integrate

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

INTERREG Atlantic Area 2014-2020 Project EAPA_232/2016

WP4: Understanding IMTA Best Practice in the AA

Action 4.2: Creation of AA expert groups to exchange current knowledge and develop best practices

Deliverable 4.2a: Synopsis of the Thematic Roundtables

Interreg Atlantic Area
European Regional Development Fund

EUROPEAN UNION

www.integrate-imta.eu

Target audience

AA Joint Secretariat	
Partnership	X
Associated partners	
Media	
Public	X

Means of delivery

E-mail	X
Website	X
Social media	

Lead partner for deliverable: **NUIG/CEVA**

Contributing partners: **ALL**

Due date of deliverable: **June 2019**

Actual submission date: **December 2019**

CONTENTS

1 INTRODUCTION

Over the course of 2018 and 2019, each partner country hosted four thematic roundtables. These were focused meetings with key national experts (from industry, academia, state institutions etc.) to address the gaps, needs and new technologies identified as relevant for each individual Atlantic Area (AA) country and develop national best practice for IMTA, which was then synthesised into best practice for the AA as a whole. Round-tables dealt with four topics: technical, environmental, economic and social, and discussions were expected to focus on three sub-topics: definition of best practice; bottlenecks to development of best practice, priority areas for development of best practice. Each meeting lasted between half and one day.

In general, participants talked freely about their views on IMTA, and the general level of response was specific and of high quality. Some difficulty was experienced at times, and in certain countries (notably Ireland and Scotland) in accessing suitable people – this was largely due to the fact that very few of the major producers have attempted IMTA before. While every effort was made to ensure roundtables were topic focused, it was very difficult, if not impossible to stop overlap from one topic to another e.g. the economic roundtable often ended up discussing social aspects. The view of most respondents was that all four aspects (environmental, technical, social and economic) were intrinsically linked, and separating them was difficult.

It goes without saying that over such a great amount of dedicated time the discussions have been diverse and nuanced. The benefits of these discussions have already been felt, as over the course of the project awareness has been raised and interest garnered. Experiences and insights have been shared amongst a broad group of stakeholders, thus aiding one of the primary aims of INTEGRATE, to share and increase knowledge of IMTA across the broad spectrum of Atlantic Area aquaculture stakeholders. Aside from knowledge sharing, throughout the workshops certain points have been reiterated time and again, thus bringing to light common situations within the Atlantic Area.

What is the problem IMTA is trying to solve? As has been pointed out by many, IMTA in its current 'industrialised aquaculture' form was conceptualised as a neat way to solve a potential nutrification problem. However, the problem that those who implement aquaculture are trying to solve is first and foremost an economic one. How do we get around this? It has been posited that the real questions are, 'for whom and why to produce?'. From the answers to this the main strategic objectives for aquaculture development and IMTA should be derived…. The questions, 'what are the goals of IMTA?', and 'who is the main proponent?' should be useful here.

Perhaps the first point to make is that we do not yet have enough collective experience of IMTA to understand what constitutes best practice. In every instance it was made clear that we need more trials, more data and more opportunity for training across and between the different sectors.

Other, more simple, generic themes were:

- Follow best-practices already developed for monoculture and expand upon these while in the process of developing specific IMTA systems practices.
- Develop cooperation between different industry sectors (often pointed out that this might be easier said than done!)
- It will be much easier to develop best-practices for land-based than sea-based IMTA and this will provide a good starting point for standard models.

With these common points made, detailed and topic specific discussions are outlined in the following, in a country by country format. While all the roundtables followed similar formats, organisers were free to tailor events to best suit the situation in their country; the same goes for the synopses submitted for each event (which you find here) so there is some variation in both style and quantity of content. Following the full reports are summary tables that show at a glance the main themes and issues by topic and country. Together, all the information, with additional material also produced in WP4, will be used to produce IMTA best-practice guidelines for the AA as part of WP4, Action 6.

2 TECHNICAL ROUNDTABLE SYNOPSIS BY COUNTRY

2.1 UK

Most of the discussions were carried out at Aquaculture 2018 on the 23rd & 24th May, with some extra interviews carried out locally on the weeks prior to the conference.

Technical: Definition of Best Practices

- Before we define best practice, we have to work out what we are doing IMTA for – at present the financial benefit isn't obvious so a lot of the other issues don't stack up. This generic issue was the one most mentioned by respondents, and it was almost always the first thing to come up once we started talking. There was felt to be a lack of incentive for farmers to 'buy in' to IMTA as the benefits weren't particularly well defined, and there was little practical information about potential reward. Several of the respondents thought this was the single most pressing issue holding IMTA back, but finding a way to resolve the lack of incentive was difficult
- The best practice of cultivation for each species to be included in the IMTA system is generally well known already, and should provide the basis of the development of the IMTA system – i.e. the production systems for salmon and several shellfish species are already very well developed and refined, there shouldn't be any issues with the culture of the individual species, but new issues (i.e. fouling) may develop in joint culture
- The question of definition arose with several respondents – what constitutes IMTA? Some producers believe that co-culture of, say, shellfish and seaweed should constitute IMTA, whereas others believe that this is missing the key component, taking the waste of finfish cultivation and extracting that waste. It was agreed that a more refined definition of what IMTA is would be required, but this may not happen immediately
- Species used should be native, and a general consensus was that seaweed (*Ulva,* dulse and kelp species) along with shellfish (Pacific oysters, Queen scallops, mussels and urchins) were the most desirable species for development. Stocking densities were a moot point – most respondents believed that this was both specific to the site and the physical methods used
- Land vs. sea based culture – most respondents believed that sea based culture was less conducive to defining a 'pure' IMTA system due to the difficulty in modelling or predicting nutrient budgets, but that, certainly in Scotland, land based systems were far less likely to be developed due to limited availability of suitable shoreline, planning issues and costs associated with pumping water etc. One respondent was adamant that the future for IMTA lay purely in land-based systems and was

not suitable for 'at sea' development as the image of IMTA ('*shellfish feeding on salmon crap'*) would be detrimental to the shellfish industry and its image of purity of product.

Technical: Bottlenecks

- Issues of supply of suitable seed stock – there is already a shortage of supply for the shellfish industry, particularly for oyster spat, and any large increase in cultivation before this is addressed will cause problems
- Practical issues of trial and error - this has been gained in finfish and shellfish culture through many years of often difficult and expensive development experience. Combining the two systems may lead to unintended consequences
- Practical aquaculture experience is essential – finding a mix of the two (shellfish/finfish) likely to be very difficult as currently there is little to no collaboration between the shellfish and finfish sectors within Scottish aquaculture. Add to this the fact that seaweed hatchery and production looks like becoming a specialised subgroup, and you have a distinct lack of cross sector experience
- Scale – raising the chicken/egg issue again, it was mentioned by several of the respondents that IMTA has a large/small scale issue at present. Normally with shellfish instillations, there is a tendency to start small and grow, raising capital and smoothing production problems as the output develops. With IMTA, the co-culture is on a comparable scale to the finfish installation, and the capital cost of doing this could be a major problem for a small producer looking to develop IMTA

Technical: Priority Areas for Development

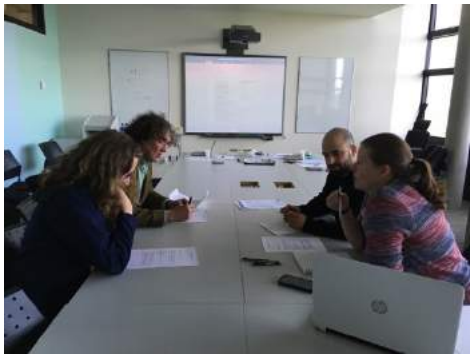
More production experience and practical trials to 'iron out' co-culture issues

- Further research into whether closed containment and/or land-based systems would be more suitable for IMTA development, rather than at-sea systems as currently envisaged
- Automation of systems – upscaling of cultivation, but better design of baskets/cages along with washing & grading facilities could reduce labour and unit costs significantly. Research needed for larger installations and new species handling.
- Separation distances - already known about for current culture, what should they be for IMTA installations – will species mix affect this?
- Further LCA of the IMTA chain

2.2 IRELAND

The workshop in Ireland was held on 13th April 2018. 19 attendees were present, (8 from academia, 9 from industry, and 2 from state agencies). Following on from an initial presentation to introduce the INTEGRATE Project and the workshop, were 5 presentations covering technical aspects of IMTA from different perspectives, these being: land-based systems; finfish; seaweeds; invertebrates and pathogen transfer. During the afternoon session, participants were divided into working groups and designated one of the three sub-topics: definition of best practice; bottlenecks to development of best practice and priority areas for development of best practice To conclude, discussion summaries were presented to all participants, and it was opened to the floor for further comments. The summary of the working group discussions is presented below.



Technical: Definition of Best-Practices

The aim of this working group was to define IMTA technical best-practice. We suggested that participants went for an overview perspective rather than individual elements of best practice for each trophic level/species, as these are too many and varied to arrive at one definition.

The following questions were used to generate discussion in the working group:

- Is it necessary to ensure direct trophic subsidisation or is a mass balance approach sufficient? i.e. What scale does IMTA act at?
- Should IMTA units be managed for overall productivity of the system or should the productivity of the individual units each be maximised without consideration of the others?
- Does partial IMTA make sense? i.e. What level of remediation should make something qualify as IMTA? How should we measure this? How many trophic levels should be incorporated to qualify as IMTA?
- What degree of trophic differentiation makes something qualify as IMTA? i.e. Where does polyculture end and IMTA begin?

The central conclusion from this group was that 'we are nowhere near a definition of IMTA technical best-practice'. It was suggested that unintentional IMTA might be considered our best examples of IMTA, if not quite best-practice; that more research and education, perhaps a travelling roadshow, was needed to explain the concepts of IMTA best-practice; and, that ecosystem services should be considered as a means by which value could be recouped from the extractive species.

Technical: Bottlenecks

General: The primary problem identified was that 'we don't know what to do or how to do it' – this breaks down initially to: 1) which species to grow, how to combine them 2) lack of technology, and tech. transfer from research to practical application (especially hatchery production of suitable species), 3) knowledge loss (research and development does not get out of the institution/enterprise where it was developed) with consequent re-invention of the wheel.

It was identified that guidelines and steps for the production of the 'secondary' species would go some way towards overcoming this bottleneck.

Specific:

Freshwater systems

- Lack of technical and practical knowledge of suitable species combinations
- Lack of knowledge of methods, and lack of facilities for hatchery production of freshwater species

At sea systems - finfish

- Expertise, time and investment is focused on the core species, leaving few resources to invest in secondary species

Invertebrates

- Space, as in farm footprint.
- Disconnect between research organisations and industry, and knowledge is not transferred.
- Trial and error approach to IMTA
- Lack of knowledge about and facilities for hatchery production for benthic species

Seaweed

- No clear technical driver for inclusion of seaweeds in sea-based IMTA (i.e. remediation not generally necessary)
- Hatchery capabilities – few species ready for commercial use
- Potential fouling issues (in both directions)

Pathogen transfer

- Minimum distance between species for disease transfer may be difficult to reconcile with distances that are optimal for nutrient transfer
- Risk of pathogen transfer was deemed not really a bottleneck but a potential future risk. It was suggested that once a strong motivation for IMTA development existed, the challenge of pathogen management would be managed/overcome (as the aquaculture industry currently adapts to disease challenges)

Space

- Different issues for freshwater and marine. Discussion around what is too close, and when is IMTA actually IMTA. Full integration with direct trophic subsidisation was not considered a likely reality. Possibility for bay scale management and unintentional IMTA more realistic.
- Relative space requirements for meaningful remediation and also regarding logistics of each enterprise also needed attention.

Technical: Priority Areas for Development

Freshwater systems

- Easy solutions/technologies to combat problems
- Expertise in algal production to optimise biomass needed to provide bioremediation without compromising other parameters (e.g. oxygen)

At sea systems - finfish

- Multi-species expertise – IMTA co-operative

Invertebrates

- Hatchery production of commercially important species
- Intensification and on-growing protocols for low trophic level species
- Critical mass in the aquaculture industry in Europe

Seaweed

- New species – summer; native
- Biofouling research
- Spatial arrangements for maximising nutrient uptake, especially over distance
- Contaminant transfer

Pathogen transfer

- Avoiding introduction of diseases with live animals and avoiding host chains or other reservoirs of pathogens in the system
- Identifying pathogens of concern that are relevant to different species in the system and that can potentially be transmitted between species (disease monitoring in different species)
- Coordinating farming activities (such as cleaning) so as not to impact on fish health
- Understanding risks
- Good husbandry

Expertise

- Knowledge transfer- platform?
- Equipment, infrastructure
- Training

2.3 FRANCE

This section reports the first French Workshop about "Technical IMTA best practices" which has been organised by CEVA and Agrocampus Ouest. This event took place on the 25th APRIL 2018 in Rennes (Brittany, France) and brought together 23 stakeholders involved in aquaculture in the French part of the Atlantic Area. Following two presentations of the INTEGRATE project and the State-of-the-Art of IMTA in France, were a series of five further presentations detailing 1/ The history of IMTA in France and in the world, 2/ the technical characteristics of the different IMTA systems that have been tested, 3/ How macroalgae/seaweed cultivation can be associated with other aquaculture productions and 4/ three feedbacks of experience from project managers and producers. The afternoon session was organised as round tables, ended by a general restitution of all the discussions.

Technical: Definition of Best Practices

- The notion of benefit and positive interaction appears to be very important, but this interaction is not defined as a directly trophic or nutritional link.
- The presence of different trophic levels is necessary, but an interrogation remains on the differentiation of the trophic levels of two fish or two shells (ex: Salmon and Labre / Oyster and St Jacques shellfish, which do not use exactly the same resources).
- Concept of maximization, optimization of the use of resources and recycling of waste. - It was also mentioned that the different species must be cultivated or reared "in the same system"
- First of all, participants agreed the difficulty of talking about “best practices” in IMTA without having a clear definition of the IMTA concept itself.

- Second, the differences between onshore and offshore systems are such that the resulting practices are far apart. So, these two systems should be separately considered when exploring what “best-practices” are.

How to size the system and design it?

- Control production volumes to achieve a balance between production and waste in order to limit the environmental impact
- Size the system according to the capacity of the environment - Realize a ZERO state and anticipate potential interactions with the environment and wildlife
- Prefer materials (nets, cages, buoys, anti-fooling ...) more ecological. The choice of materials is also important, but the reflection must be done in parallel with the economic study.
- Questioning the creation of the system: several small units preferable to one big system?

Choose the right species

- Use local strains from local species for at-sea systems
- Pay attention to the complementarity of the resources used (pay attention to macrophyte - phytoplankton competitions on a shellfish / seaweed system)
- Pay attention to complementarity on the space used in the water column
- Pay attention to the complementarity on the seasonality (to have interactions in the species over the same period, but also to have an activity all the year)

Technical: Bottlenecks

A lack of knowledge:

- Lack of knowledge about inter-species associations - middle - Lack of knowledge about zootechnical practices (densities, proportions) - Too little access to the results of experiments and research programs

Environmental constraints:

- Climatic conditions, storms: Easier to develop IMTA on land? - Global warming and ocean acidification: what impacts?

Financial point of view:

- High cost of experimentation at the outset to validate the performance of the systems (in connection with the lack of feedback and lack of information)

"Zootechnics":

- Difficulty of controlling several species

- What interactions (positive - negative?), How to manage them (eg impact of treatment of fish on other compartments, health and pathological aspects)
- Increased manpower, working time, by increasing the number of compartments and therefore the densification of the system.

Land issues have not really been addressed. Only the difficulty of access to seawater for a land-based system was mentioned.

The issue of the difficulty of controlling releases and proving the reduction of environmental impact in IMTA systems was raised.

Technical: Priority Areas for Development

Increase knowledge and capitalize on experiences:

- Boost public research to gain access to results - Do not waste time looking for problems where they are not - Experimenting on a small scale, favouring research tools

To develop priority axes for Research:

- Domestication of new species meeting the challenges of IMTA (algae and benthic species)
- Quantification of interactions between species and the sustainable use of resources

2.4 SPAIN

This technical round-table gathered four experts from academia, four from the industry and one from the regional government of Andalucía. Seven of the experts were present at the venue and two took part in the discussions via web call. The round-table kicked off with an introductory session. CTAQUA gave brief presentations on project INTEGRATE, work package 4 and the objectives of the round-tables.

Figure 1 Introductory session

Participants then engaged in discussions in a single group. To begin with, they were asked to provide a short definition of IMTA. Next up they were asked to discuss the three sub-topics from a technical standpoint by replying to the following questions:

- **What are the issues that must be dealt with during the implementation of IMTA (definition of best practice)?**
- **What are the main bottlenecks to the implementation of commercial IMTA?**
- **What are the priority areas to define IMTA best practice?**

Participants wrote their answers to each of the questions on a memo note which they then displayed on the wall panels. The memo notes were collected and answers were collated in three separate PowerPoint slides (one for each sub-topic). Finally, participants discussed the answers to each of the sub-topics and made suggestions on how to address the subsequent assessment.

Figure 2 Memo notes displayed on wall panels

The Spanish experts provided the following ideas towards the definition of IMTA:

- An IMTA system must have a source and a flow of nutrients.
- Living organisms in the IMTA system must benefit from the presence of the rest of the IMTA components.

- At least two aquatic species are required in IMTA.
- The flow of nutrients must be deliberate (this is crucial from an administrative standpoint).
- IMTA productions should lead to commercial activity, i.e. revenues should be obtained.
- IMTA production must be structured and adequately planned.
- The regional IMTA approach: provided that nutrient flow exists between them, the components of a single IMTA operation can be located in different sites and operated by different specialists.

Sub-topic discussions and subsequent assessments led to the following statements:

Technical: Definition of Best Practices

- The presence to size ratio of the different trophic levels in an IMTA system must be adequate.
- The design of nutrient flows must be suited to uptake and operation control systems.
- Species selection for the IMTA component must add value to the aquaculture operation.

Technical: Bottlenecks

- Lack of scientific knowledge about the biology and ecology of certain species.
- Lack of technical skills and suitable tools to tackle IMTA farming.
- The industry's lack of experience with IMTA hampers its adequate upscaling.
- Administrative burdens (these will be dealt with in future round-tables).

Technical: Priority Areas for Development

- Knowledge of IMTA must be improved by conducting research into species biology and farming technologies, particularly IMTA management and control systems.
- IMTA modelling in connection with site selection. Adequate modelling will allow an approach to IMTA where different companies specialise in each of the components of a single IMTA operation (fish, molluscs, seaweed, benthic components, etc.). This requires stepping up current knowledge of IMTA-ecosystem interactions.
- The development of suitable marketing strategies and the adequacy of administrative issues are considered instrumental in achieving successful IMTA operations. These will be dealt with in future round-tables.

2.5 PORTUGAL

The workshop took place on the 12th April following the frame proposed by the leaders of WP4. In the morning there were 11 oral presentations (7 – academia; 4 – SME's), followed by a free debate of three themes in the afternoon. Due to the large number of registered participants the morning session took place at the premises of Instituto de Conservação da Natureza e Florestas (ICNF) in Olhão, that kindly let us use their Auditorium. There were 47 participants in the morning session from different backgrounds: academia, industry, NGOs and state institutions. The afternoon debate involved less participants (23 people) and therefore took place in the audio-visual room of IPMA's Estação Piloto de Piscicultura de Olhão (EPPO).

Technical: Definition of Best Practices

Regarding to Definition of best practices in IMTA most of the participants divided it into: *Offshore* and *Land-based IMTA*. The reasons for this division were the different approaches and technologies used.

Offshore IMTA in Portugal is still at the very beginning or non-existent. There is only some bivalve (oyster and mussel) long lines located at the south coast of Portugal. Some of these long lines are located at Área de Produção Aquícola (APA) da Armona, and at APA de Monte Gordo where fish cages are also expected to co-exist. Some macroalgae longlines exist also off Sagres promontory.

Land-based IMTA was still divided into *Fresh* and *Saltwater*. Land-based IMTA is mostly done in saltwater earthen ponds using densities consentaneous with extensive and semi-intensive productions. The reason is connected to their traditional use in salt-marsh areas in southern Europe. Only one case of freshwater land-based IMTA production was reported using fish *Micropterus salmoides* and this is being done on a water dam in integration with wild organisms.

Most cases of IMTA in saltwater earthen ponds involve the rearing of fish, oysters and macroalgae. This is done either in one compartment or in different compartments, depending on the interest of the producer. If macroalgae is the main interest this is produced in a separate compartment. The other trophic levels are used as water fertilizers (i.e. fish, shellfish). Fish producers use macroalgae for nutrient uptake while oyster producers use fish as fertilizer of the water to increase the levels of phytoplankton in the water.

The participants were referring that the species to be cultured should be producers' choice but always taking into considerations native species.

Technical: Bottlenecks

Offshore IMTA - The main bottleneck referred by the participants for the development of offshore IMTA in Portugal was lack of appropriate technology. The highly energetic offshore environment off the Portuguese coast and the lack of sheltered areas for aquaculture required robust equipment that turns to be very

expensive for the producer. Also, the risk associated with this type of production and the high associated insurance premium makes this sort of IMTA out of the reach for small and medium-sized enterprises.

Land-based IMTA – The main technical issue highlighted was the access to free environmental data that will permit the planning and sitting of the production sites.

Technical: Priority Areas for Development

Species diversifications using native species.

3 ECONOMIC ROUNDTABLE SYNOPSIS BY COUNTRY

3.1 UK

Most of the discussions were carried out at Aquaculture 2018 on the 23rd & 24th May, with some extra interviews carried out locally on the weeks prior to the conference.

Economic: Definition of Best-Practices

What constitutes best practice?

- The economic angle brings to the fore the question (again!) – what are we doing IMTA for? There was a consensus that above all else, IMTA has to have a solid financial base, otherwise it will be very difficult to implement. There is the possibility in the future that some form of social levy/subsidy may be available to develop IMTA systems, but this was felt to be a poor substitute for a solid financial 'foundation'. Economics should be at the heart of thinking about IMTA.
- Getting the economics right depends on all the other round table aspects;
- Systems – getting the technical aspect of the IMTA correct will provide best value for money as well as (hopefully) ensuring success with good quality cultures – this will also depend on correct species (see also environmental)
- Species – Fundamental in an economic sense as each species will have a particular market niche and profit margin. A correct species mix for a particular IMTA site will mean lower technical costs, lower operating costs, and potentially less regulatory pressure, with less financial outlay. It was felt that balancing these issues with what each market requires is essential to making IMTA successful.
- Spatial and Economic mismatch - It was brought up again that the spatial mismatch within the Scottish aquaculture industry is a major barrier to development. As noted in other round tables, the finfish industry in Scotland is dominated by the Salmon industry, which runs a very well-developed system economically and technically, and doesn't have the desire to diversify into shellfish/seaweed aquaculture. On the other side, shellfish farmers have a successful system but do not have the capital or expertise to develop into finfish culture – where will the 'bridge' between these two systems come from?
- Can we develop new species as part of IMTA? Is it too much to ask that IMTA is used as a tool to fast-track the development of new, valuable aquaculture species that may not have seemed of interest in the past? Questions were asked about development of species not intended for human food, but potentially valuable none the less, such as marine worms etc. although it was realised that some of these may be more suitable for a land-based IMTA system.

Economic: Bottlenecks

- Funding – trying to resolve the spatial and economic mismatch noted above has been a recurring theme, with no easy answer. It has been commented in this, and other round tables, that the ideal way for IMTA to develop would be in a slow, organic manner, with smaller producers from the shellfish sector encouraging diversification and a skills shift to polyculture. This may happen, as there is some indication that smaller farmers may diversify into seaweed production, but there is little appetite to move into finfish production due to the technical and economic challenges this poses.
- Better modelling of likely set-up and running costs (see also below)
- Definition – if time and money is invested in developing IMTA, there is no universally agreed definition as of yet, which means that there is the possibility that investment time and money will be lost by other parties undercutting the work done with an inferior, or incorrectly described product. If there is to be investment in the sector, it was felt that there needed to be some protection to the 'copyright' of IMTA.

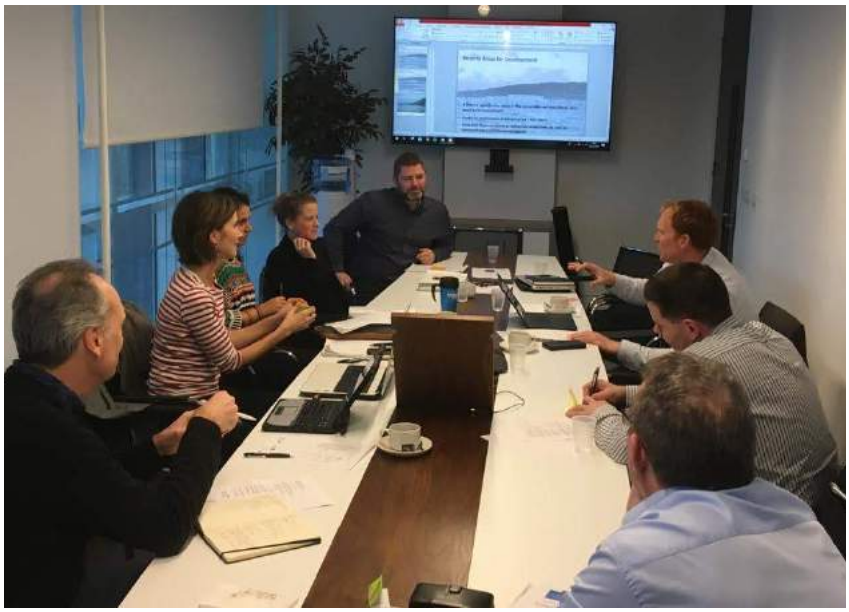
Economic: Priority Areas for Development

- Better modelling of the likely costs and constraints of setting up various IMTA systems would be helpful to the sector – these have already been attempted by some projects – i.e. IDREEM, but better business plans, i.e. akin to the BIM aquaculture business plans, would be good
- Could some novel ideas for IMTA development help the concept? Would Ideas such as carbon capture/ecosystem service development change the perception and business model of IMTA?
- Could we utilise IMTA to explain aquaculture to the general public in a new way? One of the points raised was that aquaculture is seen to suffer from a poor public perception, could an IMTA system work as a 'shop window' for the industry to show diversification and a more ecosystem-centric method of working. It was mentioned (only half-jokingly) that this could also be a revenue stream!

3.2 IRELAND

The workshop in Ireland was held on 5th December 2018. 12 attendees were present, (9 from academia and 3 from state agencies). Although we were unable to involve any industry representatives in the meeting itself, several were contacted prior to the meeting to understand their perspectives, and these were included in a presentation so that account could be taken of their comments. Following on from an initial presentation to introduce the INTEGRATE Project and the workshop were 5 presentations covering economic aspects of IMTA from different perspectives. Presentations covered the following topics; an overview of IMTA economic research; a socio-economic perspective of IMTA; application of lessons from AgInnovate (an agriculture innovation/entrepreneur programme) to IMTA; IMTA projects from the Marine Institute; and producer perspectives of the economics of IMTA. During the afternoon session, because of the relatively small number of participants, we remained as one group and discussed priority areas and bottlenecks for IMTA's

economic development. We then held a keyword brainstorming/discussion session to try to rank which components were most important to include in a definition of IMTA economic best-practice. The summary of the working group discussions is presented below.



General Comments:

Small-scale solutions and approaches, rather than large government funded regulation, may be more achievable as incremental asks are easier to say yes to.

Carrot or stick approach? IMTA could be required by legislation in order to mitigate nutrient pollution i.e. as in the Danish model where fish production cannot be increased unless nutrient removal occurs, or could be encouraged, by capitalisation of its positive attributes i.e. increased protein content of shellfish and or seaweeds, sales of secondary products.

The brainstorming session generated the following list of elements that should be included in guideline economic best practices. They are numbered 1 to 9, and the numbers in brackets refer to the number of 'votes' each suggestion received.

In the bottleneck and priority area sections below follow the same numbering system so that point 1 of the brainstorming list relates to point 1 of the bottlenecks and the priority areas. Where no related priority area or bottleneck was suggested the point was left blank; marked '-'.

1. **Ecosystem Services (7):** Quantification of services; importance of incorporating non-market values; valuation of services; nutrient trading schemes
2. **Market Development (7):** New market identification and definition; added value and secondary processing; co-products versus bi-products. Branding of 'organic plus' – 'beyond compliance' suggested to aid acceptance.
3. **Cooperative/Group (4):** Find ways to incentivise cooperation i.e. seaweed trade/industry association; utilise economies of scale by encouraging cooperation between different enterprises
4. **Diversification (3):**
5. **Economics/Cost (3):** IMTA should be cost neutral – need to determine costing at commercial scale; must be commercially sustainable
6. **Risk Analysis (3):** De-risk strategies; incorporation of de-risk strategies into tangible economic benefits i.e. by improved insurance policies etc.
7. **Public Perception (3):** Identify a problem that IMTA can solve; reduce focus on negative species
8. **Circular/Blue Economy (2):**
9. **Integrate IMTA into MSP (1):** Integrate IMTA into the Marine Spatial Planning process.

Economic: Definition of Best-Practice

In general, it was felt that it was not necessary to define IMTA economic best-practice; why make it complex? Economic best-practice is well defined in and of itself by an economically sustainable IMTA operation. The question of whether each species in an IMTA operation should generate an income or not was regarded as irrelevant. If the system is economically viable then that is sufficient.

Economic: Bottlenecks

1. Lack of quantification of ecosystem services, and viable ways to derive revenue from them.
2. Lack of developed markets for diverse secondary species.
3. Lack of representation and/or coordinated group efforts.
4. –

5. Prohibitive cost of adding additional species, i.e. in requirements of new infrastructure and knowledge, and a concomitant lack of IMTA-specific development support.

6. No economic model for IMTA and therefore no way of calculating economic risk or potential gain. Lowered risk through diversification is largely theoretical at the moment.

7. –

8. –

9. –

Economic: Priority Areas for Development

1. Valorisation of IMTA: Ecosystem services of IMTA production. The UN is pushing ecosystem services into national accounting.

2. Creation of an eco-label for IMTA products to aid market differentiation.

3. Representation groups for seaweed. Agriculture now has a bioeconomy committee – would it be possible to establish something similar for marine? (DAFM are working on this). Aim to bring seaweed producers into the Irish Farmers Association.

4. Commercialisation of research. Validation of ideas via a programme like AG-INNOVATE. Start with the problem definition and then work through 10 key scoring criteria to see if it has commercial potential. Solving producer stated problems. For example, certain land-based producers already have problems with water abstraction rates and discharge compliance. Is IMTA a viable solution in these cases? This needs to be formally evaluated.

Could a scheme equivalent to the REPS grant (subsidies for keeping fields clear) be useful/possible? This monitoring and compliance scheme is in place for agriculture – but it should be noted that there is an adverse selection problem in that people signing up to the scheme are those who are already compliant.

5. Capitalisation of lowered risk in IMTA systems i.e. by reduced insurance premiums. Is this realistic? How is risk assessed by insurers?

6. –

7. –

8. –

3.3 FRANCE

This reports the French Workshop about “Economic IMTA best practices” which has been organised by Agrocampus Ouest and CEVA. This event took place on the 19th March 2019 in Rennes (Brittany, France) and brought together 29 stakeholders involved in aquaculture in the French part of the Atlantic Area.

Welcome and presentation

Pierre Eyrolles (Agrocampus Ouest) presented the concept of IMTA to actors who were not familiar with it, the different objectives of the project INTEGRATE, and the actions relative to the workpackages. The context of the workshop, the main objectives of the day and the program were also presented before the launch of the first presentation. 3 presentations focusing on economic aspects of the development of IMTA took place in the morning.

Financial support for aquaculture project holders Support for project holders - aquaculture & innovation

Marion CHALOT (Crédit Agricole – Filière Mer) et Roland CONANEC (CBB Capbiotek) presented in a complementary way the means of support for project leaders in aquaculture and innovation or in marine biotechnology.

Marion CHALOT has expertise in the field of shellfish farming, and more specifically in mussel culture in the Bay of Mont Saint-Michel, she first presented how the Crédit Agricole analysed aquaculture projects:

- Upstream study: Supply, suppliers, technical mastery of capture ...
- Production: Method of production, location of the parks, expected yields …
- Downstream study: Mode of marketing, certification, export ...
- Other analysis criteria: Management skills of the project leader, equipment available, labour, cash...

Issues specific to the creation of a shellfish activity may be related to the price of concessions (particularly high in Mont Saint-Michel Bay), the risk of dependence on a "key man" with special skills, as well as the banking safety.

Marion CHALOT finally tackled the different investment funds dedicated to innovation (Cap Investment) and the support of start-ups with "Le Village", an incubator of companies with the support of several large companies.

Pierre GARSI requested clarification on the installation rate of young shellfish farmers. The installations of young shellfish farmers represent essentially a family context. There are very few project holders out of family context in shellfish farming because of the price of the concessions (in the Bay of Mont Saint Michel). In addition, no IMTA project is the subject of a request for accompaniment today in Ille-et-Vilaine. Marion CHALOT said that for IMTA projects, funding needs would be very specific because of the different cycles and zootechnical routes.

Roland CONANEC completed Marion CHALOT's presentation by presenting the actions of CBB Capbiotek and the various tools dedicated to supporting innovation. The CBB Capbiotek makes it possible to connect the key players in the Breton territory through a network of structures involved in innovation (170 companies, 63 research teams as well as competitiveness clusters, universities, etc.). Another role of CBB Capbiotek is to support project leaders in innovation (financing but also networking, technical watch, studies ...) and to organize collective actions (exhibitions, meetings ...).

Roland CONANEC finally presented the various tools of innovation project financing (LabCom, ADEME financing, FUI-Region, AAP-transfert, as well as aid to companies "inno").

The first remark following this presentation came from André BERTHOU. He explains that most small producers do not know about these different financing tools, and they do not know how to access them. Benoit SALAUN adds that the search for innovation or diversification of the activity is not very developed in aquaculture, and that the various initiatives are collective, or carried by the CRC which does not have access to all types of financing (in particular the FEAMP, except in the case of DLAL). Banks remain the main relay point between producers and accompanying structures. It is the banks that can redirect the project leaders to the structures giving access to a financial support tool.

Economic constraints related to shellfish farming

Sonia GACHELIN (Regional Committee of the Shellfish Farming Sector of South Brittany – CRC Bretagne Sud) and Benoit SALAUN (Regional Committee of the Shellfish Sector Farming of North Brittany – CRC Bretagne Nord) first presented the various constraints encountered in shellfish farming on different topics (production, sanitary, social, environment, administrative) specifying the associated economic aspects.

According to the professionals, the administrative management as well as the follow-up of the dossiers of health and traceability are more and more binding, and require time and thus money. Concerning the social aspects, the shellfish farming activity remains very seasonal and the profession requires derogations related to the labor rights during the Christmas period. From the environmental point of view, climatic hazards and the degradation of the environment (acidification, warming, pollution ...) are the main risk factors and cause significant losses. The mortality of oysters and mussels is no longer seasonal and can affect all stages of livestock development. It is also impossible today to insure a livestock.

In a second step, Sonia GACHELIN and Benoit SALUN proposed an analysis of a potential diversification of a shellfish system into an IMTA system. This analysis aims to highlight the constraints to this modification of the production system.

The first step identified is the design of the diversification project in IMTA with the choice of the site which includes notions of social acceptability, environmental, regulatory or administrative constraints. It's also about doing market research and calculating the investment needed for the equipment. A second step is to

identify the need to increase skills to master the IMTA system and calculate the costs associated with training.

This project design phase is very time-consuming, especially since the social acceptability of an aquaculture project is never acquired. Designing an aquaculture project adapted to a territorial development project, and therefore more easily acceptable to the local communities, requires the implementation of means of consultation also costly in time and money.

Finally, this study of constraints also highlights several economic problems induced by diversification such as the distribution of working time between the different compartments or increased administrative management.

Sonia GACHELIN and Benoit SALAUN also underlined the weak collective will to develop these systems from the industry. Shellfish farming remains a sector of activity little oriented towards innovation or diversification. According to Jehanne PRUDHOMME of the CRPMEM Bretagne, there is also no rapprochement between seaweed farmers and fish farmers to try to develop IMTA algae - fish systems. It also highlights the lack of political will or concrete action to develop marine aquaculture for several decades. Other fears about climate change and its consequences on water temperature and volumes and production periods have been raised.

Aquaculture development logic, what lessons for IMTA?

Pascal RAUX (University of Western Brittany) presented a summary of global aquaculture in terms of production volumes and evolution of practices:

- Increase in the proportion of fed species;
- Particularity of European production, focused on marine aquaculture;
- Development of aquaculture of noble species from the 80s (seabass, sea bream, salmon, shrimp) thanks to technological evolutions;
- Blue Growth objectives with the creation of strategic plans (Strategic plans, Maritime Spatial Planning, etc.).

Pascal RAUX also pointed out that aquaculture can be defined by its technological advances that try to answer to problems of water resources, nutrition, health security; as well as by its weak institutional or organizational innovations that do not manage to stop the vicious circle characteristic of the development of an aquaculture sector. This vicious circle was explained in the second part of the intervention.

Pascal RAUX explains that the development of an aquaculture sector is characterized by 4 phases:

- Introduction: a few pioneers benefit from high prices when creating a new aquaculture sector, with strong profitability, but reduced production volumes;
- Growth: This new market is attracting more and more producers, production volumes are increasing at the same time as revenues, the market is growing;

- Maturity: The market comes to saturation, the growth decreases strongly as well as the profitability of the systems of production;
- Stabilization: It settles a race to the reduction of production costs, the profitability of the systems is much lower than in the previous phases.

This development scheme leads to several notable results. On the one hand, the increase in production volumes leads to falling prices and corporate income, but also to a concentration of production sites in a small number of companies. The search for technical solutions to reduce production costs leads to mechanization or optimization of work, and therefore a reduction in the number of workers involved in the sector. Worse, the drop in prices due to increased production undermines the product image, which makes any significant price increase impossible.

For Pascal RAUX this situation is absurd from an economic point of view. Finding a technical or technological solution to lower production costs or improve the quality of a product does not solve the problem. For Pascal RAUX, the real locks are social-economic and the real question is "for whom and why to produce? ". From this issue, the main strategic objectives for aquaculture development and IMTA should be derived. If the goal is to feed the world's population with fish protein, fed species like salmon or seabass may not be the most suitable. If the will of Europe is to develop fish farming to respond to territorial development issues, local consultation must be conducted to identify the modalities of this development and its feasibility, and the notion of social acceptability takes all its meaning.

After the presentation of the morning, round tables were organized in the afternoon. The aim was to discuss the environmental best practices for the development of IMTA. The definition on these best practices, the bottlenecks for their development and the priority areas for development are presented below.

Economic: Definition of Best-Practice

At a micro-economic scale – enterprise-wide:

- Integrate environmental impacts into the business plan: internalize positive and negative environmental externalities;
- Increase the economic resilience of the company by reducing its dependence on the variability of a single production through diversification into IMTA.

On a larger scale:

- Integrate upstream consultation times to integrate the IMTA project into territorial development. This investment of time upstream of the project could save time and money for the court;
- Develop a new sector without destabilizing companies in monoculture or algae harvesting companies.

From a marketing point of view:

- Put forward an environmental or social interest to develop an adapted marketing and manage to valorise the co-productions. Differentiate the products of IMTA;
- Develop the marketing of IMTA in short circuits, or on a local market (not for export). Make the link with territorial development.

Economic: Bottlenecks

At the company level:

- The productivity gains and economies of scale generated must make it possible to offset the increase in maintenance or labour costs, or IMTA will remain less profitable than monoculture. Is the cost of IMTA offset by the social cost and ecosystem services provided?
- Difficulties in valuing all the compartments or products resulting from the IMTA, what financial return on each of the compartments? Market or outlet problem.
- Deadlines for designing the project and integrating it into a territorial development project (implementation of the consultation)

From a general point of view:

- Difficulty to access the space at sea, find sites large enough for a functional IMTA;
- Absence of reference economic model in IMTA. The seaweed farming is fragile, as is the fish farming at sea. How to attract producers already installed to the IMTA?
- Risks related to the environment (climatic hazards, climate change).
- Risks related to the investment (heavy).

IMTA name too technical - pay attention to technocratic language

Economic: Priority Areas for Development

Supporting collective experimentation, supporting companies from several angles:

- Help them identify suitable financial support
- Limit administrative costs
- Build innovation networks
- Limit risks by developing insurance tools
- Develop training

Define, demonstrate the profitability of an IMTA system: at the level of a single company or a group of complementary companies located in the same territory.

Define indicators to quantify the positive or negative externalities of the aquaculture activity.

Develop planning or regulatory documents.

Integrate IMTA into territorial development projects.

Communicate on IMTA products and practices.

3.4 SPAIN

The objective of this working group was to define and assess the most relevant aspects of the economic sphere that should be taken into account to facilitate the solid implementation of integrated multitrophic aquaculture in Spain. Experts from the business sector and, to the extent possible, with some experience in aquaculture were selected and invited. On this occasion, only one of the participants belonged to the public sector (Research). As in the previous roundtables, the activity was carried out in the Ctaqua facilities.

Presentation of the INTEGRATE project and its methodology

In order to introduce the project to the different participants, as well as to explain the development of the methodology, a short presentation was shown.

The approach consisted of placing the different participants in pairs, who were then given a sheet of paper each, with a specific question about economic aspects related to IMTA. To answer each question a limited time (5-10 minutes) was given, after which the question was passed to the couple on the right. Subsequently, when all the questions were answered by all participants, they were pooled for discussion, grouping and punctuation of concepts.

Results

The contributions of those attending the workshop were collected and processed during the event. Below are the contributions grouped per question.

From your experience, do you think this type of aquaculture can be profitable? A. Yes, why? B. No, why not?

As for the profitability of IMTA, although all participants agreed that this type of aquaculture can be profitable, there are a number of limitations that can hinder such profitability:

- Economic-financial analysis (direct and indirect benefits)
- Feasibility models
- Cost of manufactured products
- Dimension
- Volume of production of total crops of each species

- Commercial viability (existence of a specific market)

The sharing of this question opened an interesting debate about the concept of profitability applicable to this type of productive model.

In this sense, it was concluded that ecological models are not suitable for traditional economic viability analyses since they are not usually "profitable".

However, if we broaden the definition and include environmental sustainability or corporate social responsibility in this concept of profitability, it could be considered.

It also became clear that recent economic studies now consider not so much the profitability but rather the viability of a business as a complex set of other models, including commercial, sustainability, economic-financial or organisational, which must be viable on their own.

From your point of view, what would be the most appropriate business model(s) for this type of aquaculture? Why?

As for the most suitable models for this type of aquaculture, it was considered that the most important thing would be the diversification of the economic activity and the search for markets that value IMTA products, although taking into account the limitations depending on the size of the business or the natural space in which this type of installation is usually located.

Potential business advantages and opportunities

When discussing the possible advantages of this type of aquaculture, participants agreed that the main advantage lies in the diversification of production and the differential value of the product in terms of quality, niche market or through (eco)labelling

However, cost savings and their transfer to prices and scale of production would have to be taken into account in order to achieve longer production of seasonal products.

Economic tools to promote this type of aquaculture

By unanimous answer of all those present at the table, this question was merged with the previous one and the next one.

Economic strategies for the promotion of this type of activity and/or consumption of these products.

The most important strategies to take into account for the development of integrated multitrophic aquaculture and, consequently, of its products, were the following:

- Investment in marketing (access to markets, promotion and testing to promote knowledge and consumption).
- Search for more local markets (few intermediaries, focus on production without intermediaries

and marketing)

- Environmental dissemination of the activity: raising public awareness among children and adults, encouraging visits to production plants, TV/documentary programmes, definition of strategies by the different levels of administration, companies.

Ecosystem services a) Most relevant positive aspects with possible impact on the economy of the environment; b) Possible negative aspects

With regard to ecosystem services for this type of aquaculture, it was considered that these can only be positive. In this way, in equality of importance, and with the highest score, the most relevant positive aspects are:

- Fostering a circular economy
- Mitigating climate change (data lacking here)
- Safeguarding the aquaculture industry
- Empowerment and active conservation of biodiversity
- Pollution reduction

Ecosystem services II:

How could such services be rewarded?

Also by unanimous agreement of all attendees, it was considered that the most appropriate way to recognise the ecosystem services related to IMTA would be public awareness of the activity taking into account its environmentally friendly characteristics that may materialize, for example, through the facilitation of some of the administrative procedures that normally must be carried out to implement this type of activity.

Other economic aspects to be considered for the promotion if IMTA in Spain

The only added contribution to what was discussed in the roundtable was that a possible strategy for adding value to products could be convergence towards markets already established; for example, in northern Europe there may be a greater awareness of these types of products.

Conclusions:

It is essential that the development of an IMTA system, as a productive activity, should in some way be beneficial to the company carrying out that activity.

However, the enormous weight and inherent value of this type of practices that seek not only economic benefit, but also environmental sustainability, means that this should not be understood as any other aquaculture activity.

In this sense, there are numerous strategies that could or should be taken into account to guarantee that the product obtained in some way has a greater value compared to production through other more conventional techniques.

It is also very important that the production method is communicated to the general public in order to allow the consumer to decide whether this product should be available on a broader scale.

This is the only way to achieve not only an increased awareness of the importance of using this type of cultivation method, but also to attract potential investors who would promote this type of economic activity.

Finally, we must not forget the authority/influence that administration/policy has, therefore communicating the benefits of IMTA to all stakeholders is essential.

3.5 PORTUGAL

The workshop took place on October 23th at IPMA's Aquaculture Research Station in Olhão with the objective to present and discuss different point of views of the IMTA economic aspects. In summary, the focus was to list the economic advantages and disadvantages of IMTA in Portugal. Questions like "How to improve the economic production of an IMTA? Under what circumstances it can occur? Is IMTA a good option facing the floatability of the price markets (resilience increased)? What are the economic benefits enrolled in the IMTA production?" among others were debated.

Twenty-five registered participants from academia, industry, and state institutions attended the workshops (Annex). 7 oral presentations (translated agenda at the end of this document) preceded a free debate.

Economic: Definition of Best Practice

Several benefits result from IMTA: increased biomass production, reduction of environmental impact, friendly image for producer and product, transition to productive models of circular economy.

- There is a potential to use the nutrients wasted in fish culture in other production systems. It is a nutrient load that already requires treatment/reduction and normally presents spontaneous production of macroalgae.

- Attention should be paid to the amount of nutrients required for the installation of an integrated production system at the commercial level. As well as for the absence of contaminants, constancy of production, economic viability of the integrated system and existence of a consumer market.

A preliminary economic analysis advises the specialisation of production in a product for which the company has greater competitive advantage. To the main production can be coupled some secondary production, limited to one or two more products. Preferably products with important market value and that have synergy with each other, in terms of resources and/or activities used.

IMTA assay showed higher gross profit in cultivation with two main organisms (50:50, eg. oyster and meagre), compared to the cultivation of a main organism and another accessory (95:5, oyster and meagre, respectively).
It is important to have strategic solutions to reduce energy used in water circulation (eg. solar energy, gravity).

It is important to integrate concepts of ecological engineering, circular economy and ecosystem services for adding value to the final product, as well as the social and cultural component, when possible.

The production of lower trophic levels organisms (eg., invertebrates, macroalgae) and fish as secondary species can be a good option, since macroalgae grow spontaneously, but benefit from waste nutrients from fish.

In the case of macroalgae cultivation, IMTA can be a solution in reducing costs, as it provides the nutrients needed for algae growth.

The macroalgae processing in situ (eg. washing, drying) is important in adding value to the product.

The increase in the complexity of production systems requires increased skills, thus the aquaculture park/condominium model is suggested, with companies specialised in specific products, and integrated in the same area.

Economic: Bottlenecks

The biggest problems observed are algae productivity inconsistency and high production cost. Productivity consistency is important for the management of biomass collection and processing routines. Multitrophic integrated systems are already valued in countries where bioremediation is important.

The regularity of production is essential, to facing the stochasticity/seasonality of the product from extractive origin.

There is a market for macroalgae in Europe, but regularity and quality are required (eg., color, processing, species.) in production.

A bottleneck in the aquaculture and IMTA development is the non-permission to use RANs (National Agricultural Reserves) for aquaculture purposes, even in removable structures.

It is important that the discussion of licensing for analysis of specific cases will be conducted between public licensing institutions and other actors, such as local authorities, entrepreneurs, associations. The lack of license makes financing impossible.

The Direção Geral de Agricultura e Desenvolvimento Rural was asked for an Exception Regime for the licensing of aquaculture, and approval is under the responsibility of the Ministry of Agriculture. Also, it is necessary to resolve the issues of REN's (National Ecological Reserves) and Reserve Planning Plans.

There is a potential wasted in the impossibility of using effluent water for aquaculture and agriculture. Minimum parameters of water quality for use, specific distribution network, valuation of ecosystem services, among other measures, could enable the reuse of this water.

Economic: Priority Areas for Development

IMTA has environmental, ecological and biomass production importance. Algae and microalgae have potential for bioremediation of aquaculture and industrial waste, due to the nutrients available in the environment, the high productivity of algae and their spontaneous growing.

Macroalgae have high biological value (quality) as fish food, adding value to the final product, as well as in the use for human nutrition, cosmetic and pharmaceutical industries.

There is already concern about carbon emission limits in aquaculture production systems.

The European consumer (eg., France) consumes mostly local products and shows no interest in products from other regions.

Future agricultural, maritime and fisheries investment lines will most likely be focused on reducing environmental degradation, ecosystem rehabilitation and minimizing impacts on climate change. As well, investment for research and pilot projects focused mainly on circular economy of water.

It is important to demonstrate the results of investigations on pilot scales (commercial).

There is a tendency to finance cooperative projects (eg. joint producer, commercial companies and research centers) and projects focused on ecosystem services.

It is important to add the valuation of ecosystem services into legislation. In the case of aquaculture, beyond the removal of excess nutrients from the waters, it also contributes to the removal of CO_2. Ecosystem services need to be quantified to be valued, with the possibility of benefiting the producer and generating surplus for other producers (eg. CO_2).

4 ENVIRONMENTAL ROUNDTABLE SYNOPSIS BY COUNTRY

4.1 UK

Most of the interviews were carried out at Aquaculture 2018 on the 23rd & 24th May, with some extra interviews carried out locally on the weeks prior to the conference.

Environmental: Definition of Best Practices

What constitutes best practice?

- Noted by all participants – best practice is very difficult to define at the moment, as there has not been enough practical experience in Scotland – again, many of the points raised below have been raised in a different way in other roundtables.
- It was agreed that existing aquaculture works to a very defined system that varying but reasonably well understood environmental impacts – further up the scale, these are understood well by regulators and government.
- Again, the question arose, what is IMTA trying to solve, or quantify – has it been decided, and who decides it from an environmental point of view?
- In returning to a technical question – there is a need to decide what is the key environmental driver of IMTA – is it going to be nutrient reduction, will it be benthic turnover and amelioration? Are there specialised, localised aspects of the IMTA that we need to consider? For example, it was noted that nutrient removal is the most noted environmental gain for IMTA, but in a Scottish context this isn't the major environmental issue facing the industry.
- Land based (pumped) aquaculture in Scotland is a very small part of the industry, and not likely to expand in the future, but all agreed it was the ideal set-up for IMTA due to the ability to very closely control procedures and inflow/outflow. Where it could be used, it was agreed it could be a very agreeable solution.
- Co-location of existing and new IMTA sites – this was an area of interest and concern (opportunity/bottleneck?) about which there were questions. It was noted that the large scale IMTA trial in Loch Fyne, as part of the IDREEM project, had shown good to excellent growth of material, but what were the environmental benefits? It was agreed these were difficult to discern, as nutrient dispersal was almost immediate at the cage edge due to current movement and quantifying the uplift by the IMTA site was difficult. Where is the longer-term research looking at the issues of co-culture – farmers will be interested in these issues (i.e. potential disease/use of shellfish as reservoirs for pathogens *etc.*) if IMTA is going to progress.

- An issue raised was that of the correct species type for individual sites – it was felt that there was the possibility that IMTA may become a top-down idea with species suggested that weren't suitable for individual locations. It was felt that a far better solution would be to encourage local diversity and the development and 'bringing-on' of suitable local species for each location and market type.

Environmental: Bottlenecks

Species Development –the shellfish industry is already struggling with sourcing additional stock from hatchery sources, can we work on getting these sources working first?

- More information is needed about co-culture distances for different species combinations in different environmental circumstances, or can we move to a loch-based system that will budget nutrients as part of a bigger system?
- Developing practical experience – at the moment there is no cross-over experience within the aquaculture sector, or any opportunity for developers to 'learn on the job' on an existing IMTA site – how will the practical experience needed be developed? (the relevance here for environmental issues relates to the professional practical experience – noted by several participants was that the current high environmental standards in the industry come from high levels of training and experience)
- Where will the environmental monitoring and regulation come from? Can the industry develop and mature sufficiently before new environmental regulation is imposed upon it from above? There was a concern that the food safety aspect of IMTA material (in particular seaweeds) would have to be considered carefully to avoid any potential dangers.
- Environmental reward (also raised in other tables) – how do we measure IMTAs success in remediation?

Environmental: Priority Areas for Development

- More trial systems – a long term set of experiments looking at systems development, or a series of smaller trials in different locations looking at alternative cultivation methods. These could be used for practical experience, as well as developing better methods for examining the environmental effects of the co-culture.
- Ideally there could be better/cheaper monitoring systems that allowed the system dynamics to be looked at in greater detail – generally it is fairly expensive and time consuming at present to model nutrients, could this be improved?
- Update aquaculture models (FARM *etc.*) further to look at the nutrient dispersion as well as other environmental factors

- A set of guidelines about siting distances of new developments
- Further research about potential cross-over effects of co-culture, such as whether IMTA sites act as sources/reservoirs for infection/diseases that may affect finfish culture – unlikely, but a key concern of some finfish farmers
- Cross research with engineers about developing the benthic aspect of IMTA

4.2 IRELAND

The workshop in Ireland was held on 7th February 2019. 21 attendees were present, (9 from academia, 7 from industry, and 5 from state agencies). The morning saw a number of talks related to the topic, and the afternoon was dedicated to working groups and discussions. Presentations covered the following topics; Environmental Assessment of IMTA: from literature and INTEGRATE project research; Smart Monitoring: technological innovation in aquaculture; Intensification, extensification and environmental indicators; Aquaculture Monitoring; framework and reality; Modelling Interactions in IMTA and Aquaculture.
The afternoon groups of 6-8 participants discussed pre-prepared questions before each group presented their synopsis to the larger group for overall comment and conclusions.

Environmental: Definition of Best-Practices

It is not yet possible to define best-practices as not enough trials/tests have been carried out and data is insufficient to prescribe broad guidelines. However, there are certain points that can be made. As IMTA will be very area/species dependent there can be no one size fits all approach. This leads to the requirement for different BP's according to country and local aquaculture type, although perhaps it will be possible to create a set of standards with respect to resource use, protection of biodiversity and record keeping etc. Additionally, best-practice guidelines should consider or make reference to the following components:

Trophic Interactions and measurements of system efficiency:

- Quantification of the links between the IMTA species on a site or within a bay
- Nutrient budget quantification: C, N & P
- Productivity (system) effect
- Productivity of lower TL's
- Contribution to circular bio-economy (how could this be measured?)

Seabed quality / benthic impact at site:

- Effect on local biodiversity; including nursery areas for cleaner-fish and inshore fishery species
- Chlorophyll
- HAB's
- Microbial population changes

Physico-chemical parameters:

- Suspended solids
- O2
- Temperature
- Light
- Metal accumulation and dynamics

Welfare (and stock health) improvements

Environmental: Bottlenecks & Priority Areas for Development

The bottlenecks and priority areas have been considered alongside each other in the following table, as it is very often the case that they are mirror images of one another.

BOTTLENECK	PRIORITY AREA
Making 'space' for extensive production like large scale kelp cultivation	Identification of suitable areas for extensive aquaculture within the MSP framework
Lack of knowledge of benefits of IMTA especially effects on ecosystem services Bay-scale studies are lacking	Thorough understanding of ecosystem services and their sustained delivery at relevant scales Ability of adaptive strategies to adjust BP's throughout the year Ecosystem Service analysis: Are existing ecosystem services maintained or enhanced by IMTA-BP's, especially compared to prior single-species cultivation? Do contributions of IMTA-BP's support/meet established GES targets and contribute toward sustainable use?
Lack of acceptance of salmon farmers of IMTA as a means of nitrogen capture (or lack of motivation to act on this) Development of cooperation between aquaculture businesses	Assessment of trophic alignment and efficiency Assessment of remediation capacities of extractives and knowledge of interactions between IMTA species Proof that salmon farming areas have higher nutrient loads that are in need of remediation Possibility to offset emissions from terrestrial livestock production Need to provide a 'standard model' for IMTA – this is probably easier for land-based sites
Lack of certification, inclusion in national/international schemes. ISO rating is needed.	
Difficulty in quantification/regulation/definition of marine IMTA. Difficult to define what it is about bay or farm status that IMTA can be seen to affect. It is not just the farms affecting water quality at sea	Ways to account for wider benefits of IMTA at farm or bay-scale
Proof that no cross-contamination occurs between species	Cross-species disease transfer knowledge Assessment of disease risk Diseases, biotoxins and metals transfer assessment
Lack of demonstration of sustainability benefits	'Prove' environmental sustainability Increase awareness of the benefits How to include IMTA in the circular economy concept
Lack of baseline data	Site baselines
Lack of knowledge about appropriate indicators	IMTA specific indicators Monitoring standards Use of IMTA habitats for cleaner fish species. Biodiversity increase? Or at least maintenance of local diversity at IMTA sites. Extent of off-setting of impact of waste that makes up the feed e.g. soya coming from S. America and deforestation and food miles. Full accounting: feed, veterinary inputs, infrastructure Identification of suitable benthic invertebrates as monitoring species/sentinels.
Lack of global metric studies i.e. LCA; DPSIR; emergy etc.	Carbon sequestration potential of IMTA LCA carbon, energy, phosphorus
Trend for Irish aquaculture to move offshore.	This could lead to focus on a more traditional, small-scale, local, green initiative for remaining inshore aquaculture. Creative marketing opportunity.

4.3 FRANCE

This document reports the French Workshop about "Environmental IMTA best practices" which has been organised by Agrocampus Ouest and CEVA. This event took place on the 19th March 2019 in Rennes (Brittany, France) and brought together **29 stakeholders** involved in aquaculture in the French part of the Atlantic Area.

Potential environmental impact of finfish aquaculture

Christophe JAEGER (Institut National de Recherche Agronomique) presented the different impact finfish aquaculture may have on the environment and the different indicators used to quantify these impacts, as well as their limits.

Metabolic wastes were identified as the first main type of impact inducing a change of the chemical composition of water and sediments, but with high variability according to the local hydrodynamism. Fish feed, density, stock and equipment are the different levers the farmer can use to lower the impact of the metabolic wastes. Christophe JEAGER also insisted on the fact that the changes of water or sediment composition might induce negative (degeneration of Posidonia meadow), but sometimes positive impact on the environment (increase of abundance and diversity of fish and invertebrate species under the cages).

For freshwater systems, very few fish farms have water treatment equipment. This is due to the fact that lagoon treatment systems require large surfaces and drum filters are not efficient enough to fix dissolved nutrient emissions issues. Christophe JEAGER insisted on the fact that the impact of the finfish farming activity depends on the site, on the system, and on the practices implemented. Every system has its own specificities and can be controlled at different steps of the production cycle, so the levers to lower the impact of the farm might be different from one site to another.

Two other types of impacts have been highlighted, but considered as having minor consequences (In the sector of finfish farming): Chemical treatments & Animal and biological material escapes.

Few questions were asked regarding the subject of the presentation and the discussion focused mainly on the relevance of the creation of a definition of IMTA. Why do we need a definition (Yohan WEILLER)? What is the purpose? A design brief or an eco-certification might be more relevant rather than a regulatory definition (Laura FILLNGER). Joël AUBIN gave some precision about the notion of valorisation. Lagoon treatment have a water treatment value, but also a biodiversity value (these lagoons being an ecosystem with many different populations), and there is, for now, no mean to quantify these externalities.

Shellfish farming and environment

Patrick LE MAO (Institut Français pour la Recherche et l'Exploitation en Mer) first presented the evolution of the scientific, social and regulatory contexts from the 1970's to nowadays and the change of the practices, from a productivity priority to a preservation of the ecosystem and the pursue of sustainable

activities. The social context experienced major changes with the appropriation of the littoral by wealthy and aging population that put pressure on local industries to avoid the expansion of aquaculture. The regulation also induced major changes with the directives 79/409/CEE and 92/43/CEE (Natura 2000).

Patrick LE MAO secondly focused on the different types of impact shellfish farming can have on the environment:

- Introduction of allochthone species with the example of *Crassostrea gigas*;
- Trophic competition between farmed and wild shellfishes
- Modification of sediments
- Physical modification of the environment
- Modification of the diversity of the benthos
- Functional modifications of the environment

These impacts and their consequences were illustrated thanks to different examples.

Physical and chemical modification of benthic habitats induced by the deposition of sediments under oysters' table can lead to an increase of the meiofauna and a decrease of the megafauna, disappearing of endofauna specific of sand sediment and replacement by opportunistic species. An increase of the local biodiversity can be observed, due to oyster-reef creation. Clams' farming located on *Lanice conchilega* beds induced changes in the spatial distribution of shorebirds. The spatial distribution of shorebirds suffers from major changes since the creation of bouchot mussels' parks.

Finally, the major impact of aquaculture remains the introduction of allochtone species such as *Crassostrea giga,* which repartition area is now worldwide. This species colonised almost every location and leads to the creation of reefs and to the disappearing of mud beds ecosystems.

Patrick LE MAO also insisted on the indirect impact of the equipment used for shellfish farming inducing CO_2 emissions, sand and mud compacting, losses of public maritime areas. He also insisted on the fact that every activity has an impact (especially at sea with tourism), and these impacts can be managed thanks to a proper analysis and good decision making.

These different impacts can be modelled and quantified, but it remains very difficult to judge of the positive or negative aspects of certain of these modifications. However, these changes result in negative changes of the indicators used for the Water Framework Directive.

The discussion following the presentation focused on social aspects and specifically on the difficulty to create new aquaculture sites, even if this activity is well known to induce non-transferable job creation. For Guy LEGRAND, public consultation and inquiry's only purpose is to "objectify the questions and legitimate the answers" toward the creation of a new aquaculture activity. The gap between the juridical system and the local actors leads to the global opposition to aquaculture and to the failure of site creation. Several propositions were made like the concentration of the aquaculture activities in certain locations to prevent the split of these activities and major impacts on landscapes.

Environmental impact evaluation's tools and indicators

Joël AUBIN (Institut National de Recherche Agronomique) presented different methods to evaluate the environmental impacts of aquaculture. The main characteristics of the aquaculture sector and its impacts in terms of resource dependency, wastes emissions and "pollution" were highlighted, as well as the different objectives of the measurement of these impacts, being:

- An understanding of the interactions between the system and the environment
- An evaluation of the compatibility between the aquaculture system and the habitat
- The evaluation of the reversibility of these impacts
- The creation of improvement measures
- The creation of a regulatory framework

Indicators about the practices, the emissions and the impacts can be set up, the latest being the most relevant to apprehend the consequences of aquaculture on the environment, but being the most difficult to implement. These measures constitute the first lever to quantify the impact of aquaculture but are sometimes too difficult to implement and only reveal local effects.

The second step to quantify the impacts of aquaculture is the use of modelling tools. Different models were presented such as DEPOMOD, LCA and EMERGY with their main advantages and drawbacks. These different models highlighted interesting levers for the reduction of aquaculture impact. For example, LCA models revealed that food for finfish aquaculture contributes the most for the "climate change" indicator (CO_2 emissions). This information can lead to different strategies to reduce the environmental impact of finfish aquaculture, nonetheless, these models are very sensitive to the performance / yield of the studied system. The discussion following the presentation focused on the different indicators that might be relevant to set-up in order to judge or to discuss the project before its implementation. The examination of the projects' relevance on a specific territory appears as a major issue

After the presentation of the morning, round tables were organized in the afternoon. The aim was to discuss the environmental best practices for the development of IMTA. The definition on these best practices, the bottlenecks for their development and the priority areas for development are presented below.

Environmental: Definition of Best Practices

Respect of aquaculture's general good practices:

- Following the good practices already set-up in aquaculture (use of autochthonous species for example);
- Create specific good practices' guide for each system (open-sea, land-based, recirculated) with IMTA-specific recommendations such as the association of complementary species, adjusted inputs,

adoption of a systemic vision, decrease energy dependency, optimise the resources (food, water, energy, space), decrease wastes emissions;

- Improve the communication about the respect of good practices by the industry.

Adapt the scale of the system:

- IMTA scale should be local (not larger than a bay) and "compensatory" measures or CO_2 NO_2 trades should not be accepted;
- IMTA should refer to circular economy and local production and consumption.

The notion of environmental benefits:

- The notion of reduction of the impacts of aquaculture should be integrated to the definition of IMTA (**everyone did not agree on this point**);
- Take into account the plastic wastes in the strategy of the company;
- Limit the area impacted by the activity;
- Share the analysis of the environmental survey with local stakeholders (from the creation of the study to the results);
- Need for a homogenised/normalised method for environmental evaluation of IMTA. Need for an initial state survey as well as a proper follow-up. Need for carrying capacity studies. The creation of standards to evaluate the different aspects of a product (social, environmental mainly) could help the consumer to choose whether foreign product, or local products.

Certain propositions do not refer to environmental good practices but mostly to social issues already discussed in the previous workshop (set-up of new institution to improve participation and consultation of residents; improve transparency, include IMTA development in territorial project development to legitimise the IMTA system).

Environmental: Bottlenecks

Lack of knowledge:

- Difficulty to build common indicators. Lack of knowledge for environmental evaluation leading to a difficulty to set-up relevant indicators as regards of the diversity of the systems (open-sea, recirculated, in ponds);
- Lack of knowledge about species associations / interactions, need for more research about these interactions to identify systems' balance and monitoring solutions;
- Difficulty to evaluate environmental impact or environmental benefits of IMTA (Valorisation of wastes = decrease of environmental impact? // IMTA = greenwashing?);
- Cost of the environmental surveys and lack of human resources. Need for monitoring solutions.

Social issues:

- Development of IMTA inducing competition and downgrade of traditional aquaculture;
- Social acceptance issues, marine space competition;
- Difficulty encountered for diversification projects. It has been underlined that residents but also producers might be reluctant to the diversification of the systems;
- Governance with no representativeness of NGOs and residents.

Complexity of IMTA:

- Diversity of systems and associated good practice;
- Relevance of a common certification regarding the diversity of the systems questioned.

Some other points have been highlighted in relation with economic, social and technical aspects (loss of productivity of the main species? Difficulty to valorise the secondary production; high investment; social acceptance; willingness to pay a premium; lack of appropriate species to solve benthic impacts;

Environmental: Priority Areas for Development

Give IMTA a definition:

- Give it a regulation framework. Maybe multiple definition is needed (regulatory, scientific, technical)
- Find a new wording for IMTA (too complex)
- Give a precise good-practices guide or design brief

Pursue effort in different research fields:

- Improve knowledge about aquaculture's impact on the environment (especially for open-sea systems). Measure the impact of the system to prove its environmental benefits and to solve the negative points
- Find diversification solutions for small scale producers
- Master the production cycle in IMTA systems and monitor the different species interactions
- Modelling (investment, economic sustainability)
- Create a homogenised template for environmental survey with a ZERO STATE, a proper follow-up survey and relevant indicators so the different stakeholders can easily evaluate the projects with common references.

Social levers for environmental issues:

- Sensitisation to environmental issues during aquaculture training and education. Creation of prototypes.
- Improve consulting and participatory tools to include IMTA project to the territorial project
- Facilitate the interactions between the different aquaculture industries (shellfish farmers, fish farmers, seaweed farmers). Set-up "project co-construction committee" gathering the different stakeholders at a very local scale.

Improve communication about IMTA and sensitisation of consumers to local products with less environmental and social impacts.

4.4 SPAIN

This roundtable was held in order to define and develop the concepts that would be most relevant at the environmental level when implementing Integrated Multi-Trophic Aquaculture (IMTA) in Spain. To this end, different experts in the field, both from the public and private sectors, have participated in discussing their different points of view. The objective of this working group was to define the most relevant aspects of the environmental sphere that should be taken into account in order to facilitate the implementation of IMTA in Spain in a relevant way.

METHODOLOGY

For the development of the roundtable, a group of experts in aquaculture environment and, to the extent possible, with some experience in Integrate Multi-Trophic Aquaculture, were selected and invited. Of the 9 participants, 5 were from the public sector, administration, and the other 4 from the private sector.

As on previous occasions, the roundtable was held at the CTAQUA facilities and, as during the previous roundtable on social aspects held in March 2019, the same methodology was chosen given the level of effectiveness achieved. The **participatory approach** allowed for reflection and participation of all participants of the roundtable.

The event was structured as follows:

- **Presentation of the INTEGRATE project and its approach**

In order to introduce the project to the different participants, as well as to explain the development of the approach, a short presentation was given.

- **Roundtable methodology:**

Once the presentation was done, the activity was started. The working methodology consisted of placing the different attendees in pairs, each pair given one sheet of paper, with a specific question on environmental aspects applicable in IMTA. To answer each question a limited time (5-10 minutes) was given, after which the question was passed to the couple on the right and the question was taken from the couple on the left, and so on.

Image 1. Participants answering the questions

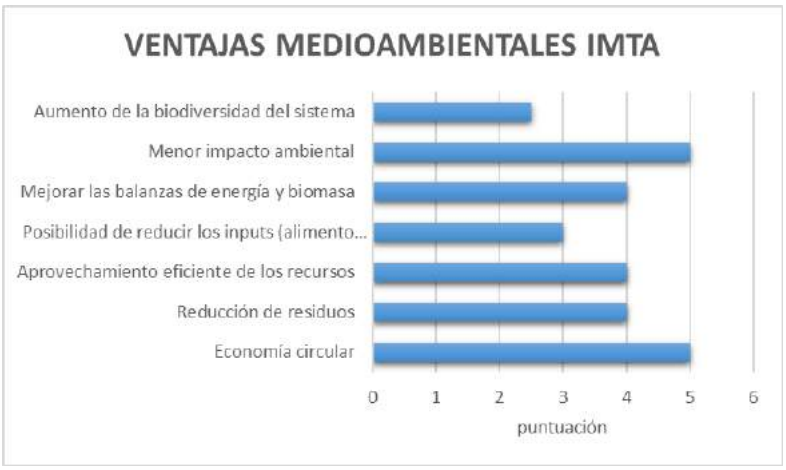
Subsequently, once all the questions were answered by all participants, they were pooled for discussion, grouping and assignment of points to the concepts. The contributions of those attending the workshop were collected and processed throughout its development.

QUESTIONS AND RESULTS

1. From an environmental point of view, what would be the main advantages or disadvantages of IMTA cultivation?

As the most relevant aspects of this first question, it was concluded that the main **advantages** from an environmental point of view of IMTA, from greater to lesser importance are:

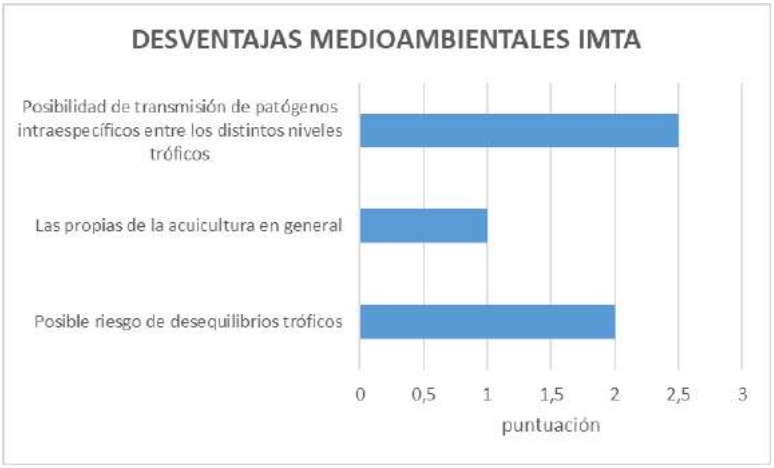
- **Circular economy and lower environmental impact (5 points)**
- Improvement of the energy and biomass balance, efficient use of resources and reduction of waste (4 points)
- Increased biodiversity of the system and potential to reduce external food and water inputs (3 points)



Graph 1a. Question 1 Results-Advantages of IMTA

Although their scores were very low, the following aspects were considered as possible main disadvantages of the implementation of IMTA, also of greater to lesser importance:

- Possibility of transmission of intraspecific pathogens between different trophic levels (2.5 points)
- Possibility of trophic imbalances (2 points)
- Those of aquaculture in general (1 point)



Graph 1b. Results of question 1-Disadvantages of IMTA

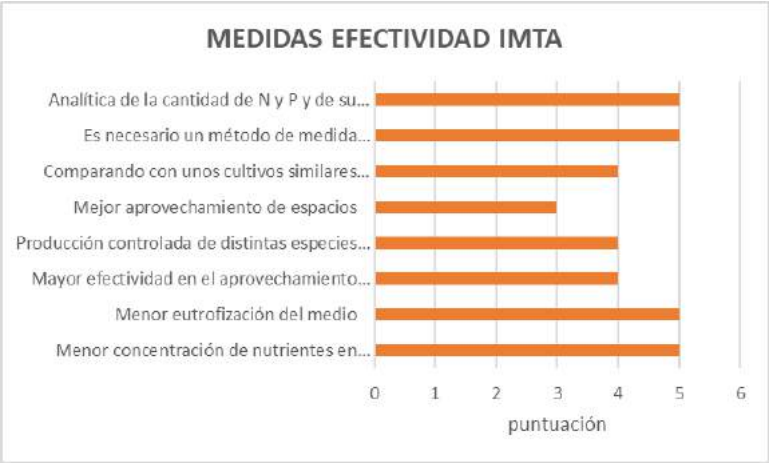
2. How would you justify or measure the effectiveness of IMTA cultivation?

As for the measurement or quantification of the effectiveness of IMTA cultivation, from highest to lowest value, the most relevant aspects were:

- Measurement and analysis of the amount of N and P and of their origin in the cultivated organisms of the different trophic levels, and, therefore, of the concentration of nutrients for demonstration of the lesser

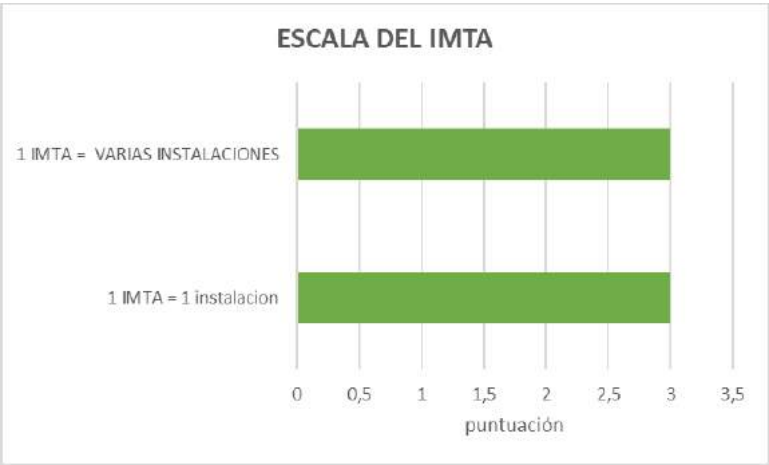
eutrophication of the medium. Such a measure should be carried out in a comprehensive manner, the implementation of one-off measures would not be sufficient (5 points).

- Greater effectiveness in the use of water, food and energy; controlled production of different species and trophic scales; and comparison with similar cultivation systems that are not part of IMTA (4 points).
- Better use of space (3 points).



Graph 2: Measures of the effectiveness of IMTA cultivation.

3. SCALE: From an environmental point of view, would IMTA be more effective when the same company or facility produces all trophic levels, or when several facilities provide the cultivation? Why?



Graph 3. Results of question 3.A: IMTA Scale

In this respect, it is considered that the scale of the cultivation, i.e. IMTA from a single facility or company dedicated to the cultivation of species of all trophic levels, or, in contrast, several facilities or companies

each dedicated to the production of a trophic level, would, in principle, have no influence on the effectiveness, as long as the design is appropriate.

4. SCALE: In the second case (different facilities), how would you justify or measure the benefits of IMTA?

In the case of grouping several facilities, the measure of effectiveness would be carried out *a priori*, similar to if it were the same facility that assumed the cultivation of all trophic levels.

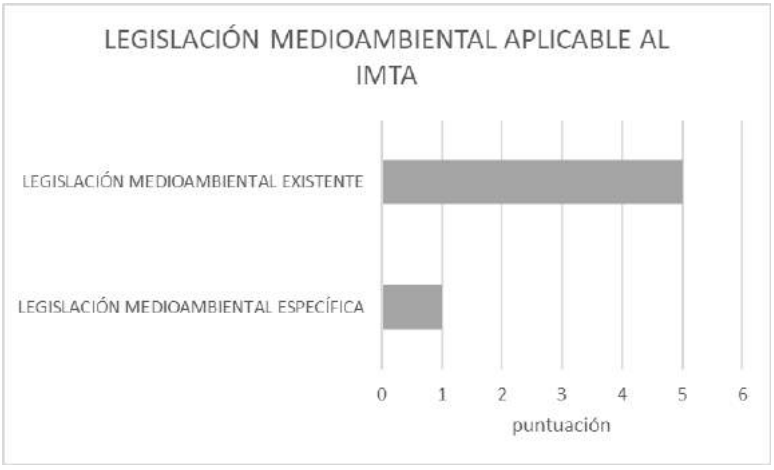
In this way, from greater to lesser importance, they would be:

- Disposal of waste from the installation or company 1, Less need for investment in the installation to take advantage of waste and the possibility of making it profitable in installation 2, Use of the same measurement tools (4 points).
- Existing companies do not need to be transformed into IMTA systems (3 points).
- Each company can better focus on one type of cultivation and specialize. It would be more efficient in its task, the distance of transfer conditions its profitability (2 points).

Graph 4. Results of question 3.B. IMTA Effectiveness in the case of several installations.

5. LEGISLATION: Would you develop specific environmental legislation for IMTA or incorporate it into existing legislation? Why? Advantages and disadvantages.

Finally, with regard to the appropriateness of developing a specific environmental legislation for this type of cultivation, it was almost unanimously concluded that it would be better to adapt it or incorporate it into the existing one.



Graph 5. Results of question 4: Application of environmental legislation to IMTA

This would facilitate and accelerate the regulatory process, since the development of a specific regulation for this type of aquaculture would be very complex.

CONCLUSIONS

It is indisputable that in the establishment and development of an economic activity in sensitive areas such as the sea or intertidal areas, as is the case with aquaculture activities, consideration must be given to the instinctive normative instruments which, from an environmental point of view, influence the area.

In this third and penultimate roundtable of the project, the interest and support to develop and promote this type of more sustainable cultivation has been demonstrated by the different environmental institutions with competence in these areas, in order to increase protection of the environment.

However, in order to demonstrate such sustainability, it is necessary above all to have greater control over the effectiveness of this type of cultivation, as well as better knowledge and demonstration of its potential benefits for the environment.

In order to achieve this, it would be necessary to further progress in the technical development of this type of aquaculture, which is still in its infancy in Spain. There is no evidence for the time being of facilities that perform this type of cultivation in a manner recognized as IMTA on an industrial scale.

In this regard, it is necessary to support this type of aquaculture and to encourage it from all possible levels, since there is great hope for aquaculture as a productive activity in Spain.

4.4 PORTUGAL

The workshop took place on January 17th at IPMA's Aquaculture Research Station in Olhão. The following questions were used to stimulate discussion:

What methods of analysis are used and/or should be used to evaluate IMTA? Trophic flow; pathogens and / or contaminant flows; LCAs and other evaluation methods?

Environmental: Definition of Best Practices

IMTA production in earthen ponds is an improved system comparatively to regular semi-intensive fish production.

On joint production of fish, filter feeders and macroalgae, phytoplankton not only increase DO and capture excess nutrients but also serves to feed filter feeders.

The presence of filter feeders is very important because they control microalgae density and particulate matter in the ponds allowing for a more constant level of DO and higher transparency.

There is better water quality in IMTA with filter feeders and higher savings in the energy costs for water aeration.

In IMTA systems involving filter feeders and where all organisms are confined together there are advantages to control macroalgae growth due to competition with phytoplankton for nutrients.

Environmental: Bottlenecks

Fish diseases are one of the reasons fish producers referred for not wanting seaweeds close to fish cages. Apparently, seaweeds can be a vehicle for fish parasites.

Environmental: Priority Areas for Development

Although the bibliography and the projects so far show that IMTA is a production process less impactful to the environment and subject to technical control, it is necessary to reinforce this attribute, demonstrating that it is one of the methods of "compliance" or significant contribution to the parameters of the DQEM - Marine Environment Quality Directive.

IMTA can be, to a greater or lesser extent, a contribution to the fulfilment of the requirements of the Marine Environment Directive. This is intuitive for those who work with the subject, but it will be necessary to demonstrate "decision makers", this is, the institutions that have to decide what should be supported and how, underlining the capacity of IMTA to supply protein while preserving the environment.

5 SOCIAL AND REGULATORY ROUNDTABLE SYNOPSIS BY COUNTRY

5.1 UK

Social & Regulatory: Definition of Best Practice

- It would be fair to say that for most of the participants, the social aspects of IMTA were of interest, but were not the main area of interest. Each respondent was aware that IMTA had to prove itself to the public at large, and prove its 'perception' in the greater eyes of the industry, but the first interest of the group in IMTA generally fell in the technical or economic sectors.
- An area that was brought up in previous sections came to the fore again – what are we doing IMTA for? Most of the group understood why IMTA appealed to the public and the greater perception, but again it was felt that the economic/environmental definition of IMTA was of more interest to parties than the social aspect, and that some of the social aspect was poorly defined. Again, it was noted that for a farmer to buy into IMTA, there needed to be both practical information as well as knowledge of potential reward, and both of these were lacking at the moment.
- It was noted that the IDREEM project had shown that the public perception, across Europe, of aquaculture, was more positive than had been expected. A lot of respondents to the surveys carried out by the project understood the trade-offs that were made environmentally by the aquaculture industry, but valued the economic and social benefits the industry brought. Again, it was felt by some participants that if we are already starting the discussion at this level, the work of IMTA will be made easier.
- Consultation and liaison – if IMTA takes off, it will lead to the first large scale increase in stocking densities for several years, and there will need to be specific education to the wider stakeholder community about IMTA and why the further development is happening – the good image of IMTA could be lost by a greater perception that it is merely new development by another name. Some parties, in particular local fishery groups, often automatically object to new aquaculture development as they do not wish to see any ground taken out of use for fishing. If development can be framed to demonstrate benefits – i.e. providing habitats for nursery grounds, this negative perception could be overturned.
- It was felt that issues around food safety will need to be examined in greater detail – a couple of the respondents during the process were negative about the overall concept of IMTA, due to the perception that IMTA was in essence 'feeding crap' and would dilute the image that Scottish shellfish has of being very 'clean'. It was felt that once consumers learnt more about IMTA, there might be a backlash, or negative publicity, when it is realised where the nutrient inputs are coming from. This is, of course, the essence of IMTA, but for a fickle consumer market, or a media outlet trying to spin a negative aquaculture story, it could set the development of IMTA back.

Social & Regulatory: Bottlenecks

- Again, similar issues came up that were noted in previous sessions. These included the planning framework for IMTA, and regulatory acceptance. It was felt that IMTA is currently looked on very favourably by the regulatory authorities, but is it a sustainable attitude in the longer term?
- Marketing of IMTA to the consumer – the development of a consumer base in each country that can differentiate the IMTA product is a key step, how do we educate people about IMTA? Where does this education tie into explaining what happens in the rest of the aquaculture industry? Does IMTA open a new 'can of worms' about the industry and its environmental effects?
- One of the areas that had been previously mentioned – definition, cropped up again. It was felt that for the industry to take IMTA on and work with it, closer definition of what IMTA meant was required. Ultimately this would work to enhance the product and protect the reputation of IMTA, while stopping any party using the phrase to try to increase their sales, even if the basic principles were not being met.
- Some asked which sector will lead the social development of IMTA? It was felt that the industry is better leading in the technical/environmental/economic areas, but leaving the social aspect purely to the academic sector was not ideal either. It was felt that trade bodies may have a large part to play in facilitating this development, but education will take both time and money, and a change in attitude from all involved within the industry.
- Tied into the above point, but noted again in the discussion was the disparity in the industry between shellfish/seaweed and finfish – In Scotland, more so than in other countries, there is very little practical crossover between the two sectors, and finding a way to match the economic scales, as well as the practical skills of the two industries is essential before any further development of social issues can occur.

Social & Regulatory: Priority Areas for Development

- Many of the ideas for further areas for development were similar to other sessions – it was, again, felt that one area of IMTA cannot be developed in isolation, but must be carried out in unison with other areas.
- Most of those spoken to felt that, of the sectors, the developmental needs of the social aspect of IMTA were the smallest, and that the priority for development lay with technical, economic and environmental.
- Further economic development of the IMTA model, under a series of scenarios, will provide producers with information they need should they wish to diversify and adapt.
- Further, and more in-depth, consumer studies could be carried out to determine the public attitude to IMTA and to examine the social and economic values

- What accreditation would IMTA aspire to? There could be developmental studies to examine which style of scheme could work best with which particular system, and which organisation would be best to administer it.
- Could IMTA herald some design changes to aquaculture facilities and sites? – if IMTA brings a greater footprint to aquaculture development, perhaps some time and effort can be expended in examining ways of blending infrastructure into the environment with greater sensitivity.

5.2 IRELAND

The workshop in Ireland was held on 8th February 2019. 22 attendees were present, (7 from academia, 7 from industry, and 8 from state agencies). The morning saw a number of talks and the presentations covered the following topics; IMTA Trends within Aquaculture; IMTA and Marine Development in the Gaeltacht; IDREEM project and IMTA social experiences; IMTA from a Licensing Perspective; and IMTA from a Marine Spatial Planning Perspective. The afternoon was dedicated to working groups and discussions. Groups of 7 - 8 participants discussed one of: the definition of best practices; bottlenecks; and priorities for development of best practices, before each group presented their synopsis to the larger group for overall comment and conclusions.




Social & Regulatory: Definition of Best-Practice?

In this working group participants were asked to consider what IMTA best practice should address. The answers are provided below, in no particular order but grouped according to similar themes.

In general:

A The public image of aquaculture should be addressed. Use and promotion of best-practices should help in this regard.

B IMTA assessment: what kind of enhancement can be achieved, outside of what is being produced? For example, can IMTA be used to enhanced local biodiversity? Or can its nutrient scrubbing characteristics be used in order to improve reception outside of the aquaculture industry? 'Social' best-practices should focus on these possibilities.

Within the aquaculture and/or marine community:

C Multi-stakeholder perspectives must be sought. Listening and problem solving between opponents should be facilitated.

D Community building – this relates to the need to transfer skills between the different aquaculture sectors i.e. between finfish and shellfish producers.

E Transparency; there is an attitude of secrecy within certain sectors of industry that needs to be addressed. People don't want to share data.

In the wider community:

F Interaction with 'non-aquaculture' people in order to counter the message of the anti-aquaculture lobby that tends to be very vocal.

G Exposure – increase the familiarity or decrease the strangeness of IMTA; related to F above, and to points 1 and 3 in the table below

H IMTA should facilitate creation of good quality employment.

Social & Regulatory: Bottlenecks & Priority Areas for Development

	BOTTLENECK	PRIORITY AREA
1	Lack of knowledge and interest from both aquaculture producers and from the public	Education opportunities – at school and from an early age; within the community Marine Institute programmes e.g. Explorers; strengthen and incorporate into existing curriculum
2	Poor image of finfish industry; could bring IMTA 'down' rather than pulling finfish 'up'	Move away from biogeochemical benefits towards physical biodiversity benefits e.g. niches for cleaner fish, to improve social acceptability. Accentuate the co-benefits and take an active rather than a reactive approach.
3	Abundance of misinformation by the vocal minority; Research showed that negative views of aquaculture were associated with higher levels of education.	Normalise the source; farm to fork approach. For example, RTE has a programme 'Neven Maguire's Irish Seafood Trails'. Utilising a format like this to promote producers using sustainable methods? This is also promoted through Bord Bia (the Irish Food Board). Or, something like the Tidy Towns analogy whereby there is a prize or grant made available to the best performers. Targeted research to bust the myths.
4	Lack of incentive to take up IMTA	Demonstrate the benefits of IMTA
5		Produce 'social best-practice' guidelines.

As a final point, participants were asked to suggest alternative names for IMTA, which is often criticised for sounding too technical. Suggestions were:

- Integrated Aquaculture: similar but simpler
- Circular Aquaculture: capitalising on the 'circular economy' paradigm which is becoming more widely known
- Optimum Aquaculture

It was stressed that the name should be kept simple.

5.3 FRANCE

This reports the French Workshop about IMTA Social best practices which has been organised by Agrocampus Ouest and CEVA. This event took place on the 14th NOVEMBER 2018 in Rennes (Brittany, France) and brought together 16 stakeholders involved in aquaculture in the French part of the Atlantic Area.

Pierre Eyrolles (Agrocampus-Ouest) presented the concept of IMTA to actors who were not familiar with it, the different objectives of the project INTEGRATE, and the actions relative to the workpackages. The context of the workshop, the main objectives of the day and the program were also presented before the launch of the first presentation.

Conflicts related to the implementation of aquaculture sites in France

Soizic SCHWARTZ (DPMA) presented a survey about the litigations in the creation of aquaculture sites for the last 10 years. 24 disputes in 10 years have been identified, 2 started during the public inquiry. According to the results, the litigation has no link with the importance of aquaculture in the region where it occurred. The amount of litigation appears to be very low compared to the total amount of aquaculture site creation. The main motives for litigation are:

Marine space competition and use conflicts (14)

The rejection of the demand for marine exploitation (AECM) (6)

The opponents to aquaculture projects are mainly environmental NGO's (7), municipality (6), residents/pleasure boaters/fishermen (5), shellfish farmers (2) and yachting professionals (1).

It appeared as very important to well define the litigation and the context of the survey.

One litigation might involve multiple cases and producers. Only litigations that lead to the courthouse are inlcuded.

The survey explored the proportion of litigation compared to the number of site creations. A site creation can refer to a demand for the cultivation of a new species, a reallocation of a concession, or creation of a concession in a location previously free of aquaculture activity.

Those previous points can lead to different conclusions:

The number of litigations is very low, but those cases are very dissuasive. It is difficult to estimate the number of projects abandoned before the litigation process.

The definition of a site creation has been discussed and considered as not very relevant. The proportion of projects that lead to a litigation might have been underestimated if we considered only the creation of aquaculture sites where there was no aquaculture activity.

The motives announced during the litigation might be different from the real arguments for the opposition to the project.

The discussion following the presentation first focused on regulation issues. Soizic SCHWARTZ presented a state of the art of the regulation in France regarding the environmental survey requirements. Since 2010 there is no explicit dispensation of environmental survey for aquaculture projects. Aquaculture systems can be assimilated to ZMEL (Zone de mouillages et équipements légers – Light equipment and anchorage

zones). To prevent litigation, consultation and environmental surveys must be applied through good practice guides written by technical or environmental public institutes. Marie FEUVRIER from the environmental NGO highlighted the lack of participatory process that might explain this opposition to aquaculture projects.

The consumption of aquaculture products in France, which place for IMTA products?

Jérôme LAFON (FranceAgrimer) presented general information about seafood consumption in France and focused on aquaculture products.

The main interests for seafood from the consumers' point of view are the taste and the health benefits, the price being perceived as the main barrier to consumption. The main criteria used to describe sustainable aquaculture are the CO_2 emissions (or the environmental impact) and the quality of the product. The social aspects (employment, relocation) are not perceived as essential. Shellfish farming and especially mussel farming benefit form a good image, unlike marine and land-based fish farming. It is important to notice that consumers really lack knowledge about the diversity of species offered by fisheries and aquaculture in France.

First results from a survey made by ITAVI and Via Aqua about Recirculated Aquaculture Systems (RAS) were also presented.

Producers and aquaculture professionals were first investigated on the way to promote products from RAS systems. The argument about the use of this technology cannot bring any added value to the product from their point of view. On the contrary, the environmental argument and the local aspects might be used as marketing tools.

Consumers were also investigated. Social aspects (economic performance of the company and employment) are not points of concerns. The RAS technology is not perceived as a threat but the consumers demand transparency toward this practice.

The first challenges to answer for IMTA products are:

Reaching the same quality as traditional aquaculture products;

Ensuring sanitary standards;

Promoting those products with eco-friendly arguments (CO_2 sequestration for example), in the case those products are not competitive enough.

Producers must pay attention to the fact that the degraded image of one species might deteriorate the image of a co-cultured species in an IMTA system. It is also important to communicate on the aquaculture practices and to organise production sites visits so the consumers can understand the process of production and trust the products and the producers

Commercialisation: Definition of Best Practices

- Determine how IMTA practices can be promoted:

The environmental benefits of IMTA practices could improve the image of the company, as the local production aspect. It could also be a way to discriminate those IMTA the products via marketing tools.

IMTA might be presented as a solution for the performance of aquaculture company

Polyculture with common interests between the different species

Innovative activity, complementary to existing aquaculture

- Creation of an eco-label:

It might be a way to promote those environmental benefits, but one must pay attention not to downgrade the other practices. IMTA must not replace other aquaculture practices.

- Determine the environmental benefits for the different systems:

Offshore and land-based systems present very different characteristics and advantages. The different species in these systems cannot be promoted for the same reasons as they do not play the same role in the system.

Commercialisation: Bottlenecks

- Lack of understanding or bad image of the IMTA practices:

The wording IMTA might be too complex, too scientific

Is it interesting to promote the IMTA practices or IMTA technology for offshore systems? To communicate on the fact that mussels feed on fish wastes?

The acceptance of new practices and new products can be very difficult. The lack of information about the meaning of IMTA and its practices might be confusing and generate mistrust.

The image of aquaculture is not always positive (ethics differences between fish, shellfish, algae farming).

- Quality standards:

Traceability and sanitarian safety must be guaranteed, as for standard aquaculture products.

The quality of the products must also be approved and should be eligible for general quality labels such as Label rouge for example.

- Difficulties to set-up a label:

The creation of a label focusing on environmental benefits of IMTA might be interesting, but in this case, for offshore farming, the environmental aspects can be promoted only for fish farming as no added value of IMTA for algae or shellfish can be highlighted.
Offshore and land-based practices have also different characteristics, and the environmental benefit must be studied before one can communicate on it.

- Technical aspects in relation with social issues

Insuring the local provenance of the farmed species
New skills needed for the employees
Increased prices of these products

Commercialisation: Priority areas for development

- Definition of IMTA (scale of the concession, company or bay):

With a definition of IMTA establishing the requirements of environmental benefits and their levels, it would be possible to guarantee environmentally friendly products through eco-labels with clear standards.
Define the added value of IMTA regarding environmental global challenges

- Demonstrate the environmental benefits of the different systems:

Clearly establish environmental benefits of the systems to communicate on it. Land-based and offshore systems might be promoted on different aspects.
Promotion of local production and sustainable practices, environmental benefits
Find a place for IMTA without downgrading traditional aquaculture

- Improve communication from the aquaculture sector:

Communication on the IMTA practices, visits of production sites, promotion of aquaculture products and improvement of their image (“natural”, “biomimetic”, “local”)
Set-up educational and training courses

- Define the targeted markets

Supermarkets, local, delicatessen, industry?
Food? Cosmetics?

Social & Regulatory: Definition of Best Practices

- Sustainability forward:

Better economic and environmental management

Environmental care (no GMO, limited inputs, cultivation of marine biodiversity)

IMTA might be a way to better manage the environment, the marine areas and the economy of aquaculture sectors

- Communication on the practices from the industry:

Communication from the professionals apart from implementation projects. Creation of communication and educational tools about aquaculture practices and not only products, with production sites visits

- Participatory process to build the IMTA projects:

The conception of an aquaculture activity based of the common interest. The IMTA activity must be integrated to the territory and to the activities already in place;

The co-construction of the projects might be undertaken by alternative structures such as local authorities or marine areas, perceived as more neutral than local fisheries and aquaculture administration or professional organization by several stakeholders;

Work on the representativeness of different stakeholders: shellfish farmers must be represented to the management committees of watersheds, but residents and environmental NGOs should also be represented to marine culture committees, to increase concertation.

- Regulations:

Revise texts or regulations to enhance and facilitate the implementation of innovative systems and allow new species for farming

Social & Regulatory: Bottlenecks

- Lack of knowledge:

Non acceptance of the technique by the producers

Lack of knowledge of the marine environment

Lack of visibility on the market of these products

- Regulation:

Inefficiency of texts like SMVM and marine space management tools

- Social acceptability:

Inefficiency of communication, consultation or participatory process in some cases.

Environmental survey? How to solve this challenge? How to make it approved?

Social & Regulatory: Priority areas for development

- Definition of IMTA

Clearly establish environmental benefits of such practices

- Promote the sector and the products:

Communication on the IMTA practices, visits of production sites, promotion of aquaculture products and improvement of their image

- Education, training, cooperation:

Skill improvement is required to develop IMTA. Aquaculture employees might be demanding for training

- Socio-economic studies to experience the profitability of such systems

Ensuring the profitability of IMTA systems might enhance its development, inciting producers to change their practices;

If IMTA products are not competitive enough, economic studies might give answers to know how to promote and add value to these products

5.4 SPAIN

The objective of this roundtable was to define the most relevant aspects of the social sphere that should be taken into account in order to facilitate the implementation of IMTA in Spain in a relevant way.

Methodology:

A group of participants was selected and invited under the criterion of representativeness, i.e. they had to come from different disciplines: industry, academia and public institutions.

The roundtable was held at Ctaqua's facilities and a methodology was chosen with a **participatory approach** that allowed the reflection and participation of all attendees of the roundtable.

The event was structured as follows:

Presentation of the INTEGRATE project and its approach

In order to introduce the project to the different participants, as well as to explain the development of the approach, a short presentation was given.

Presentation of the Project and the approach

Roundtable methodology:

Once the presentation was done, the activity was started. The approach of the work consisted in placing the different participants in pairs and giving each pair a sheet of paper with a specific question about social aspects applicable in IMTA. To answer each question a limited time (5-10 minutes) was given, after which the question was passed to the couple on the right and the question was taken from the couple on the left, and so on.

Participants answering the questions

To the participants connected via Skype, all the questions were sent by email and they responded to each of them individually, maintaining the time allocated to each question, so that they were synchronized with the colleagues in the room.

Five questions were posed and subsequently, when all the questions were answered by all participants, everyone came together for discussion and grouping of concepts.

Given that the response time devoted to each question was sometimes somewhat higher than planned and considering the large number of aspects generated for each of these questions, the decision was made to assess all concepts. This final evaluation would be done through an online form sent after the workshop (25/02/2019). To date not all participants have responded to the online form.

The methodology selected was very dynamic and participatory, and a lot of interesting information was obtained from it. Therefore, it would be used again in the next environmental and economic roundtables. However, as the duration of this was somewhat prolonged, the decision was taken to introduce as an improvement of the technique the limitation of responses to a maximum of 2-4 per couple, so that the assessment could be carried out within the duration of the event.

Results

The contributions of those attending the workshop were collected and processed immediately.

Joint discussion and assessment of the different responses

a) How can we treasure/capitalise IMTA benefits? (e.g. market acceptability, ecolabels/certification etc.)

As most aspects were more relevant to this first question, it was concluded that the best way in which the benefits of IMTA could be capitalized are the following:

- Corporate social responsibility
- Awareness raising through dissemination of the benefits of IMTA (training centres and universities, consumer information, campaigns from public administration, media including social networks)
- Marketing or "Communication" of benefits
- Generation of employment
- Reduction of environmental taxes and others
- Priority access to concessions and authorizations and/or the possible reduction of administrative procedures deadlines
- Priority in the processing of subsidies for specific support for this type of aquaculture practice
- Carbon sequestration and implications for the carbon market, although more studies are needed to measure this withdrawal
- Creation of an eco-label that differentiates IMTA from classical aquaculture

b) Point of view of the social aspects that should be taken into account for the definition of IMTA good practices (e.g. possible conflicts with other activities or other types of aquaculture in the area, etc.)

Although this was one of the questions asked, the decision was made to remove it from the assessment as it was considered very similar to number 4, where all the answers were included.

c) To what extent can legislation encourage or hinder the development of good practice in IMTA?

With regard to legislation, the following aspects were considered to encourage or hinder the development of good practices of IMTA in Spain:

Promotion:

- Aid through financing and compensatory aid or tax reductions

- Differential support or prioritization of aquaculture initiatives that follow IMTA principles as long as good practices are demonstrated and the associated objectives are met
- Prioritize it in all existing sectoral legislations
- Take the Andalusian model: in order to promote it in Decree 58/2017 of 18 April, which regulates marine aquaculture in Andalusia, this type of aquaculture is already contemplated (definition and specific zoning), as well as in the EMFF aid (European Maritime and Fisheries Fund).
- Delimiting areas suitable for cultivation integrated with other coastal practices according to the principles of Marine Spatial Planning
- Limiting pollution that reaches croplands - legislation associated with agricultural and livestock practices

Impediment:

- The lack of specific legislation opens up the option for interpretation, so this aspect is often in itself a major bureaucratic hurdle. To avoid it, the following conditions must apply:
- Progress must be made on the benefits of this type of system, which is still little known. Studies are needed to establish the benefits.
- Pilot actions should be carried out to identify technical measures to be implemented and to promote R&D.
- Special attention must be paid to health and environmental implications.
- Information should be provided in order to establish clear limits for contaminants in culture water and in cultured species.
- Limitations in order to avoid the introduction of alien or invasive species and their pathogens.

d) What should be taken into account when defining good practices in multi-trophic systems?

As for the definition of good social practices applicable in IMTA in Spain, the following aspects were considered:

- Integration with the landscape and the environment
- Generation of (quality) employment and improvement of workers' incomes
- Promotion of new economic activities and new uses
- Obtaining healthy, safe and quality products (organoleptic)
- Efficient response to local demand for the product in order to be less dependent on imports
- Favouring the improvement of the image of aquaculture products
- Activity open to society by means of visits, demonstrations, tastings, etc.
- Compatible or synergistic with other activities (tourism, gastronomy, crafts, etc.).

- Economically profitable
- Strictly controlled process both at the process level and at the level of the different cultivated species
- Adaptable and/or compatible with the diverse and extensive existing regulations (product quality, food safety, animal welfare, environmental management, sustainability, social responsibility).

e) Can good communication of the environmental benefits of IMTA lead to increased consumption of products derived from these methods?

Finally, regarding the effect of good communication of the sustainability of IMTA on the final consumer, the answers concluded that the aquaculture products produced through this method would generally be well received by the final consumer. The current market trend is being marked by a consumer who is increasingly aware and concerned about the environment, as well as the "naturalness" of the products he or she consumes and, therefore, demands more and more information about what he or she consumes. In addition, in many cases, this consumer is willing to pay a higher price for something that meets their expectations in terms of quality, safety, security and environmental sustainability.

However, real stakeholder involvement would be necessary to get the message across to the consumer (controlled and "safe" products, environmentally friendly products, etc.).

Although it is a costly and complex process, perhaps it would be advisable to design an ecolabel certification for this type of product or seek alliances with owners of certification schemes that already do this.

Participants of the social roundtable

Conclusions

Implementation and development of an economic activity such as aquaculture will have a series of direct and indirect implications on the marine and social environment, thus rendering it a costly and complex process.

During this roundtable, although it is true that the magnitude and scope that this type of aquaculture could have on society was shown, the most relevant aspects that could promote or hinder the correct development of IMTA in Spain have been detected, structured and defined.

In this sense, three clear pillars have been defined on which acceptance of IMTA would depend, such as legislation, which would require greater progress in technical and economic knowledge of this type of aquaculture, food safety and security, employment and acceptance by the end consumer.

To this end, although it is true that at a technical and economic profitability level the most logical form seems to be a priori a greater route of this relatively young practice, for the promotion of its consumption, as well as the assurance of an exhaustive control of the process, the use of new or already existing certification standards is presented as a good option.

However, in order to obtain more conclusive results, it is necessary to wait until the remaining roundtables (environmental and economic) have been held before an overarching comparison can be made.

According to the progress made to date in the framework of the project, for the specific case of Spain, Integrated Multi-Trophic Aquaculture is presented as a complex production method per se, which covers and intertwines such a variety of aspects to be taken into account (social, environmental, technical,

economic and regulatory), that it is necessary to first see it as a whole and then to be able to disentangle and regroup all the aspects or conclusions obtained from the different points of view of the different experts who have been, and will be, participating in these working groups.

5.5 PORTUGAL

The workshop took place on January 17th at IPMA's Aquaculture Research Station in Olhão. The following questions were used to stimulate discussion:

What methods of analysis are used and/or should be used to evaluate IMTA? Trophic flow; pathogens and / or contaminant flows; LCAs and other evaluation methods?

SOCIAL AND REGULATORY ASPECTS: Reduction of conflicts between the parties involved/improvement of the use of space in the coastal zone? What is the ideal licensing/regulatory environment? How to capitalize on the benefits of IMTA, (market acceptance, use of eco-labels / ecological standards?).

Twenty-three registered participants from academia, industry, and state institutions attended the workshops (Annex) that counted with a total of 11 oral presentations (4 on Environmental and 7 in Social and Regulatory Aspects) (translated agenda at the end of this document), followed by a free debate of each theme.

DISCUSSION

The concept of IMTA Production can hardly be defined by quantitative values of production, for example, using the concepts of intensive or extensive production (X kg of fish / m3 of water or m2 of surface)! It should be developed and explained as a contributing process for the Sustainability of the Aquatic Environment.

It is not enough to assert IMTA as less polluting, but above all as a **useful tool for the CIRCULAR ECONOMY**, capable of producing "Protein for direct / indirect human feeding through the recycling of by-products or organic waste, but also as a producer of living organisms important for the conservation of marine ecosystems (e.g. sea cucumbers, oysters (Japanese / Portuguese, or other species to be tested) for each "site" depending on the need for "reconstruction of the environment" and the trophic niche and / or service ecosystem that it performs.

At the same time, it is important to focus on "smart campaigns" to raise awareness about the quality of the product with a view to creating a "MARKET", but even more difficult, for the institutional / administrative "stakeholders" that license / authorize the activity (DGRM, IPMA, ICNF ...), demonstrating the advantages

of this productive method, both in environmental terms, but also as job creation and improvement of the quality of life of riverine communities - nurserymen and fishermen.

The reporting of information on any activity that depends on water for its support is crucial, so that in the global assessment of the various uses of the water body, all the factors that may affect its quality are present. Only knowing all the aspects that can affect the quality of water and their uses we will be able to promote a sustained and integrated use of water resources, thus benefiting all those who depend on it.

All this information will feed into the planning processes in order to better define general measures and guidelines appropriate to regional and local specificity. Promoting measures to make compatible the various uses safeguard the good state of water and its integrated use.

This guarantee is only possible through appropriate interaction between water users and the various entities involved in the licensing of activities and water resources management.

6 MAIN THEMES – CONDENSED RESULTS

The summary results of the 5 separate round-tables per topic are presented below, according to sub-topic and with details according to partner countries. This gives an overview of the commonalities and differences between each country.

TECHNICAL

BEST PRACTICE	Best practices are generally known for the component species but need to be developed for IMTA specific issues – definition of degree of separation/consideration of pathogen and contaminant transfer/definition of degree of trophic integration	UK, P
	What degree of trophic differentiation between species is appropriate i.e. when does polyculture become IMTA?	F, IE
	What constitutes 'the same system', with regard to nutrient flows?	F, UK, IE
	What are the 'correct' relative production volumes?	F, SP, P
	Local strains of component species should be used	F, UK, IE
	Attention should be given to the complementarity of resources e.g. phytoplankton versus macroalgae	F
	Attention should be given to the complementarity of space, both vertical and horizontal	F
	Attention should be given to the complementarity of season between organisms in the system	F, P
	Design of flows must be suited to operation control systems	SP, P
BOTTLENECKS	Lack of technical knowledge, skills and tools	F, UK, IE, SP, P
	Lack of technology transfer from research to industry	
	Lack of experience hampers up-scaling	
	Lack of hatcheries/seed stock for IMTA species, particularly benthic/invertebrate component	UK, IE
	Difficulty in managing several species; the focus is invariably on the primary species	F, IE
	Interactions between species with regard to e.g. nutrient flows, pathogens and medicines is not yet understood or quantified	F, IE, UK, P
	Mismatch in scale of various industries as they are currently practiced	UK
PRIORITY AREAS	Technology transfer/travelling roadshow	IE
	Production experience and practical trials	UK
	Development of new species	F, UK, IE
	Design of IMTA management and control systems	SP, P
	Quantification of interactions (nutrient, pathogen, medicine etc.)	F, SP, IE, P
	Knowledge of appropriate separation distances and relative spatial requirements	UK, IE
	Larger installations; scale; critical mass	UK, IE, P

ECONOMIC

BEST PRACTICE	There needs to be a solid financial base irrespective of potential subsidies. A definition of economic best-practice is not necessary – economic viability equates to best practice	UK, IE
	Technical and environmental aspects will determine economic success	UK
	Use IMTA as a means to bring new species to market	UK
	Internalised positive and negative externalities should be factored into business plans	F, P
	IMTA sector development should not destabilise traditional monoculture practices	FR, UK, IE
	IMTA should be developed alongside and in accordance with regional / local development	FR
	Strategic solutions to energy consumption should be sought	P
	Species with an already determined commercial value should initially be chosen	P
	IMTA products should be well differentiated	FR
BOTTLENECKS	Access to funding; this is needed to overcome the industry mismatch in scales (UK, IE) and/or to mitigate the prohibitive cost of adding infrastructure (IE); to develop necessary species and to prove/improve the concept. The industry should be developed in a slow, 'organic' fashion	UK, IE
	IMTA currently involves too much financial uncertainty. There is a lack of available models and/or business plans from which to project/assess economic risks and possibilities	UK, IE, FR, SP
	Currently there is no definition or eco-label for IMTA products leading to an 'unprotected brand' and difficulty differentiating	UK
	Lack of quantification of and ways to valorise ecosystem services. Is the cost of IMTA offset by social and environmental services provided? Who will pay for these?	FR, IE
	There is a lack of developed markets for secondary species	IE, SP
	IMTA can involve high production costs and variable productivity	P
PRIORITY AREAS	Development of capitalisation ecosystem services along with definition of indicators to asses ecosystem services	UK, IE, FR, SP, P
	Development of financial models/demonstrate viable IMTA economics and profitability/capitalise the lowered risk of IMTA*	UK, FR, SP
	Creation of an eco-label	IE, SP, P
	Efforts to commercialise research/diversify products and search for markets/invest in marketing	IE, SP, P
	Support collective experimentation and effort/develop aquaculture condominiums & parks/create seaweed representation groups	IE, FR, P
	Integrate IMTA into territorial development projects including planning and regulation/develop local markets	FR, SP
	Use IMTA to overcome the poor image of aquaculture	UK

* Note that, to date, lowered risk has not been sufficiently demonstrated across a broad suite of IMTA systems.

ENVIRONMENTAL

BEST PRACTICE	Not enough experience to define best-practices yet; need to follow current monoculture best-practices and develop from there	UK, IE, FR
	To assess B-P's there is a need for baseline data; homogenised and normalised methods for the environmental evaluation and continuous monitoring	IE, FR
	Core components:	
	• Local scale; better to encourage local diversity and the development and 'bringing on' of suitable local species for each location and market type	UK, FR
	• Biodiversity enhancement	IE, SP
	• Should refer to the circular economy	FR, IE, SP
	• Focus on productivity of lower trophic levels	IE
	• Should take into account benthic impact	IE
BOTTLENECKS	Information is needed about appropriate co-cultivation distances	UK
	Lack of opportunity for IMTA practical experience; cross-training between aquaculture sectors is needed. Currently the high level of environmental standards in monoculture reflect a skilled workforce and long-standing experience.	UK
	Monitoring is expensive	FR
	There is a lack of full accounting knowledge e.g. LCA's; lack of quantification of externalities	UK, IE, FR, SP, P
	Lack of understanding of the effects (relative to monoculture) on ecosystem services	
	We don't have mechanisms to capitalise the benefits of IMTA	
PRIORITY AREAS	Better and cheaper ways to model nutrient dynamics; update existing models like FARM	UK
	Inclusion/prioritisation of environmental issues during aquaculture training	FR
	Production of a set of standards regarding resource use, biodiversity effects and record keeping	
	Research trophic interactions between wild and cultivated organisms	FR, SP
	More trial systems – for training, experience, and monitoring the environmental effects of co-cultivation	IE, P
	Production of guidelines for the siting distances of new developments	
	Research disease reservoir/vector potential of organisms in proximity	UK, IE, SP, P

SOCIAL

BEST PRACTICE	Social aspects are not the prime interest of the industry; technical and economic aspects are more interesting. IDREEM demonstrated a more positive public image of aquaculture than expected	UK
	IMTA must not negatively impact traditional monoculture practices and or business models	FR
	IMTA should be developed with a sensitivity to the locality and activities already in place; IMTA should foster local demand for local products	FR, SP
	BP's should refer to corporate social responsibility	SP
	IMTA should generate quality employment opportunities	SP
	IMTA should generate healthy, safe and quality products	SP
	IMTA (planning and regulatory process) should aim to reduce conflict between marine stakeholders and take into account multiple perspectives	P, IE
	BP's should refer to principles of the circular economy and its positive social implications	P
	Regulation of IMTA should be straightforward and simple	P
BOTTLENECKS	Practical information about and a 'reward' for practicing IMTA is fundamental and missing. There is a lack of interest in IMTA within the public and the aquaculture sectors (IE)	UK, IE
	Food safety issues and the negative perception of where the nutrients are coming from in IMTA systems	UK, FR
	Lace of crossover between aquaculture sectors hinders transfer of technology	UK, FR
	The acronym IMTA is too technical and complex	FR
	Non-acceptance of techniques by producers	FR
	Lack of visibility of products	FR
	Inefficiency of regulatory texts and marine spatial management tools	FR
	Lack of communication and participatory process between the aquaculture and other marine stakeholders	FR
	The poor image of finfish aquaculture may negatively affect the image of IMTA. There is a great deal of misinformation surrounding aquaculture.	IE
PRIORITY AREAS	Biodiversity benefits to local fisheries (and other environmental benefits) should be quantified and capitalised	UK, FR, IE
	Further and more in-depth studies are needed to examine the social and economic values	UK, FR, IE
	IMTA product differentiation, capitalisation and education of consumers is necessary; a definition would be helpful	UK, FR, SP
	Research into mitigation of the visual/landscape impact of IMTA farms that will have a larger footprint than traditional monoculture farms	UK, SP
	Traceability and food safety guarantees need to be implemented	FR
	Co-operation and co-construction of projects led by a neutral agency. Representation of 1 sector to another.	FR, SP, IE
	Development of schemes to reduce taxes, give priority access to concessions and a priority in access to subsidies*	SP
	Education; within schools and also within the wider community. Familiarisation with IMTA is fundamental	IE

* Note that this point could be in contrast to the second point in the social best-practices section that suggests IMTA should not impact traditional monocultural practices

7 CONCLUSIONS

Technical: The first INTEGRATE workshops confirmed the rising interest for IMTA from the aquaculture stakeholders in each of the five countries. An enthusiastic participation and efficient contribution was noted for each of the five expert groups. First of all, a clear common definition of IMTA systems is needed and it appears difficult to run discussions focusing on technical aspects without considering economics, environmental, social and regulatory contexts. However, a deep technical analysis of IMTA best practices was reached by each group.

The technical best practices of IMTA were mainly associated with 1/ the cultivation of local species (i.e. species with related abiotic needs and tolerance), 2/ the combination of existing and adapted cultivation methods rather than the development of new technologies/systems and 3/ the importance of guaranteeing an optimal nutrient flow between compartments. These three points induce that an IMTA structure will be a combination of skills, knowledge and tools that have previously been separately developed.

In general, it was felt that there was a substantial lack of technical expertise (especially for at-sea systems), with regard to both production of species for all IMTA components, and knowledge of their interactions. This hampered the ability to define best-practice and was the major bottleneck to development of IMTA. Contained within 'technical expertise' are many distinct factors, as detailed in the table. As anticipated, the bottlenecks and priority areas for development are mirror images of each other.

To conclude, these five workshops about the technical approach of IMTA showed that instead of different perceptions of IMTA related to differing aquaculture histories, the AA countries: 1/ are looking for a better transfer from basic/applied research and producers, and 2/ are waiting for a common step-by-step improvement of scientific and technical knowledge of the cultivated species and combinations of different cultivation methods.

Environmental: The key environmental driver of IMTA is more efficient resource utilisation, with regard to nitrogen, carbon and phosphorus in particular. But there is a risk that IMTA engineers natural systems at the cost of those same natural systems – much greater knowledge is needed of pre-existing baselines, what to monitor, how to monitor and 'scales of assessment', along with greater understanding of IMTA-host ecosystem interactions, such as trophic competition between wild and cultivated organisms. We need to create homogenised and normalised methods for evaluation of IMTA and its continued monitoring, but in a way and at a cost that is not prohibitive. Creation of a set of IMTA standards, regarding resource use, biodiversity, record keeping etc. would be a good starting point but there is a large amount of work to do here. In general, land-based systems are much easier to define, quantify and monitor as they are closed or semi-closed, and it was felt that basing models on these systems, as a first pass, was a good way to proceed.

Qualification and quantification of the ecosystem services different IMTA operations provide is key, such as biodiversity enhancement and other services such as sequestration, habitat provision, shoreline protection. Also necessary is full accounting using cradle-to-grave/global metrics that incorporate several criteria to give an idea of how IMTA is doing in regard to different aspects of sustainability. However, again we are up against the current dearth of data. To illustrate the point, to date, there is only one, peer-reviewed IMTA life cycle assessment (LCA) (Beltran et al. 2018*).

Economic: In this case there was quite a lot of consistency between countries, which indicates that while the systems and species of aquaculture vary between country and region, the financial challenges faced in establishing and managing IMTA operations are more ubiquitous.

In the first place it was considered that defining economic best-practices was rather an academic (unnecessary?) exercise, as to some (a large) extent the market itself will determine in what way IMTA will be able to be implemented. It cannot be implemented without a solid financial base in the first place; this should be at the heart of IMTA thought and design and is dependent on other aspects, predominantly technical, social and regulatory ones. This highlights the fundamental mismatch alluded to in the introduction; that the environmental problem IMTA can help solve or avoid, does not yet have any direct positive effect in promoting its establishment. Which leads us to consider the valorisation of externalities.

One of the great potential benefits of IMTA is that it takes account of its own waste. While theoretically this results in greater system productivity and therefore greater profitability, this has not been sufficiently demonstrated at a scale that encourages producers to invest in, or convert to, IMTA systems. Time and again, the potential solution of valuing externalities (i.e. polluter pays principle) is raised. This seems obvious and sensible, but how should it be done? How should the costs be recognised and incorporated to become increased profit? Most often this is discussed in the context of ecosystem services; and we are returned to the fact that these have not been valued yet, and there are limited mechanisms for their trade. Another model is the 'Danish system' whereby finfish production can only be increased if measures for nutrient reduction are put in place. It is perhaps more straightforward to implement something like this but requires legislative intervention. Other administrative mechanisms to favour IMTA were posited such as reduction of taxes, priority access to concessions and priority in subsidies however it should also be noted that it may be contentious to favour one form of aquaculture (IMTA) over others.

Markets are under-developed for potential secondary species. There is an opportunity to capitalise on the potential niche image of IMTA but this will require some effort at product differentiation. This could be

* Beltran AM., Chiantore M., Pecorino D., Corner RA., Ferreira JG., Cò R., Fanciulli L., Guinée JB. (2018) Accounting for inventory data and methodological choice iuncertainty in a comparative life cycle assessment: the case of integrated multi-trophic aquaculture in an offshore Mediterranean enterprise. The International Journal of Life Cycle Assessment 23, (5), 1063-1077.

achieved via a specific IMTA eco-label, co-ordinated with consumer education activities that will facilitate educated consumer choice. The special potential for development of local markets was also highlighted, in keeping with the high-quality, sustainable product image.

While product diversification is often cited as reducing risk, it also comes at the price of adding complexity and investment costs, and therefore arguably increasing risk. There was some discussion around how it might be possible to monetise the hypothesised decreased risk through lowered insurance premiums, however it is highly likely that we do not have sufficient data yet to convince insurers that IMTA production is a sufficiently reliable reduction of risk. Furthermore, financial models and the ability to risk assess IMTA operations are lacking which does not give potentially interested producers a mechanism for assessing investment. This comes back to a lack of data again; without further investment in scaled research and commercialisation trials, the data necessary to produce meaningful figures will not be available.

Social and Regulatory: Again, it was asked 'what problem is IMTA trying to solve?'. It was felt not primarily a social one, except as expounded by its promoters, but this is not the prime interest of the industry! Technical and economic problems attract more interest. The oft cited leverage of attaining good public perception was not such a strong motivator for producers (although it was mentioned more in the economic workshops). IDREEM demonstrated that public perception was better than had been thought, and opposition is often down to a very vocal minority which is less likely to be persuaded by communication about the benefits of aquaculture/IMTA in any case.

It was discussed that IMTA should be sensitive to territory and the activities already in place within an area. It is important that a place for IMTA is found that does not do any harm to more traditional aquaculture practices. Fostering local demand for local products was thought to be appropriate to the image of IMTA, and a potential way to develop markets. Likewise, IMTA design should integrate within the landscape and environment, which is consistent with the environmental best-practices mentioned above.

When considering who should lead the social development of IMTA it was felt that trade bodies are best placed to do so. Developing synergisms and cooperation between IMTA and other aquaculture stakeholders could lead to co-construction of projects, which would get over the difficulty of sector-specific knowledge. This could be led by a neutral agency to avoid entrenchment of any pre-existing conflicts, should they exist. Representation of one sector to another, and development of opportunities for training across different sectors will also be important. In achieving this, education of producers, consumers and regulators alike will be important due to a lack of specific knowledge about IMTA and/or knowledge of the marine environment in general. In this, projects such as IDREEM and INTEGRATE are making good headway.

As a final point, IMTA was deemed too 'technical' a term for ease of communication. It should be developed and explained as a contributing process for the sustainability of the aquatic environment.

In conclusion, it can be seen that there is much consistency between topics in terms of both problems and potential solutions, and that the most important jobs to do in the first place are to keep generating commercially relevant data, and to progress the market possibilities for IMTA products through various means, including development of the IMTA 'brand' via an IMTA definition and an eco-label. A fitting end to this report comes with the words of our Portuguese partners; "It is not enough to assert IMTA as less polluting, but above all as a useful tool for the circular economy, capable of producing protein for direct/indirect human food through the recycling of by-products or organic waste, but also a producer of living organisms that can be helpful for marine conservation depending on the trophic niche they occupy and/or ecosystem services that they perform".

Acknowledgements: The INTEGRATE partnership is very grateful to all those who attended the roundtables, and for the valuable contributions and input to the discussions that have allowed us to gain a detailed view of IMTA in the AA, and the benefits to and challenges of developing this sector.

www.integrate-imta.eu

JOIN US ON

Twitter: @INTEGRATE_IMTA

Authors (alphabetical): Brunner L., Cunha, EM., Dove C., Dunbar, MB., Eyrolles P., Ferreira H., Hughes A., Jacquemin B., Laguerre H., Le Bris H., Lesueur M., Luthringer R., Malta E., Partida B., Perreira R., Ratcliff J., Soler A.

WP4 Coordinators: Jessica Ratcliff and Bertrand Jacquemin

Date: 6/12/2019