (i.e. opening parts of production farms to the public with live sales or fishing routes) are worth developing. And although communication tools on a very large scale can be envisaged, it must be ensured that this is not counterproductive. Commercials are sometimes viewed as caricatures and thus not very credible. Using popular scientific, non-technical publications or documentary media would be preferable.

4.3.3 Communicate about IMTA principles and aquaculture practices

Two target groups have been identified for this recommendation: on the one hand, the industry including producers, financers and decision-makers, and on the other hand, the public and consumers. The initial objective is to highlight these practices and give them visibility. It is very important to ensure that professionals can take ownership of available IMTA practices and that other stakeholders or decision-makers can finance and support them. As regards consumers and the broader public, it is important to provide simple, credible information about these systems to reassure them about product quality.

The specificity of IMTA systems and their diversity make them difficult to understand and reflect an image of complexity. It is important to clearly the concept by distinguishing between open, semi-open and closed systems in order to better communicate about the benefits of each system. Their benefits should be emphasised on a case-by-case basis without opposing other aquaculture practices and IMTA. Once again, appropriate communication tools will make it possible to disseminate credible information. Distributors (fishmongers, supermarkets, etc.) will also have a role to play in promoting sustainable aquaculture practices. Involving them in IMTA communication and promotion would be an efficient way to reach a wider audience. Scientific reports supporting environmental benefits are also needed. Studies on the economic viability of IMTA would also be valuable tools to convince financers to support the sector.

4.3.4 Give IMTA products visibility to enable market differentiation

This means planning a dedicated marketing strategy for IMTA products. The general public's knowledge of aquaculture is quite limited. Due to its complexity, IMTA could create distrust if its development is not accompanied by professional communications activities. While creating an eco-label can facilitate the transmission of the benefits of IMTA practices, precise specifications, adapted to different forms of IMTA, must still be defined and proof of the environmental interest of these practices supplied.

Promoting IMTA products at a local scale is recommended. Indeed, the IMTA concept is based first and foremost on the environmental benefits of practices and on optimising resources. An economic model based on exporting IMTA products at an international level is not recommended for European production. Moreover, since current production levels are very low and production costs fairly high, the main commercial opportunities remain niche markets on which producers can sell at premium prices. It would also be interesting to focus on short supply chains that correspond to IMTA's ecological philosophy and which, by decreasing the number of middlemen, allow for better commercial development at the source. However, care must be taken not to compare IMTA products with those of traditional aquaculture, to avoid weakening the sector. A strategy based on the environmental certification of companies or the production method could be another solution to consider.

5 Conclusions

These recommendations are the result of a survey conducted over a wide range of French and European stakeholders. They reflect the barriers to and levers for the development of IMTA which have emerged from the analysis of these interviews. Many of these recommendations are not specific to IMTA, but are general to all aquaculture production activities. This result underscores the fact that the potential environmental interest attributed to these practices does not always facilitate the development of these systems and the creation of projects. Other technical, social and economic obstacles need to be removed to establish a context that favours the development of aquaculture and therefore of IMTA.

The IMTA sector needs to go through a research and development phase in order to prove the environmental value of certain species associations, particularly in an open environment. Although the results concerning shore-based systems (recirculated systems or saline lagoons) are more encouraging, the number of production sites remains very low and the volumes produced are negligible. New, robust and locally-adapted (in environmental, socio-economic terms) IMTA models must be created and tested to provide reliable evidence of the economic and environmental benefits of IMTA. Without this first step, the profession will not start setting up such systems, despite the theoretical advantages they bring in terms of production diversification and thus economic resilience for companies.

Access to new production sites and interactions with other (economic, touristic or residential) activities on the coast are two major issues. Work must be carried out in collaboration with the administrative services to facilitate access to production sites as well as diversification approaches using IMTA for existing producers. Providing support for project sponsors is also essential, but the reduction in the financial resources made available to decentralised administrative services leads project sponsors to turn to other organisations for support. Additional resources must be put in place to offset the disengagement of the State from these support missions.

Finally, the IMTA sector must be open to a wider audience. It suffers from a lack of visibility and is only well understood by a handful of experts. Consultation tools must be developed to better integrate projects in their local contexts. This approach remains the responsibility of the project sponsor, but support from relevant structures is necessary from a methodological point of view. Communication about aquaculture in terms of local and regional development or ecosystem services, to both decision-makers and a broader public, should encourage the establishment of new aquaculture sites. These communication efforts must make the understanding of aquaculture activities more accessible, so that the public can take ownership of the issues involved. The latter point is all the more important as without transparency in the production methods, a sector as complex as IMTA is likely to encounter difficulties in marketing its products.

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