AQUASPACE

Ecosystem Approach to making Space for Aquaculture

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Acronyms

AA	Appropriate Assessment (EU Habitats Directive, Article 6)
AC	Autonomous Communities (ES)
AIDP	Aquaculture Industry Development Plan (Australia)
AIZ	Aquaculture Interest Zones (ES)
AFBI	Agri-Food and Bioscience Institute (Northern Ireland)
AMA	Aquaculture Management Areas (FAO)
APA	Aquaculture Production Areas (PT)
AZA	Allocated Zones for Aquaculture (IT)
CCRF	Code of Conduct for Responsible Fisheries (UN FAO)
CFP	Common Fisheries Policy (EU)
CMO	Common Market Organisation (EU)
COM	Communication (EC)
DAERA	Department of Agriculture, Environment, and Rural Affairs (Northern Ireland)
DAFM	Department of Agriculture, Food and the Marine (IE)
DFO	Department of Fisheries and Oceans, Canada
Defra	Department for Environment, Food and Rural Affairs (UK)
DEM	Digital Elevation Model
DG MARE	Directorate General for Fisheries and Maritime Affairs (EC)
DGRM	Directorate General of Natural Resources, Safety and Maritime Services (PT)

DHPCLG	Department of Housing, Planning, Community and Local Government (IE)
DMA	Disease Management Areas
DPSIR	Drivers – Pressures – States – Impacts – Responses
DSBM	Sea Basin Strategy Documents (*documents stratégiques de bassins maritimes*) (FR)
DSF	Maritime Front Strategy documents (*documents stratégiques de façades*) (FR)
DSR	Drivers – Stressors – Responses
EAA	Ecosystem Approach to Aquaculture (UN FAO)
EC	European Commission
EEZ	Exclusive Economic Zone (UN)
EIA	Environmental Impact Assessment
EMFF	European Maritime and Fisheries Fund (EU)
EPBC	Environment Protection and Biodiversity Conservation Act 1999 (Australia)
EPCHSAAF	Special Framework for Spatial Planning and Sustainable Development for Aquaculture (Greece)
ETF	Enablers Task Force (IE)
EU	European Union
EUMOFA	European Market Observatory for Fisheries and Aquaculture (EU)
FAO	Food and Agriculture Organization (UN)
FCILC	Foyle, Carlingford and Irish Lights Commission (Island of Ireland)
FIGIS	Fisheries Global Information System (UN FAO)
FMA	Farm Management Areas
GEcS	Good Ecological Status (EU WFD)
GES	Good Environmental Status (EU MSFD)
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GIS	Geographical Information Systems
GMO	Genetically Modified Organisms
ha	Hectare
HAB	Harmful Algae Bloom
IC(Z)M	Integrated Coastal (Zone) Management
IM	Integrated Management (Canada)
IMP	Integrated Maritime Policy (EU)
IMTA	Integrated Multi-Trophic Aquaculture
LBOGEM	Basic Law on Planning and Management of the National Maritime Space (*Lei de Bases do ordenamento e Gestão do Espaço Marítimo Nacional*) (PT)
LOMA	Large Ocean Management Areas (Canada)
M	Nautical Mile
MAGRAMA	Ministerio de Agricultura, Alimentación y Medio Ambiente (ES)
MCAA	Marine and Coastal Access Act 2009 (UK)
MFZ	Marine Functional Zoning (China)
MHW(M)	Mean High Water (Mark)
MiPAAF	Ministero delle Politiche Agricole Alimentari e Forestali (IT)
MLW(M)	Mean Low Water (Mark)
MMO	Marine Management Organisation (UK)
MEPA	Malta Environment and Planning Authority (Malta)
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MPS	Marine Policy Statement (UK)

MS	Member States (EU)
MSFD	Marine Strategy Framework Directive (EU)
MS-LOT	Marine Scotland-Licensing Operations Team (Scotland)
MSP	Maritime Spatial Planning
NGO	Non-Governmental Organisation
NI	Northern Ireland
NIMBY	Not In My Back Yard
NMP	National Marine Plan (Scotland)
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf (USA only)
OECD	Organisation for Economic Co-operation and Development
PCB	Polychlorinated Biphenyls
POEM	Maritime Space Plan (*Plano de Ordenamento do Espaço Maritimo*) (PT)
POM	Programme of Measures (EU MSFD)
PPA	Project Profile Analysis (Australia)
RAS	Re-circulating Aquaculture Systems
RBMP	River Basin Management Plans (EU WFD)
RFMO	Regional Fisheries Management Organisation
RPB	Regional Planning Bodies (USA)
SAC	Special Area of Conservation (EU)
SEA	Strategic Environmental Assessment
SME	Small and Medium Enterprises
SNML	Sea and Coastline Strategy Framework (*Stratégie Nationale pour la Mer et le Littoral*) (FR)
SPA	Special Protection Area (EU)
STECF	Scientific, Technical and Economic Committee for Fisheries (EU)
SwAM	Swedish Agency for Marine and Water Management
SWD	Staff Working Document (EC)
SWOT	Strengths – Weaknesses – Opportunities – Threats
UCC	University College Cork (IE)
UK	United Kingdom
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea (UN)
WATER	Where Aquaculture can Thrive in Europe (App)
WFD	Water Framework Directive (EU)
WG	Working Group
WNMP	Welsh National Marine Plan (Wales)
ZICU	Zones of Informal Concentration of (aquaculture) Units (Greece)
ZODA	Zones of Organised Development of Aquaculture Farms (Greece)

Executive Summary

Spatial planning for aquaculture is receiving increased attention globally, due to the need to optimise the use of space in the context of other uses—the aim is to increase global production of aquatic products, while maintaining environmental sustainability. The European Union is particularly concerned with food security, given that 71% of the fish consumed in the EU are imported.

The central goal of the *AquaSpace* project is to optimise and increase the area available for aquaculture, in both marine and freshwater environments, by adopting the Ecosystem Approach to Aquaculture (EAA), and spatial planning for aquaculture in the wider context of the Maritime Spatial Planning (MSP), Water Framework Directive (WFD), and Marine Strategy Framework Directive (MSFD) and other policy mechanisms. The core objectives of *AquaSpace* are to (i) support increased production; (ii) provide employment opportunities; and (iii) promote economic growth of the aquaculture sector.

This policy review assesses current approaches to spatial planning for aquaculture in Europe, along with Norway, the United States of America, Canada, China, and Australia, leveraging the *AquaSpace* partnership and the *Galway Statement*. The review covers both marine and freshwater environments, which benefit through integration because (i) more useful information is provided to policy-makers and managers through the analysis of countries as a whole; and (ii) there is a mutual learning process resulting from the comparison of the two environments.

Historic production and planning for the future

An analysis of aquaculture production in the EU since 2000, based on FAO Fisheries Information system (FIGIS), shows that aquaculture production in the EU has fallen by approximately 8% since 2000, from 1.4 million tonnes in 2000, to 1.28 million tonnes in 2013. The fall results from significant drops in three of the top five major producing countries (France, Italy, Spain). The United Kingdom and Greece are notable exceptions and have increased production of salmon (UK), and seabass and sea bream (Greece). Smaller producer Member States have generally increased production, but not sufficiently to offset the fall in production in France, Italy, and Spain.

Over the same period, production in Norway has increased by 154%, Canada by 27%, China by 100%, and Australia by 140%. The US situation is comparable to the EU. The annual growth rate between 2000 and 2013 in those countries (excluding the USA) ranged from 2.7% to 7.6%, compared to the average annual decrease of 0.8% in the EU28.

There has been some diversification, with an increase in the number of species being cultivated. The main species continue to be Mediterranean mussel (*Mytilus galloprovincialis*), Rainbow trout (*Oncorhynchus mykiss*), blue mussel (*Mytilus edulis*), Atlantic salmon (*Salmo salar*) and Pacific cupped oyster (*Crassostrea gigas*), accounting for more than three-quarters of all production.

The aquaculture guidelines produced by the European Commission (EC, 2013a) identified the need to increase aquaculture across Europe, and considered development of spatial planning for aquaculture as a key enabler of that activity. Following these guidelines, EU countries produced multi-annual aquaculture plans and the EC produced a summary document outlining the key components (EC, 2016a). All EU Member States have set targets to increase aquaculture production, with variable target dates—production is *projected* to increase to approximately 1.76 million tonnes by 2025, representing an annual growth rate of 2.7%.

In the context of spatial planning, most EU Member States highlight the need to improve spatial planning for aquaculture, and some propose how this might be achieved, e.g. through better mapping,

use of technologies such as GIS, and undertaking studies to identify potential new areas. Few (if any) countries commit to increasing the amount of space allocated to aquaculture in any definitive way.

Government, Industry, and Researcher views on aquaculture

The *AquaSpace* project used a questionnaire and workshop as a paired approach to investigate government, industry, and researcher views on increased use of space for aquaculture, and barriers and solutions to aquaculture development in the EU. The EAA is viewed as the main instrument for framing aquaculture planning; there is compatibility between the current approaches of the EU and the more global approaches advocated by EAA through the Food and Agriculture Organization (FAO), but there remains a significant amount to do in terms of implementation.

Most EU Member States have a pre-existing legal framework for aquaculture planning but implementation of this varies: this has substantial consequences for growth of the industry, particularly with respect to licensing, which is seen as rigid and inflexible, time-consuming and expensive, and within that context limits the increased use of space. Aquaculture zoning is the most applied spatial planning approach in the countries represented at the *AquaSpace* workshop. Experiences with this approach should therefore inform the development of Maritime Spatial Plans and locally-relevant coastal plans under national legislation or equivalent measures. The workshop also found there is a general lack of incentives to foster the implementation of aquaculture planning, at national and local levels, and that this needs to be addressed—application of the EAA may be one way to achieve this.

Maritime Spatial Planning

Analysis showed that MSP should be complementary to the EAA as it reflects many of the same key principles: integrated, adaptive, participatory, and coordinated. The MSP Directive applies to marine waters of EU Member States but not to coastal waters, which come under the WFD, so immediate development of MSP, including aquaculture, may be a future requirement if production moves offshore, once technical challenges are resolved.

However, under the provisions of the MSP Directive, maritime spatial plans must 'take account of' land-sea interactions and the particularities of their marine regions as well as the impacts of existing and future activities and uses on the environment. The way in which MSP will be implemented at EU Member State level, and particularly at local level, is therefore critical, along with the governance structures in place, and how different sectors and stakeholders are involved in plan development. Portugal appears to be a country advanced in MSP preparation, and has explicit conflict resolutions mechanisms built into its MSP process, which could be a learning opportunity for other EU Member States.

Scale is an issue for MSP implementation, as the Directive foresees regional level implementation and coordination, whereas aquaculture often requires sectoral and site level implementation based on an overall strategic plan. Given most EU Member States are currently implementing MSP, it is critical that aquaculture is seen as a co-partner in the overall governance structure, and failure to include aquaculture does not hinder its effectiveness. International examples show that there is no overarching maritime spatial planning being undertaken, but where it is practised, it is driven by environmental protection and not economic growth. Spatial planning in the EU needs to consider both—not one at the expense of the other.

Freshwater spatial planning

At EU level, there is no commonly agreed definition of land-based spatial planning, and it is not an EU competence, residing instead under national jurisdictions. Consequently, implementation for

aquaculture varies nationally. There is, however, a need to ensure marine-based and land-based systems are complementary, especially where land-based planning affects coasts.

Freshwater aquaculture is governed by national legislation more comprehensively than by the EU, but certain EU legal instruments, including EIA, the WFD, and the Birds and Habitats Directives, will have implications for the sector in terms of drainage water that impacts upon the achievement of good ecological status, for example. Aquaculture policy tends to cover all forms of aquaculture and may not be wholly reflective of the needs of the freshwater sector.

Spatial planning for freshwater production, particularly pond production, appears to be a secondary issue, given most Eastern EU Member States do not see increased use of space as growth approach. Targeted objectives and measures for areas of aquaculture production need to be fully integrated into the second round of WFD River Basin Management Plans (RBMPs), however, so that the possible impacts of the sector and its future requirements can be considered in the context of the whole river basin.

EU Policies affecting spatial planning

Several EU laws and policies have relevance to the spatial planning and management of aquaculture. In terms of legislation, the principal instruments are the Birds and Habitats Directives, the WFD, and the MSFD. The Common Fisheries Policy, though referred to as a policy in EU terms, has a strong legal basis and has many implications for the spatial planning and management of aquaculture, such as the prevention and management of the introduction and spread of invasive alien species, though the latter is not related to spatial management *per se.* Guidance from the EU is available on the interaction of various pieces of legislation with aquaculture, but often this is too vague to have practical effects.

There need to be workable and visible mechanisms to link high level environmental objectives with area and site-level operation, i.e. a joined-up approach that covers MSFD and WFD GES with EIA findings and licensing of farms. These mechanisms, if they exist, are not currently obvious.

Application of the WFD and/or MSFD are not incompatible with aquaculture production and should therefore be a positive development for the aquaculture industry, in terms of improved water quality status, for example. Different types of aquaculture need to be reflected, distinguishing between species that provide ecosystem services (e.g. shellfish), and those that have more direct impacts (e.g. finfish production). There is no mention of aquaculture in either Directive except as a pressure, but it is clear that aquaculture must be included in the overall implementation of both the WFD and MSFD, given that sector growth is imperative.

As sectors grow, and particularly in light of the Integrated Maritime Policy, sea-basin strategies, and Blue Growth objectives, so too does the need for an operational approach to the assessment of cumulative effects. Evidence from experience with the EIA Directive suggests that cumulative impacts are still the most ignored aspect of impact assessment. Strategic management approaches such as MSP will need to address this gap.

National Strategic Aquaculture Plans

Aquaculture licensing in almost all EU Member States is complex and often inflexible. National strategic plans identify the need to amend legislation governing aquaculture to make licensing process more effective. Almost all countries have proposed the creation, or updating, of manuals or guidance documents so as to clarify applicable procedures for developers. This could be combined with over-arching EU guidance on WFD, MSFD, Natura 2000, and EIA requirements as a way of making that more meaningful for site operations.

The Italian National Strategic Aquaculture Plan is the only plan of all those examined that refers to the FAO EAA and zoning approaches. Other countries utilise zoning to a certain degree but this is identified as an area that needs more work and greater implementation. In some countries, there are legal barriers to zoning specific areas for future aquaculture development. Furthermore, in many countries aquaculture is viewed in the context of co-use, which negates the concept of zoning. Additional questions with respect to the zoning concept have been raised e.g. by the insurance industry, for whom a concentration of industry equates with increased risk, and therefore higher premiums. These are issues that can only be addressed within EU Member States. Compliance with environmental legislation such as the Birds and Habitats Directives and water quality Directives would appear to have had detrimental impacts on licensing processes, particularly in terms of the time taken to obtain licences, and the level of information needed to supplement licence applications.

Very few of the national plans mention MSP or Integrated Coastal Management (ICM), and this needs to be addressed in future plans.

Spatial planning under the Ecosystem Approach

Legally, the Ecosystem Approach has a basis in both the MSFD and the Common Fisheries Policy (CFP) but nowhere in EU Directives is the concept explicitly defined, which could have implications for how it is, and if it is, implemented. The conceptual basis of the Ecosystem Approach must be translated into practical actions for spatial planning to achieve its overarching goal: integrated management that conserves ecosystems and equates to the sustainable use of ecosystem goods and services.

EAA has been developed by the FAO as a means to enhance aquaculture production in an environmentally and socially acceptable way that takes account of multiple uses of space, and is compatible with the legal basis defined in the MSFD and the CFP. The EAA should form the basis for development of spatial planning under the Ecosystem Approach within the EU.

An analysis of the governance structures to implement the Ecosystem Approach is much more difficult due to the range of sectors and institutions it involves. This is complicated by the division of competences between the EU and internal Member State structures.

There are strong linkages between the ecosystem approach and spatial planning as defined by the FAO (and guidelines produced), which means they are strengthened by being 'integrated' in their perspective, but to date it would appear they are equally weakened in the context of EU development by being regarded as separate technical processes. FAO's linked activities related to the ecosystem approach to aquaculture and spatial planning, to be published in 2017, will provide an approach for EU Member States to consider.

Aquaculture and other-use issues affecting spatial planning

Interactions between aquaculture and other activities may be either synergistic or antagonistic, but these effects are not always predictable and may be cumulative, so they need to be included in any assessment of aquaculture under MSP and the EAA. Conflicts between aquaculture and other sectors and uses are not yet fully realised, but their potential impacts should be considered in current planning processes that will impact on forward planning, development of zones, and aquaculture areas.

The case studies in this review (Section 11) point to the need for a cohesive approach, in which aquaculture is an equal partner in development decisions, rather than being treated as a secondary planning consideration—where necessary, aquaculture can have preference over other uses. Public perception, in particular, can impact aquaculture development and it is important to make decisions on scientific grounds, and in the best interest of aquaculture as a sector, rather than allow perception, often misguided, limit growth potential. In this review, research undertaken towards the application

of viewshed analysis to support spatial planning decisions provides evidence to inform planning decisions through explicit recognition of the spatial qualities of one component of the ecosystem services provided by visual amenity.

Aquaculture and environment issues affecting spatial planning

Environmental considerations in spatial planning of aquaculture are a complex mix of appropriate zoning, site selection, and area management, evaluation of carrying capacity at varying scales, use of EIA, and consideration and measurement of impacts assessed through monitoring. It is not possible to consider use of marine and freshwater space on a standalone basis.

Evaluation of the environment in spatial management in aquaculture is not new, and Member States, and countries worldwide, have recognised the need to ensure ecological systems are not overloaded, and environments unnecessarily impacted. National legislation and application of thresholds and other regulatory requirements reflects this understanding.

Spatial management has often developed out of specific needs, such as the need to constrain disease outbreaks, and there are few examples where aquaculture spatial planning has been applied in the context of industry growth. Environmental management of aquaculture activity in Member States must now be considered more in the context of EU policy and regulatory instruments, such as the WFD, MSFD, and others, including consideration of cumulative impacts and other uses, aligning with the requirements of spatial planning for aquaculture development.

Where aquaculture will thrive is linked directly to species being grown in environments and under environmental conditions they would experience in nature, based on a mix of physical and environmental factors, which have been summarised in Section 9, and used to develop a specific tool for assessment of appropriate zones and areas in which aquaculture can develop best, depending on species.

Aquaculture and market issues

Aquaculture production in the EU must be analysed in the context of aquaculture and fisheries, as both farmed and wild products are often in direct competition. Analysis has shown that the EU is the largest trader of fishery and aquaculture products worldwide in terms of value, but is the largest importer of fishery products in the world, and sustains a trade deficit. Self-sufficiency rates in fisheries related catches are healthy, whereas aquaculture products such as molluscs, salmonids, and crustaceans illustrate the extent on which the EU relies on imports, particularly from other parts of Europe, such as Norway.

A strong competitive advantage of EU aquaculture is related to the quality and sustainability of its aquaculture products, and the degree of future success depends in part on maintaining healthy marine and freshwater environments, as outlined above. Educating consumers should also be a major driver for change in the European aquaculture industry, to ensure purchasing decisions are made with relevant high quality information that includes a shift from fishery towards aquaculture products.

There is also opportunity to expand global export markets, in countries where local fisheries and aquaculture products do not benefit from the stringent levels of quality control which exist in the EU. Increased wealth increases demand for safe protein, which is a pillar of sustainable aquaculture. Within the EU consumer market, understanding of the mechanisms and motivations that drive the consumption of aquaculture products is crucial to bring producers and consumers closer together.

The European Maritime and Fisheries Fund (EMFF) provides incentives for EU aquaculture development, however investigation regarding species selection driving growth, requires micro and

macro analysis of price structure. The price paid for aquatic products by the consumer requires understanding of the price structure in the supply chain, and how value is apportioned along the different stages. While numerous 'space' related factors constrain EU aquaculture expansion, price structure analysis, particularly export-focused, coupled with the inability for small-scale producers to develop the sales and logistical platforms required, presents a significant market-related bottleneck.

Feedback from Industry

This review has identified a range of policies and other factors that affect the spatial management of aquaculture. As a complementary perspective, industry and aquaculture managers, based largely on their own first-hand experience in the aquaculture business, have contributed case studies that emphasise not only the challenges within a country, but those felt specifically by the authors in their own business. There are selected examples from the EU, Norway, the USA, and Canada, emphasising the issues facing aquaculture and its expansion.

The first set of case studies focus on finfish species grown in freshwater and marine environments, and the second group relates to marine shellfish production. These documents highlight specific spatial management challenges and other relevant issues that, in the eyes of industry, limit the capacity to improve production and increase output. These case studies therefore help articulate core issues and barriers, and contribute towards putting the more general scope of this review into perspective.

Conclusions

This review aims to provide a broad perspective on the status of EU aquaculture, the limiting factors identified by practitioners, managers, and the scientific community, and make recommendations for future growth. We have carried out a thorough internal analysis at the European Union level, and draw on examples from outside the EU to examine what has been done better elsewhere, and what is less good.

The well-known ecologist H.T. Odum put forward the concept of the macroscope, i.e. the need to examine other models in order to analyse and improve our own. By drawing on the experience of *AquaSpace* partners and associates in Norway, USA, Canada, China, and Australia, together with the contributions of industry, managers, and support services such as insurance underwriters, we have combined EU and international expertise to provide a blueprint for aquaculture expansion in Europe, essential for guaranteeing food security in a rapidly changing world. We hope the lessons we have learned in producing this review will be useful in bringing together the various EU sectors that must unite to achieve the triple aims of increased food security, employment, and trade balance.

1. Introduction

This policy review assesses current approaches to spatial planning for aquaculture in Europe, along with Australia, Canada (and the United States of America), China and Norway as comparators, using the opportunity to benefit from participating *AquaSpace* partner experience; and in the North American context provide a link to the Galway Atlantic Declaration process. The review covers both marine and freshwater environments, which although different in context, provide more useful information to managers and other readers when integrated from the perspective of countries as a whole, rather than the more traditional approach of separate reporting; and this report, and the wider *AquaSpace* Project and partners, benefit from the complementary lessons learned in the two contrasting environments.

Spatial planning for aquaculture is receiving increased attention globally (FAO and World Bank, 2015; Meaden et al., 2016; Aguilar-Manjarrez et al., in press), with consideration of how best to apply the most equitable use of space for aquaculture in the context of other uses and users, balanced against the need maintain environmental integrity but increase global production and trade of fish products. The global increase in production required is estimated at an additional 30 million tonnes by 2050 (Da Silva, 2012), to satisfy demand as global population increases. With a slowing of output from capture fisheries, it is likely that a large part of this future increase will come from aquaculture production.

Technical improvement in nutrition and feed, species growth, improved disease treatments and efficiencies in production methods and culture practices will continue to achieve some of the production expansion required without addressing spatial use *per se*. Such activity will not be sufficient to achieve the required increases in production, however, and an increase in allocation of space for aquaculture will be inevitable as regions and countries try to achieve improved food security and access to protein-rich sources of food products. In the EU, the need for aquaculture specific development plans is defined in Article 34.2 of Regulation No. 1380/2013[1]. The need for explicit spatial planning for aquaculture is embedded as a requirement in the Strategic Guidelines for the sustainable development of EU aquaculture issued by the European Commission in 2013, and countries of the EU have developed multi-year aquaculture plans that incorporate in general terms aims for improved spatial planning.

The Blue Growth agenda in Europe advocates the sustainable expansion of aquaculture in production terms, which by inference will require optimisation of existing spatial use, but also the need to increase space for aquaculture. Interpretation and compatibility between that agenda and implementation of other regulatory instruments, such as the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD), Maritime Spatial Planning (MSP) and other Directives, is not completely clear, however, despite the EU having issued guidance (EC, 2016b). In 2014, all EU countries produced Multi-Annual National Strategic Aquaculture plans, which should, if fully implemented, achieve an increase in production by 2030. Although not mandated, most plans define in broad terms how this can be achieved, including commitments to improve spatial planning, as defined in the EC guidelines (EC, 2013a).

The application of zoning, site selection and area management that defines spatial planning for aquaculture, requires various governance instruments and policies and the application of appropriate tools and models (Corner and Aguilar-Manjarrez, in press) to ensure allocated space can be defined

[1] Regulation (EU) No 1380/2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. Article 34.2 states that "By 30 June 2014, Member States shall establish a multiannual national strategic plan for the development of aquaculture activities on their territory".

and implemented in an environmentally and socially acceptable way. Ultimately, planning decisions concerning the application of more space for aquaculture development comes down to national and local decision making which focus on site selection, environmental impact assessment and local social acceptance. These decisions, however, must be consistent with over-arching development plans, including defining suitable areas for aquaculture (and other users), under the framework of national and EU policies which influence those planning decisions, such as the current pressure to move to commercial activity further offshore. There needs to be a compatibility between the desire to increase aquaculture production within the EU, and thereby increase employment, reduce imports and improve food security; and the acknowledged requirement that the aquaculture industry will need more space to achieve this; with policies (regional, national and local) and management decisions which would allow that to happen.

Spatial planning can operate at all scales of governance: international, national, regional, sub-regional and local. At international level, spatial planning of marine spaces tends to follow the maritime jurisdictional zones prescribed in the United Nations Convention on the Law of the Sea (UNCLOS) in line with the rights and duties contained therein. In the EU, the regional level is most prominent in terms of policy and cooperation and most recently a regional approach to implementation has been advocated in legislation such as the WFD and the MSFD. When considering specific economic sectors, such as aquaculture, spatial planning policies at both national and local scales tend to have the most influence and impact. Coastal areas represent a significant challenge to spatial planning for many reasons including the traditional land-sea and jurisdictional divides which occur there, the divide between marine and freshwater systems, the dynamic nature of coastal areas and rising sea levels, land-use and population pressures, infrastructural investment and multiple economic sectors present on the coast, and the often unclear competences between central and local government, Member States and the EU.

Aquaculture expansion, must be organised and conducted in a systematic and coordinated way to ensure it is sustainable. Expansion requires appropriate consideration of governance, environmental, social and socio-economic requirements, which form the principles of the EAA (FAO, 2010), and accordingly must be part of any aquaculture expansion plans. The ecosystem approach is spreading as a policy-driven but science-based process for the management of all human activities in the marine environment, with the goal of establishing healthy and productive seas and oceans. EAA has been defined by FAO (2010) as "*a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems*".

EAA reinforces the long-established need to improve planning for aquaculture development. First, the growth is associated with an increase in the number of aquaculture companies and facilities and, therefore, a major occupation of space usually considered as being "in the public domain", such as coastlines, maritime areas or river basins, in which multiple activities often co-exist with conflicting interests. Second, the emergence of new economic activities (e.g. wind farms) and the ecosystem approach bring new stakeholders, in addition to the traditional ones (fisheries, tourism, agriculture, shipping, etc.). Third, the EAA is increasingly appreciated as a suitable tool to address the challenges of sustainable development, including the harmonisation of aquaculture development and environmental conservation.

Public perception of aquaculture is exacerbating some of those challenges. Social acceptance affects aquaculture development in Europe and competition with other prospective uses of the marine space, impacts consumption, marketing and profitability. Therefore, addressing public acceptance of aquaculture will improve its long term environmental, social and economic sustainability.

In a broader context, an appropriate governance structure for spatial planning for aquaculture under the EAA would, among others, contribute to:

- Minimising fish disease risks and better response to outbreaks;
- Better coordination and integration of approaches to the use and management of natural resources;
- Better understanding of cumulative and combined environmental effects and of interactions between users and the environment;
- Improved filter-feeder productivity and yield;
- Mitigation of conflicts with other users of resources, improving accountability and transparency through relevant stakeholder involvement at all levels;
- Synergies among farmers having access to common post-harvest processes and other services;
- Increased legal certainty investors if areas for aquaculture are allocated;
- Aquaculture development being promoted in designated and suitable areas;
- Provide information to potential aquaculture investors;
- Reduction of the bureaucracy (*red tape*) and time-consuming procedures for aquaculture licensing;
- Simplification of monitoring processes;
- Increase social awareness and positive perception of aquaculture;
- Maintaining optimal environmental quality standards;
- A more resilient sector, better adapted to shocks;
- More effective mechanisms for governments and other institutions including civil society organisations to deliver services and fulfil their commitments to sustainable aquaculture development;
- Improved status and public perception of aquaculture and support a level playing field with respect to allocation of space with other economic activities.

Not all of the above is covered in the *AquaSpace* project, as it needs consideration of numerous factors including disease management, assessment of cumulative effects, evaluation of carrying capacity, technological developments in culture practices, licensing, and monitoring among others, which are not considered directly here. In this overall context, however, a review of current and future spatial use for aquaculture in Europe needed to be undertaken, with a thorough consideration of relevant policy and management issues.

In Europe, broad discussion on aquaculture production is generally described in the context of perceived “stagnating” production. Analysis for this review shows that production in countries that provide the highest contribution to aquaculture output in the EU have in fact reduced production since 2000, with some notable exceptions. Other smaller producing countries have, in general, increased aquaculture production, but from a low starting position; so, the net increase is minimal and does not offset the lower production in the major producer countries. The net effect is that overall aquaculture production in the EU decreased by approximately 9% between 2000 and 2013, rather than there being “no change”, which stagnation implies. European aquaculture production is reducing, whilst other major world producers are massively increasing their aquaculture infrastructure and output.

The countries of the EU maintain a heavy reliance on imported fisheries and aquaculture products, estimated to be 71% of all aquatic products consumed (calculated from EU, 2016). Access to imports may be more difficult in future because, as countries develop economically, the general trend is for those countries to consume more protein, including fish products (Kearney, 2010), which has the potential to reduce availability for exports to other parts of the world that rely on imports, particularly

from developing to developed countries (Ahmed, 2006), such as in the EU. The combination of this possible reduction on access in world markets plus the desire to nonetheless reduce reliance on imports as part of food security measures, means the 28 countries of the EU must increase aquaculture production in the next 10-20 years, and increase it quite substantially. Availability and suitability of space is liable to be one of the key driving characteristics of that development.

The review identifies major issues, gaps and barriers to implementation of the Blue Growth agenda, as it relates to the optimisation and increase of spatial use for aquaculture. It has been achieved through a complementary set of activities, which includes:

- A brief analysis of production statistics for the EU28 nations, plus Australia, Canada, China and Norway; to provide context for the work undertaken, including summaries of national aquaculture plans where appropriate;
- Development and deployment of questionnaires to identify the major issues and gaps, targeted to key set of respondents; and an associated workshop, to which a sub-set of those respondents were invited to review the survey results, and to develop recommendations based on a set of working group discussions;
- An analysis of policy and management issues affecting the increase and optimisation of space for aquaculture in the context of other EU and national policies, which have been informed by shared information from the case study activity undertaken within Work Package 4;
- A desk-top analysis of review of likely impacts of other sectors on the use of marine and freshwater space for aquaculture, and indication of how spatial planning can ensure equitable use;
- A desk-top analysis of environmental considerations, focusing on limitations of species to use specific marine and freshwater space, and not on environment impacts from aquaculture, although this is briefly mentioned; which supported development of a web-based application (**W**here can **A**quaculture **T**hrive in **Eu**r**o**pe - WATER), reported elsewhere;
- A desk-top analysis of aquaculture-market issues; which supported development of an App called the Aquaculture Investor Index, also reported elsewhere.

Thus, the review draws together information from all the tasks within Work Package 2 of the *AquaSpace* project, *Accurately Identify Industry-Wide Issues and Options*, covering policy-management issues, interaction with other sectors, environmental requirements, and aquaculture marketing issues; to then define issues, barriers and gaps in optimising and increasing space for aquaculture development.

Section 2 provides the overall context for the review by analysing production data for all EU Member States, relative to Norway, Canada, Australia, and China (*AquaSpace* partners) to evaluate the shifts that have occurred since 2000, in species composition and production. This is combined with a summary of aquaculture plans produced by EU countries in consideration of future development. Section 3 presents critical results from a questionnaire and associated regional workshop on spatial planning and management of aquaculture incorporating aquaculture zoning, site selection and area management. The questionnaire was completed by leading figures in aquaculture, policy management, trade bodies and ancillary industries such as insurance, selected by the *AquaSpace* consortium to be representative of the sector; and a sub-group of stakeholders attended the workshop. Sections 4 and 5 cover the law and policy frameworks for marine and freshwater aquaculture respectively in *AquaSpace* partner countries in the EU and internationally. Information on the implementation of MSP to date, a new approach to planning activities in the marine environment which is now a legal requirement under EU law, is presented within the marine section. Land-based planning systems which can sometimes govern both freshwater aquaculture developments as well as

nearshore or coastal aquaculture are then outlined. Section 6 explores the interpretation and implementation of other EU legal instruments and policies such as the WFD, MSFD, Blue Growth agenda and Strategic Guidelines for the sustainable development of EU aquaculture (EC, 2013a) with a view to determining the implications these have on the spatial development of aquaculture. Section 7 how aquaculture can develop in the context of the ecosystem approach, and determines whether the ecosystem approach is imbedded in EU Directive and other legislative instruments. Section 8 considers issues related to aquaculture and other users and uses, and given the general lack of social acceptance of aquaculture in those who share coastal environments, presents a viewshed analysis showing how tools can be used to evaluate aquaculture-other use interactions. Section 9, considers the relationship between aquaculture and the environment related to policy and assessment of what species traits are critical in determining where aquaculture can thrive. There is no consideration of the impacts of aquaculture. Section 10 evaluates the importance of markets and market decisions and the need to improve aquaculture growth within the EU and whether it is feasible to sell the products if production increases as anticipated. In section 11 industry practitioners provide case studies where aquaculture has been restricted and identify the barriers to further development. This leads into the final chapters which concludes the review with a consideration of implications for policy on increasing use of space for aquaculture, and barriers and opportunities for implementation (Chapter 12).

Together this analysis will assist in the identification of major gaps, barriers and opportunities available to better implement the optimisation and increased use of space for aquaculture development under the ecosystem approach to aquaculture.

2. Aquaculture production statistics and national plans

2.1 Aquaculture production in the European Union

Aquaculture production across Europe encompasses a varied mix of species, culture types and practices, conducted in a range of environments and locations, and utilising variable amounts of space. The first part of this section presents a summary of production statistics covering the period between 2000 and 2013. The data analysis was conducted on information downloaded from FAO Fisheries Global Information System (FIGIS[2]) in September 2015 (FAO, 2015). Information relates only to "Aquaculture" production, not fisheries, though for some countries specific definitions of what constitute aquaculture varies.

The European aquaculture sector is dominated by a few species; salmon and trout, bass and bream; mussels and oysters; and carps; although the entire aquaculture sector encompassed reported cultivation of 116 species and production of 1,279,417 tonnes in 2013, similar to that reported by Eurostat for 2014 (Eurostat, 2016). In general, the primary species identified above have not changed over the period being analysed, but there has been a change in overall production, which impacts upon our view of stagnation in the industry.

The aquaculture sector within Europe has been deemed to have stagnated in recent years, which implies little or no change over time. There has, however, been significant shifts in that overall output between countries and between species, and in terms of overall reported production during the 13 years being evaluated.

Rather than stagnating, analysis reveals that production output has decreased by approximately 9% between 2000 and 2013, from 1.405 million tonnes in 2000 to 1.279 million tonnes in 2013 (Table 1). Within these totals the top three producers in 2000 were Spain, France and Italy, who between them produced 56.4% of EU28 production[3]. By 2013 these same producers accounted for a still significant but much reduced 47.2% of all production in the EU28, the decrease in contribution the result of these three countries having reduced production output by nearly 26% on average between 2000 and 2013 (Table 2). This represents a notable decline in aquaculture output from Spain, Italy and France that significantly impacts the overall reduction seen. In 2013, Spain and then France remained the two largest producers, followed by the United Kingdom which has grown its production output, in 3rd, with Italy 4th (Table 1).

Table 1 shows that the Top 10 producer countries in 2000 remained the same in 2013, albeit in a slightly different order, and accounted for 82.1% of EU28 production in 2013, against 93.4% in 2000, and indicates that the remaining 18 countries are currently making a larger contribution to aquaculture production than previously. Total production for the Top 10 producers reduced overall by 12% between 2000 and 2013, with 7 of the top 10 countries all decreasing levels of production over this period. Table 1 also shows that of the remaining 18 countries in the EU28, 15 countries increased their production between 2000 and 2013, and only the Czech Republic (static), Finland (-11.6%) and Belgium (-88.7%) showed no increases. However, the total production in 2013 for these 18 countries combined, was slightly less than that produced by the 5th largest producer in 2013, Greece. Thus between 2000 and 2013, significant reductions in production in some of the largest producer countries

[2] FIGIS was preferred over Eurostat, so that information on international consortium partners could be included in the analysis, based on the same dataset. Differences between data reported to FIGIS and Eurostat are not assessed.

[3] That some countries were not in the EU in 2000 has been ignored.

has badly affected overall production, and although the remaining countries continue to increase their output, this is insufficient to offset the larger reduction in aquaculture production.

Table 1: EU aquaculture production in 2000 and 2013 (data from FAO, September 2015). Consortium partner countries denoted by an asterisk.

Country	Production in 2000 (tonnes)	Production in 2013 (tonnes)	Change (%)	Change (% of 2000 total baseline)
Spain*	309,229	223,700	-27.7	-6.1
France*	266,802	202,210	-24.2	-4.6
Italy*	216,525	162,620	-24.9	-3.8
United Kingdom*	152,485	194,630	27.6	3.0
Greece*	95,418	144,595	51.5	3.5
The Netherlands	75,231	60,410	-19.7	-1.1
Germany*	65,891	25,289	-61.6	-2.9
Ireland*	51,247	34,198	-33.3	-1.2
Denmark	43,609	71,610	64.2	2.0
Poland	35,795	35,208	-1.6	0.0
Czech Republic	19,475	19,357	-0.6	0.0
Finland	15,400	13,613	-11.6	-0.1
Hungary*	12,886	14,918	15.8	0.1
Romania	9,727	11,007	13.2	0.1
Portugal*	7,537	7,889	4.7	0.0
Croatia	6,876	12,019	74.8	0.4
Sweden	4,834	13,366	176.5	0.6
Bulgaria	3,654	12,152	232.6	0.6
Austria	2,847	3,237	13.7	0.0
Lithuania	1,996	4,211	111.0	0.2
Cyprus	1,878	5,340	184.3	0.2
Belgium	1,871	212	-88.7	-0.1
Malta	1,746	3,939	125.6	0.2
Slovenia	1,181	1,226	3.8	0.0
Slovakia	887	1,085	22.3	0.0
Latvia	325	643	97.8	0.0
Estonia	225	733	225.8	0.0
Luxembourg	0	0	0.0	0.0
Total	1,405,577	1,279,417		
Overall EU growth (%)		-9.0		

While EU aquaculture production has been reducing, other countries production output has been increasing. World Bank (2013) estimate the global average annual increase in aquaculture production was more than 8%, against the EU28 decreasing at an average rate of approximately 0.8% per year, which means EU production is reducing in both absolute terms and in its contribution to global production.

Table 2: Summary data of aquaculture production (tonnes), mean annual increase and cumulative increase between 2000 and 2013 for each country within the EU28, plus Norway and 3 non-EU partner countries. Data from FAO (September 2015).

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Mean annual change in production for 2000-2013 (%)	Overall change in production for 2000-2013 (%)
Austria	2,847	2,393	2,333	2,233	2,267	2,420	2,503	2,539	2,087	2,141	2,167	2,904	3,126	3,237	1.05	13.70
Belgium	1,871	1,830	1,834	1,261	739	414	128	128	126	576	539	101	277	212	-6.82	-88.67
Bulgaria	3,654	2,938	2,308	4,465	2,489	3,145	3,257	4,032	5,157	6,723	7,921	5,527	5,975	12,152	17.89	232.57
Croatia	6,876	10,468	9,095	9,505	10,917	12,127	15,497	14,045	13,878	14,229	13,991	12,846	10,440	12,019	5.75	74.80
Cyprus	1,878	1,883	1,862	1,821	2,445	2,436	2,787	2,450	2,887	3,416	4,116	4,667	4,334	5,340	14.18	184.35
Czech Republic	19,475	20,098	19,210	19,670	19,384	20,455	20,431	20,447	20,395	20,071	20,420	21,010	20,763	19,357	-0.05	-0.61
Denmark	43,609	41,573	32,026	37,772	42,814	39,012	37,188	31,168	36,066	35,130	38,175	37,918	38,586	71,610	4.94	64.21
Estonia	225	467	257	372	252	555	703	772	813	654	573	388	581	733	17.37	225.78
Finland	15,400	15,739	15,132	12,558	12,821	14,355	12,891	13,025	13,439	13,627	11,772	11,275	12,659	13,613	-0.89	-11.60
France*	266,802	251,655	251,758	239,601	242,167	244,925	237,375	237,451	238,249	234,000	224,520	207,255	205,210	202,210	-1.86	-24.21
Germany*	65,891	53,409	49,852	74,280	57,233	44,685	35,379	44,994	43,977	38,907	40,694	39,141	26,360	25,289	-4.74	-61.62
Greece*	95,418	97,512	87,928	101,434	97,143	106,208	113,384	113,297	115,068	122,011	121,244	137,214	137,594	144,595	3.96	51.54
Hungary*	12,886	13,056	11,574	11,870	12,744	13,661	14,686	15,864	15,687	14,825	14,245	15,584	15,133	14,918	1.21	15.77
Ireland*	51,247	60,940	62,568	62,516	58,359	60,050	53,122	57,104	44,868	47,512	46,490	44,266	36,102	34,198	-2.56	-33.27
Italy*	216,525	218,330	184,285	191,884	118,217	181,101	172,793	179,409	149,003	162,432	153,494	164,151	162,618	162,620	-1.92	-24.90
Latvia	325	463	430	637	545	542	565	729	584	517	549	546	575	643	7.53	97.85
Lithuania	1,996	2,001	1,750	2,356	2,697	2,013	2,224	3,377	3,008	3,422	3,191	3,280	3,582	4,211	8.54	110.97
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
Malta	1,746	1,235	1,116	887	868	736	1,936	2,716	2,702	2,868	2,916	2,156	4,066	3,939	9.66	125.60
Netherlands	75,231	57,042	54,429	66,540	78,598	71,370	45,553	56,841	46,896	55,641	66,945	43,800	46,149	60,410	-1.52	-19.70
Poland	35,795	35,460	32,709	35,436	35,131	37,920	35,867	35,628	36,813	36,509	30,757	29,043	32,261	35,208	-0.13	-1.64
Portugal*	7,537	8,209	8,288	8,033	6,700	6,696	7,894	7,416	7,352	6,728	8,225	9,165	10,318	7,889	0.36	4.67
Romania	9,727	10,818	9,248	9,042	8,137	7,284	8,088	10,312	12,532	13,131	8,981	8,353	10,007	11,007	1.01	13.16
Slovakia	887	999	829	881	1,180	955	1,263	1,199	1,071	823	687	814	1,286	1,085	1.72	22.32
Slovenia	1,181	1,262	1,289	1,353	1,571	1,346	1,369	1,352	1,315	1,307	778	1,397	1,154	1,226	0.29	3.81
Spain*	309,229	309,091	254,949	268,279	293,839	219,335	292,829	281,729	249,707	266,669	252,342	271,953	264,154	223,700	-2.13	-27.66
Sweden	4,834	6,773	5,618	6,334	5,789	5,880	7,549	5,365	7,595	8,540	10,644	13,441	13,757	13,366	13.58	176.50
United Kingdom*	152,485	170,516	179,036	181,838	207,203	172,813	171,848	174,203	179,187	179,093	201,091	198,439	203,037	194,630	2.13	27.64
TOTAL EU28	1,405,577	1,396,160	1,281,713	1,352,858	1,322,249	1,272,439	1,299,109	1,317,592	1,250,460	1,291,498	1,287,466	1,286,633	1,270,103	1,279,417	-0.69	-8.98
Norway*	491,329	510,748	551,297	584,423	636,802	661,877	712,373	841,560	848,359	961,840	1,019,802	1,143,893	1,321,119	1,247,865	11.84	153.98
TOTAL EU28+Norway	1,896,906	1,906,908	1,833,010	1,937,281	1,959,051	1,934,316	2,011,482	2,159,152	2,098,819	2,253,338	2,307,268	2,430,527	2,591,222	2,527,282	2.56	33.23
Canada*	127,665	153,046	172,046	167,798	145,018	154,587	171,629	152,486	155,349	155,728	162,146	162,370	173,252	172,097	2.68	34.80
Australia*	31,746	35,403	38,566	38,793	44,142	42,787	49,376	55,799	58,912	65,085	71,667	72,462	77,232	76,062	10.74	139.60
China*	28,465,178	29,874,867	31,866,489	33,668,450	35,946,139	37,619,441	39,585,660	41,177,565	42,673,599	45,283,992	47,833,948	50,176,577	53,947,017	57,116,939	7.74	100.66

Within *AquaSpace* partner countries, Australia has increased production by 140% between 2000 and 2013; Canada by 27%; and China has doubled production over this period. The largest increase (in %-terms) comes from Norway, which has increased production, mainly of salmon, by 154% over the period. Mean annual rates of increase between 2000 and 2013 were 7.1%, 2.7%, 5.5% and 7.6% in Australia, Canada, China and Norway respectively, compared against the EU28 decrease of 0.8% annually (Table 2). In absolute terms China produces more than 50% of global aquaculture production. In a European context, Norway overtook the production achieved by the EU28 in 2012, with approximately parity in production in 2013 (Figure 1), according to FAO (FIGIS, accessed 2015).

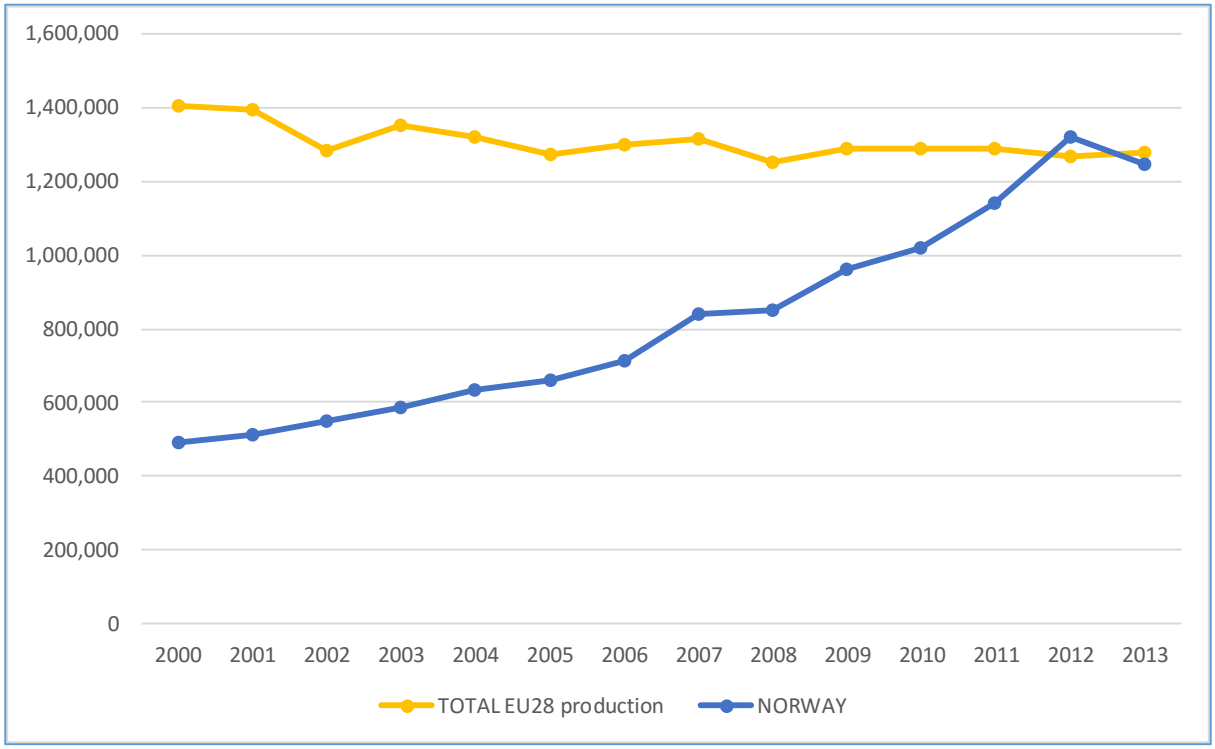


Figure 1: Total aquaculture production in EU28 countries combined against Norway over the period 2000 to 2013 (Data from FAO FIGIS database, 2015).

As previously identified, the main species grown within the EU has changed little since 2000, although the reported number of overall species produced has increased from 78 in 2000 (Table 3) to 116 species in 2013 (Table 4). In order to support this diversification, countries and companies alike have to improve their understanding of how new species can be cultivated and develop new strategies that reduce historical reliance on a few key species. The EU (2016) identify species such as meagre, turbot, catfish, clams, and to a certain extent Bluefin tuna production, being explored more vigorously than some other species. There is, however, more progress required before species choices change significantly and failed attempts at producing Atlantic cod (*Gadus morhua*) in Norway, United Kingdom and Iceland, are testament to how difficult it is to produce aquatic candidates economically through aquaculture, even when supported by significant research and background knowledge.

In 2000, aquaculture within the EU was dominated by Mediterranean mussel (*Mytilus galloprovincialis*), Rainbow trout (*Oncorhynchus mykiss*), blue mussel (*Mytilus edulis*), Atlantic salmon (*Salmo salar*) and Pacific cupped oyster (*Crassostrea gigas*), which accounted for more than three-quarters (77.5%) of total production (Table 3). By 2013, these same species accounted for 68% of

aquaculture production, with production of seabass and bream increasing as a percentage, as production output of other key species was reduced. The reduction in output of 116,000 tonnes between 2000 and 2013 is accounted for by lower production of nearly all of the top 20 species grown in the EU, with a few exceptions, including Atlantic salmon and European sea bass (Table 3, Table 4), both of which increased. Overall, approximately three-quarters of production occurs in marine waters and nearly one-quarter is produced in freshwater (including low salinity brackish waters).

Table 3: List of top 20 species plus other species grown through aquaculture within the EU28 in 2000, in order of production (tonnes). Total number of species = 78. Data from FAO FIGIS database (2015).

Common name	Scientific name	Production in 2000 (t)	% of total	Cumulative % of total	Environment	Group
Mediterranean mussel	*Mytilus galloprovincialis*	374,665	26.66%	26.66%	Marine	Shellfish
Rainbow trout	*Oncorhynchus mykiss*	238,495	16.97%	43.62%	Brackish and Freshwater	Fish
Blue mussel	*Mytilus edulis*	188,951	13.44%	57.07%	Marine	Shellfish
Atlantic salmon[4]	*Salmo salar*	146,952	10.46%	67.52%	Marine	Fish
Pacific cupped oyster	*Crassostrea gigas*	140,283	9.98%	77.50%	Marine	Shellfish
Common carp	*Cyprinus carpio*	74,188	5.28%	82.78%	Freshwater	Fish
Gilthead seabream	*Sparus aurata*	59,547	4.24%	87.02%	Marine	Fish
Japanese carpet shell	*Ruditapes philippinarum*	56,365	4.01%	91.03%	Marine	Shellfish
European seabass	*Dicentrarchus labrax*	42,149	3.00%	94.03%	Marine	Fish
European eel	*Anguilla anguilla*	10,658	0.76%	94.79%	Freshwater	Eel
Freshwater fishes nei	*Osteichthyes*	8,632	0.61%	95.40%	Freshwater	Fish
European flat oyster	*Ostrea edulis*	5,805	0.41%	95.81%	Marine	Shellfish
Silver carp	*Hypophthalmichthys molitrix*	5,355	0.38%	96.19%	Freshwater	Fish
Turbot	*Psetta maxima*	4,785	0.34%	96.53%	Marine	Fish
Common edible cockle	*Cerastoderma edule*	4,678	0.33%	96.87%	Marine	Shellfish
Grooved carpet shell	*Ruditapes decussatus*	3,790	0.27%	97.14%	Brackish and Marine	Shellfish
Flathead grey mullet	*Mugil cephalus*	3,548	0.25%	97.39%	Marine	Fish
Sea trout	*Salmo trutta*	3,029	0.22%	97.60%	Marine and Freshwater	Fish
Gracilaria seaweeds	*Gracilaria spp*	3,000	0.21%	97.82%	Marine	Algae
North African catfish	*Clarias gariepinus*	3,000	0.21%	98.03%	Freshwater	Fish
Other (n=58)		27669.0	1.97%	100.00%	All	All
Total		1,405,544				
		By groups				
Fish		779,829				
Shellfish		611,211				
Algae		10,658				
Eels		3,032				
Other		814				

[4] Atlantic salmon is an anadromous species, aquaculture stages include a freshwater hatchery and parr growth stage, followed by a marine smolt and pre-adult stage, referred to as on-growing. Reported production only refers to harvest for sale from the marine environment.

Table 4: List of top 20 species plus other species grown through aquaculture within the EU28 in 2013, in order of production (tonnes). Total N=116 species. Data from FAO FIGIS database (2015).

Species	Scientific name	Production in 2013 (t)	% of total	Cumulative % of total	Environment	Group
Mediterranean mussel	*Mytilus galloprovincialis*	276,817	21.64%	21.64%	Marine	Shellfish
Rainbow trout	*Oncorhynchus mykiss*	178,265	13.93%	35.57%	Brackish and Freshwater	Fish
Blue mussel	*Mytilus edulis*	163,958	12.82%	48.38%	Marine	Shellfish
Atlantic salmon	*Salmo salar*	163,631	12.79%	61.17%	Marine	Fish
Gilthead seabream	*Sparus aurata*	109,030	8.52%	69.70%	Marine	Fish
Pacific cupped oyster	*Crassostrea gigas*	89,328	6.98%	76.68%	Marine	Shellfish
European seabass	*Dicentrarchus labrax*	78,259	6.12%	82.79%	Marine	Fish
Common carp	*Cyprinus carpio*	69,560	5.44%	88.23%	Freshwater	Fish
Brown seaweeds	*Phaeophyceae*	40,042	3.13%	91.36%	Marine	Algae
Japanese carpet shell	*Ruditapes philippinarum*	31,933	2.50%	93.86%	Marine	Shellfish
Turbot	*Psetta maxima*	9,833	0.77%	94.63%	Marine	Fish
Marine fishes nei	*Osteichthyes*	7,451	0.58%	95.21%	Marine	Fish
North African catfish	*Clarias gariepinus*	4,643	0.36%	95.57%	Freshwater	Fish
Bighead carp	*Hypophthalmichthys nobilis*	4,190	0.33%	95.90%	Freshwater	Fish
Grooved carpet shell	*Ruditapes decussatus*	4,129	0.32%	96.22%	Brackish and Marine	Shellfish
European eel	*Anguilla anguilla*	4,017	0.31%	96.53%	Brackish and freshwater	Eel
Chars nei	*Salvelinus spp*	3,931	0.31%	96.84%	Freshwater	Fish
Silver carp	*Hypophthalmichthys molitrix*	3,786	0.30%	97.14%	Freshwater	Fish
Sea trout	*Salmo trutta*	3,454	0.27%	97.41%	Freshwater and Marine	Fish
Atlantic bluefin tuna	*Thunnus thynnus*	2,345	0.18%	97.59%	Marine	Fish
Other (n = 96)		30,816	2.41%	100.00%	All	All
Total		1,279,417				
		By groups				
Fish		661,365				
Shellfish		573,353				
Algae		40,393				
Eels		4,017				
Other		288				

2.2 Use of space in European aquaculture

European aquaculture production has declined over the last 10-15 years, but there is almost universal acceptance that, at a strategic level, aquaculture production must increase within Europe. Some countries in the EU previously had aquaculture development plans, but a concerted effort to improve both strategic planning and production in a coordinated way across Europe has only developed recently, as one strand of the Blue Growth agenda (EC, 2012b). The Blue Growth agenda highlights aquaculture as one of five sectors where resources of European coasts, seas and oceans could be a major contributor to jobs and growth opportunity. The European strategic guidelines for aquaculture development (EC, 2013a) included the requirement for each country to produce a multi-annual national Strategic Aquaculture Plans (summarised in Section 2.3[5]), and the issuance of additional European guidance on the linkage between aquaculture development and other Directives (WFD, MSFD) in 2016 (EC, 2016b) highlight the importance of aquaculture to Europe's food development programme, and Blue Growth agenda.

The European aquaculture guidelines highlight the importance of spatial planning in aquaculture development, but also highlights the difficulty aquaculture faces in developing aquaculture-specific strategies, in the face of other aquatic uses under MSP, for example. Several authors (EC, 2013a;

[5] Also available at https://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans_en

Hofherr et al., 2012; OECD, 2014; STECF, 2014) identify that European aquaculture is hindered by competition for space, which, along with a lack of priorities, fragmentation in licensing; and difficulties from digesting environmental requirements and related investor concerns, are limitations on aquaculture development.

Recent work by FAO (Meaden et al., 2016) and a soon to be released guidance document (Aguilar-Manjarrez, pers. comm.) on aquaculture zoning, site selection and area management highlight the growing world-wide application of spatial planning for aquaculture. There is a need for marine and freshwater stakeholders, and those in the aquaculture sector to develop spatial plans that include aquaculture development, to optimise and increase spatial use, while at the same recognising the need to consider carrying capacity and wider-scale impacts from multiple sites in an area, and the intimate link between these components in marine and freshwater/land environments.

Identifying precisely how much space EU aquaculture currently utilises is not an easy task and there are only limited analyses carried out. Although most countries have aquaculture licensing procedures, such procedures are often de-centralised (EC, 2013a) and databases do not exist in most countries to identify the leases issued and the amount of space occupied, as part of any lease arrangements. The EU is not unique in this and similar problems of collating useful information exist in other countries, such as Canada and Australia, because of fragmented regional approaches that do not necessarily implement the same strategies for licensing and data collection. Norway has recently taken one major step in development of a single database covering the whole country[6] that allows users to identify how many farms are distributed in each coastal location, along with lease, production limits and other useful information on aquaculture sites. Scotland has produced a similar database-led web application[7], although neither the Norwegian or Scottish examples allows the user to determine information on spatial use specifically.

Hofherr et al (2015) evaluated use of marine space, based on information available from FAO, and suggested that as little as 630 ha are used in the production of 95% of European marine aquaculture. Given that most marine aquaculture occurs in inshore waters, Hofherr et al (2015) concluded that the amount of coastline impacted by marine aquaculture ranges between 0.5% and 3.0% of national coastlines (10 EU countries evaluated), although is higher for small island states (e.g. Malta) or those with very short coastlines (e.g. Slovenia); and that production most often occurred in distinct clusters or areas (Figure 2).

As far as is known there has been no similar study for freshwater production. In an analysis for this review the stocking density of Carps produced in freshwater extensive or semi-intensive pond systems is variable (500 – 1500kg ha^{-1}), so a figure of 1000kg ha^{-1}, is not unreasonable to provide an estimate of area use. Carp production in Europe in 2013 was 80,860 tonnes (Table 4), which therefore suggests a land/water surface use of approximately 81,000 ha. This is not unreasonable, given Poland, as Europe's largest carp producer, estimate 60,000 ha is utilised for carp production. The area used by aquaculture compares against agricultural land use, which is estimated at 175 million ha, or 40% of European land mass.[8] 81,000 ha is an area equivalent to half of Greater London distributed across the whole of Central Europe.

[6] See website at http://kart.fiskeridir.no/default.aspx?gui=1&lang=2
[7] See website at http://aquaculture.scotland.gov.uk/
[8] http://ec.europa.eu/eurostat/statistics-explained/index.php/Farm_structure_statistics

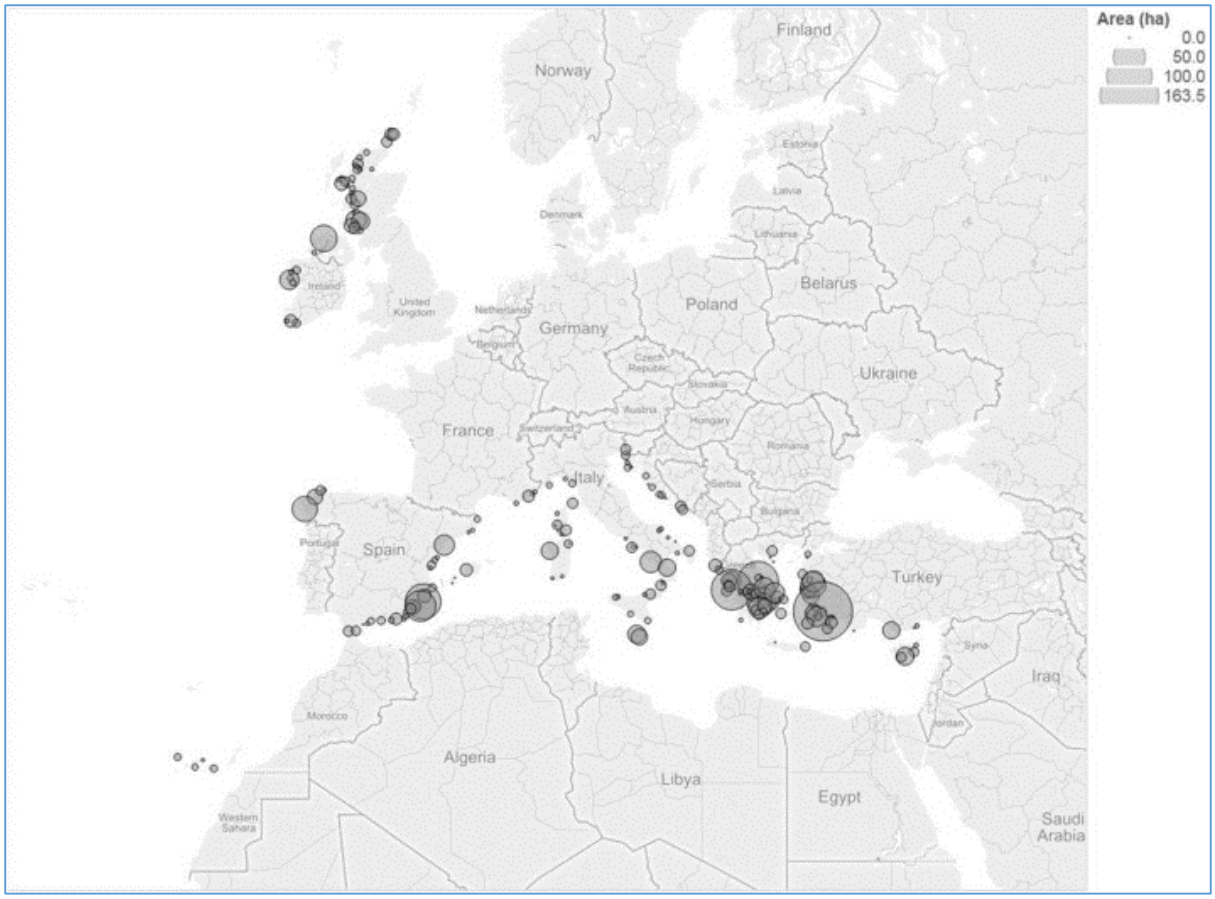


Figure 2: Clusters of marine aquaculture production in the European Union, area denoted by scale (from Hofherr et al., 2015).

Estimates for trout production in freshwater are more difficult still, because methods of growth include recirculating aquaculture systems (RAS) and intensive pond systems that have diverse and very different stocking densities, and infrastructural requirements for space. Intensive systems in the UK typically stock trout at 20 – 80 kg m^{-3} (North et al., 2006) and assuming a conservative 2m water depth (for tanks, raceways or ponds), equates to production of 10 – 40kg m^{-2}. Using this as a simplistic measure, the 178,000 tonnes of trout produced in Europe in 2013 (Table 4) would equate to an area between 445 and 1780 ha. The relationship between land use for water (tanks, ponds etc.) and land for other infrastructure within an intensive trout farm is not known. If we assume that the water component of a farm is just 10% of the overall land requirement, and 90% is for feed storage, offices and other infrastructure, and applying the measure above, then the area required to produce the 178,000 tonnes of trout in Europe increases ten-fold between 4450 to 17,800 ha in total. The area required for trout production, representing 13.9% of EU production in 2013 (Table 4), is thus significantly larger than is occupied by 95% of marine culture, representing 72.6%[9] of EU production in 2013 (Table 4).

The course nature of these calculations is recognised but the critical result is understanding that the amount of space needed for current levels of aquaculture production, in marine and freshwater environments, is very small, relative to the space available. While there are recognised limiting factors

[9] 95% of 76.4%, the proportion of total production from marine culture in the EU in 2013.

in marine and freshwater aquaculture (e.g. disease, water quality control) the additional space should be available in inshore waters and on land, in addition to the need to develop suitable technology that would allow a move to more offshore marine environments, which is advocated by, among others, the European Commission (EC, 2013a).

2.3 National aquaculture plans: production and space

As stated previously, the aquaculture guidelines produced by the European Commission (EC, 2013a) identified the need to increase aquaculture across Europe, and considered development of spatial planning for aquaculture as a key enabler of that activity. Following these guidelines EU countries produced multi-annual aquaculture plans and the EC produced a summary document outlining the key components (EC, 2016a). The following table (Table 5) is a summary of those plans[10].

Table 5: Summary analysis of EU Member States multi-annual aquaculture plans. Consortium member countries denoted by an asterisk.

Country	Production in 2013 (t)[11]	Proposed increases by 2020, unless stated	Spatial planning for aquaculture: activity proposed (abridged from plan overviews)
Spain*	223,700	320,000	Establish common criteria to identify areas of aquaculture interest across autonomous regions. Develop a Geographical Information System (GIS) for the spatial planning of the Spanish aquaculture. Support investment in new sites and the creation of new aquaculture companies. Reinforce positive interactions within Natura 2000.
France*	202,210	265,000	Improved use of spatial planning to support aquaculture development in favourable environments. Improve knowledge of links between aquaculture and other regional activities to support inter-sectoral integration at regional level.
United Kingdom*	194,630	254,000	Create regional Marine Plans that incorporate aquaculture production areas for priority development. Development of regional hubs to aid coordination of input from the aquaculture industry to improve representation within the marine planning process.
Italy*	162,620	206,854 (by 2025)	National Guidelines to allocate zones specifically for aquaculture (AZA). Support Regions in the adoption of marine spatial plans. National Guidelines to implement EIA procedures for new aquaculture farms. Water quality management of areas allocated to shellfish culture.
Greece*	144,595	170,000	Implement national Framework for Spatial Planning and Sustainable Aquaculture Development that will implement use of a spatial development model; establish new production sites; will reorganise existing sites; regulate relations between coastal zone stakeholders; consider diversification; develop offshore aquaculture; and encourage organic aquaculture methods.
Denmark	71,610[12]	55,000	Preparation of national and regional spatial plans for freshwater and marine aquaculture, and pro-actively allocate aquaculture production areas that are prioritised for development.
Netherlands	60,410[13]	48,000 (by 2023)	Use of multi-purpose space at sea, especially with offshore wind.
Poland	35,208	61,000	No development plans. Aim to maintain current area of production for extensive aquaculture (being 60,000 ha). Increase via intensive culture. Initiate marine production by 2020.
Ireland*	34,198	81,700 (by 2023)	Aquaculture incorporated into a marine spatial planning system to spatial map aquaculture sites and exclusion areas. To commission a

[10] Taken from the country plan summaries at https://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans_en.

[11] 2013 production figures come from FIGIS database (http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en), but are substantively the same as recorded via Eurostat, unless otherwise identified via footnotes.

[12] Section 2 notes that Denmark re-categories what it considers aquaculture, leading to discrepancies between FIGIS database and declared production via Eurostat, used in the summary documents. Summary declared production in 2013 was 31,790 T, so proposed increase is 70% over 2013 levels.

[13] There is a large discrepancy between production in the Netherlands declared in FIGIS for 2013 (i.e. 60,410 T), and that reported in the strategic multi-annual plan for 2014 (i.e. production of 46,605 T). The declared increase in production is 3% above that reported for 2014, by 2023.

			study to identify and provide guidance to farmers in developing tourism-related opportunities for producers. Study integrated multi-trophic aquaculture and synergies with offshore wind or other marine renewable energy.
Germany*	25,289	52,000	Establish concept for sustainable mussel production in the Baltic Sea. Designate priority areas for integrated multi-trophic aquaculture systems (mussels and/or algae) in the Baltic Sea in the spatial plans at the federal state level.
Czech Republic	19,357	20,000	None specifically mentioned, except shift to intensive recirculation systems.
Hungary*	14,918	27,000 (by 2023)	None mentioned.
Finland	13,613	20,000	Finland has an adopted aquaculture spatial plan to identify suitable areas in marine system, which will be integrated into the national marine spatial plan.
Sweden	13,366	25,000	Promote inclusion of aquaculture in municipal spatial planning and to increase the number of areas and the total areas declared suitable for aquaculture.
Bulgaria	12,152	20,000	Spatial planning to be an integral part of sustainable socio-economic development, achieved through the co-ordination of regional and sectoral plans, policies and programs.
Croatia	12,019	24,050	Designation of aquaculture zones in spatial plans and stabilisation of production in accordance with environmental protection and water management needs.
Romania	11,007	36,000	Establish the production potential for aquaculture and identify best areas for aquaculture, to be integrated in spatial planning via GIS mapping.
Portugal*	7,889	35,000	Improving the legal and regulatory framework. Development of existing instruments for managing territorial waters and identify and creation new aquaculture production areas.
Cyprus	5,340	6,332 (by 2023)	Promotion of Marine Spatial Planning and designation of at least 2 new zones for aquaculture and providing assurance to existing aquaculture businesses.
Lithuania	4,211	6,400 (by 2022)	Current capacity for pond aquaculture is underexploited, so increasing use of existing ponds.
Malta	3,939	10,500	Regulate management of Aquaculture Zones and identify new zones.
Austria	3,237	5,500	Development of RAS system, optimisation of existing pond sites, and possibly development of new sites.
Slovenia	1,226	2,420	Study for areas suitable for development of aquaculture in terms of spatial potential, water quality and nature conservation.
Slovakia	1,085	2,170	No new space; modernisation of existing locations.
Estonia	733	None specified	Areas suitable for aquaculture will be mapped.
Latvia	643	2,256	None specified.
Belgium	212	1,032 (By 2022)	None specified.
Luxembourg	0	0	Not applicable.
Total	1,279,417	1,757,214	Increase of 37.3% over 6-10 years

The production defined in the 27[14] country summary plans, for delivery by 2020 to 2025 is 1,757,214 metric tonnes, which is an increase of 37.3% over 2013 values, at a rate increase of just under 2.7% per year to 2025 across the EU28, across all environments and species, noting that environments and species vary between individual countries. This represents a substantial increase in production compared to the decline seen over the previous 13 years. The calculated rate of 2.7%, based on the country plan summaries (base year 2013 out to 2025, scaled to 2030, based on FAO production data), gives a prediction of 57.3% growth in aquaculture production overall by 2030. In 2014 Lane et al (2014) predicted increases of 100% in the culture of coldwater and warmwater marine fish, 40% in freshwater production and 30% in Shellfish output by 2030, using data from EiTIP (2012), using 2010 as a starting base. According to FAO data presented here (Table 2) production fell between 2010 and 2013 (this review baseline), but a comparison of the data shows Lane et al. (2014) predicted a 56.8% increase in

[14] No production in Luxembourg, so no need for an aquaculture plan.

overall production by 2030, against the 57.3% proposed in the country plans. Equivalent values at 2025 were 39.3% and 37.3% using Lane et al. (2014) and country plans respectively. At the time of this report there is no evaluation of the status of implementation. A mid-term monitoring and evaluation of these plans is due in 2017.

In the context of spatial planning, most of the summaries (available in English) of the aquaculture plans (available in national languages)[15] highlight the need to improve spatial planning for aquaculture and some propose how this might be achieved, through better mapping, use of technology such as GIS and undertaking studies to identify potential new areas. Few countries commit to increasing the amount of space allocated to aquaculture in any definitive way, however. It is noticeable that most of the freshwater producers do not see the need to allocate more space, simply to improve the infrastructure and modernise their production systems, to improve overall output. All countries, however, recognise the need for spatial planning as a key development, and nearly all countries realise that this requires integration of aquaculture into marine and land-based spatial plans, within which aquaculture companies and representative groups can become key stakeholders, and not simply have arbitrary limitations or unfavourable proposals thrust upon them.

[15] In analysis completed for this study there are differences between the country aquaculture strategic plans used in this study, and proposals defined in EMFF Operational Programme reports, which each country produced in 2014. In analysis, 19 of the country plans assessed that production is above that proposed in EMFF documents and 8 country plans were below that defined in the EMFF operation programme documents. At 2023 there is an apparent 246,747 T excess within the country plans, compared to EMFF submissions.

Aquaculture production statistics and country plans - Key Observations

- National law, policy and industry definitions of what constitutes 'aquaculture' varies. This makes it difficult to contrast production figures and determine trends both of which are fundamental for effective future spatial planning.
- There are variations in the plans proposed in each country's aquaculture multi-annual strategic plans and those defined in EMFF Operational Programme reports produced in 2014. 19 of the country plans were above EMFF data and 8 were below. There is a need to reconcile the two sets of conflicting information being used at EU level, and perhaps this can be achieved at the mid-term review in 2017.
- FAO production figures indicate that there have been changes in overall production, which impacts our view of stagnation in the industry and has consequent implications for the type of planning needed, as well as the tools/data necessary to implement such planning.
- Significant reductions in production in some of the largest producer countries has negatively affected overall production, and although remaining countries continue to increase their output, this is insufficient to offset the larger reduction in aquaculture output and consequently the recognised need to increase aquaculture production within the EU.
- Over three-quarters of aquaculture production occurs in marine waters, with just under one-quarter produced in freshwater. Planning policy needs to recognise these differences and focus accordingly.
- Most marine aquaculture occurs in inshore waters that will probably not come within the scope of the MSP Directive and associated Plans. Future plans will need to be cognisant of this fact so that objectives align and implementation can be effective.
- Identifying exactly how much space European aquaculture currently utilises is not easily determined with few analyses conducted to date. Having a means to determine this is critical.
- The amount of space needed for current levels of aquaculture production, in marine and freshwater environments, is very small, relative to the space available.

3. Survey and workshop on spatial planning for aquaculture

3.1 Introduction

In any review, to support quantitative data there is a need to gather qualitative information that is not always available through literature or is otherwise difficult to access. For *AquaSpace*, project partners agreed that case studies (through Workpackage 4) would provide localised instances were spatial and other characteristics could be undermining industry's ability to increase aquaculture production (see D4.1). This was complemented by additional stakeholder opinion derived through a questionnaire paired with an associated Workshop that discussed the questionnaire outcomes and drew broad conclusions and recommendations to feed into the overall review process.

3.2 Context

The research findings here have been developed in the framework of the *AquaSpace* project to support optimisation and increased use of space for aquaculture by considering how this can be achieved through application of the EAA (FAO, 2010), MSP and land planning and other instruments, to deliver food security and increased employment opportunities through economic growth.

Governments assume the need for a better governance framework that applies a more integrated aquaculture planning and management approach, with an increased level of recognition by policy makers within the European Union and nationally that this must include the potential of the EAA, translated in regional and international efforts to create enabling environments for the sustainable development of aquaculture.

In a global context, the Code of Conduct for Responsible Fisheries (FAO, 1995) outlines that "*States should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities*". Furthermore, the EAA is considered as the main instrument in which the framework of aquaculture planning should be developed globally (FAO, 2010), with the link between spatial planning and EAA pushing through success and sustainable development of aquaculture (FAO and World Bank, 2015). Holistic approaches in planning for aquaculture have been identified as a critical component of overall management. GESAMP (2001) recognised some 15-years ago that the only way to address the complex interactions between resources, ecosystem and resource users, and to promote sustainable aquaculture development in the coastal zone is through a more integrated approach; in the framework of some form of integrated spatial management.

Similarly, EU Directive 2014/89/EU establishes a framework for MSP and aims to have Member States contribute, through national maritime spatial plans, "to the sustainable development of energy sectors at sea, maritime transport, fisheries and aquaculture sectors, and to the preservation, protection and improvement of the environment, including resilience to climate change impacts"[16], although no similar Directive exists for land-planning as that remains a Member State competence, not an EU one. On a sector-basis, the Strategic Guidelines for the Sustainable Development of EU Aquaculture (EC, 2013a) highlight strategies for "securing sustainable development and growth of aquaculture through coordinated spatial planning".

Furthermore, aquaculture planning policies have been directly addressed in the last reform of the Common Fisheries Policy (CFP) in 2013. Member States are required to establish non-binding strategy guidelines as a multiannual national strategic plan that, among other things, aims at "integrating

[16] Article 5.2

aquaculture activities into maritime, coastal and inland spatial planning"[17]. These multiannual plans shall include some objectives and measures for achieving aquaculture development, and among others, shall guarantee "reasonable certainty for aquaculture operators in relation to access to waters and space" which, can only be achieved with an aquaculture planning process. Finally, the Commission shall encourage the exchange of information and best practices among Member States and shall facilitate the coordination of national measures foreseen in the multiannual national strategic planning[18] concerning business security, access to Union waters and space, and simplification of licensing procedures.

To date coastal management and planning has been largely based on sectoral-based approaches to management: tourism planning, fisheries planning, aquaculture planning, harbour planning, etc. Evidence, however, from the literature and the survey suggest important strides towards the application of several of the principles contained in the EAA, even without explicit recognition to the approach (FAO, 2012: 140).

In general, therefore, there is compatibility between the current approaches of the EU and the more global approaches advocated by FAO. What was needed was to gain perspective from an international group of experts to 1) identify the main drivers for zone planning and area management of aquaculture, including governance, environmental and socio-economic considerations and 2) to summarise the steps and approaches implemented for spatial planning for aquaculture, identifying the major gaps, the barriers to implementation and steps to conform to the ecosystem approach to aquaculture.

3.3 Approach

The questionnaire survey on aquaculture was co-ordinated by the FAO and formed the first part of a paired approach to obtain stakeholder perspectives with outcomes from the questionnaire being presented at the second part, a dedicated Workshop held on the 18th – 19th February 2016 in Venice. The basis for the questionnaire and workshop design were consideration of spatial use for aquaculture in the context of zoning, site selection and area management (FAO and World Bank, 2015). Questionnaires were based on a previously tested approach used in other parts of the world by project partner FAO, adjusted and extensively tested within the consortium prior to deployment, collation and analysis between September 2015 and January 2016. To capture sufficient information two questionnaires were developed for country specific responses covering Mediterranean countries of the General Fisheries Commission of the Mediterranean (GFCM) and other European countries (Non-GFCM, where only introductory information was different), along with supranational entities and industries that were not country specific, such as European level trade associations and insurance. The experiences of International partners were also included.

Questionnaires were released through a web-portal and completed anonymously, but specific invitations were made to approximately 100 known and identified individuals, to complete the online survey which was by invitation only. Respondents completed the survey in November 2015 and the analysis was finished in January 2016. FAO led feedback and analysis from respondents in GFCM countries, to conform with their existing terms of reference to support Mediterranean aquaculture. Other analysis was completed by partner UCC. However, the terms of analysis were agreed prior to any review of responses, and analysis was completed to an agreed format to ensure cross – questionnaire consistency.

[17] Article 34(1)(e) of Regulation No. 1380/2013.
[18] Article 34(6) of Regulation No. 1380/2013.

Following analysis of responses, a sub-set of those initially invited to complete the survey, were invited to a workshop in Venice. The workshop had two key aims: (i) to present and discuss key findings from the questionnaire survey, and (ii) to draw main conclusions for spatial planning and management of aquaculture in the context of the project for policy-makers. The workshop, AQUACULTURE ZONING, SITE SELECTION AND AREA MANAGEMENT - Assessment of policy-management issues was organised by partner FAO/GFCM, and hosted by *AquaSpace* partner BLUEFARM s.r.l. Workshop participants included experts from a range of sectors, including government, industry (including trade associations and insurance) and research. European coverage and international coverage was extensive and included stakeholders from: (i) 9 countries of GFCM area of competence; (ii) 6 countries of other parts of Europe; (iii) United States of America and Canada; (iv) work package leaders of *AquaSpace* (v) workshop facilitators. Total attendance was 44 individuals (see MS5 for names).

The workshop was arranged as follows:

- Technical background with presentations on different aspects related to aquaculture zoning, site selection and area management;
- Review and discussion of key findings from the questionnaire survey and analysis (Section 3.4);
- Working groups (WGs) discussions focusing on main aspects related to management topics on spatial planning (Section 3.5).

A summary report was prepared and issued to all project partners, to keep them informed of the process undertaken and key findings (Milestone MS5).

3.4 Questionnaire on spatial planning

The questionnaire design was based on the recently published FAO and World Bank (2015) Policy Brief – "Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture" and developed in close collaboration with *AquaSpace* partners. It contained 48 questions under seven headings, namely: Law and policy framework for aquaculture; processes and steps for aquaculture spatial planning; zoning; site selection; aquaculture management areas (AMAs); spatial technology; and public perceptions of aquaculture.

The research design allowed the gathering of qualitative perceptions on aquaculture spatial planning based on the three profiles of respondents. Their perceptions were adapted from the Likert scale included in the questionnaire to a numerical scale ranging from 1 to 5 (Table 6).

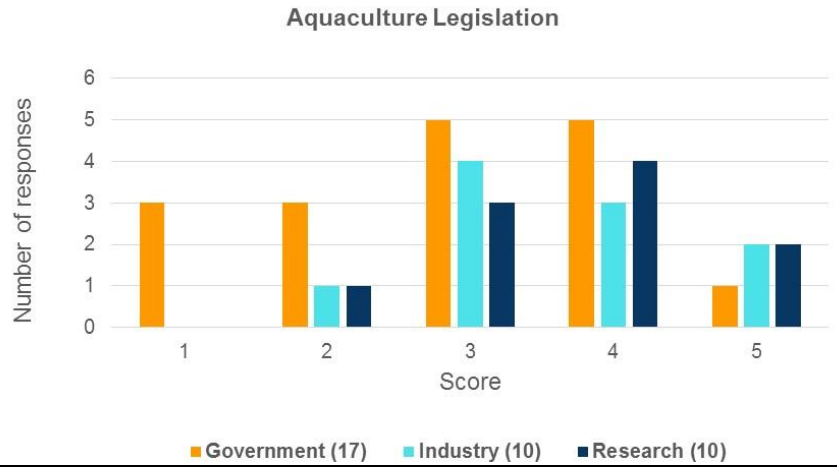
Table 6: Adaptation from the Likert scales of the responses to a numerical scale.

Likert scale	Numerical translation
No, there is no process/mechanism/regulation in place.	1
There is a minimum process/mechanism/regulation in place.	2
Yes, a process/mechanism/regulation is/are somewhat present and implemented.	3
Yes, a process/mechanism/regulation is/are present and implemented to a good extent.	4
Yes, a process/mechanism/regulation is/are present and widely / fully implemented at the ground level.	5

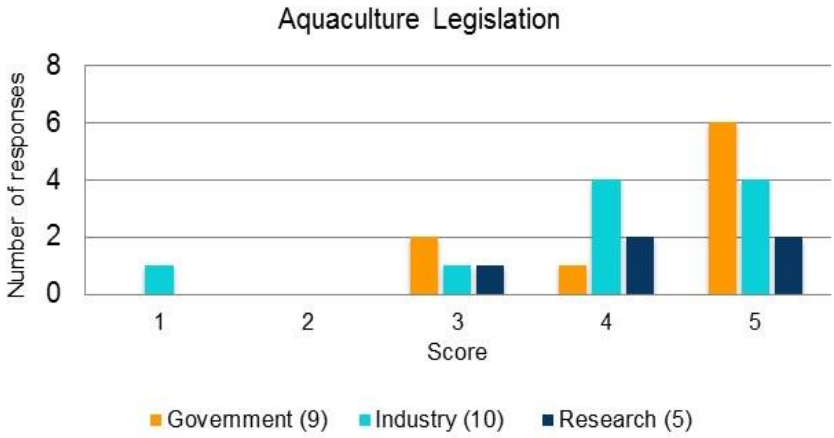
Overall, the effective response rate was an encouraging 47% and an example of the type of questions posed and the graphical analysis conducted is given below – full details are available in the *AquaSpace* reporting under Milestone MS5.

Question posed: In your country, is there any specific legislation regarding aquaculture activities?

GFCM Response



NON-GFCM Response



Question posed: How important is specific legislation regarding aquaculture activities to execute your activity?

Supranational Response

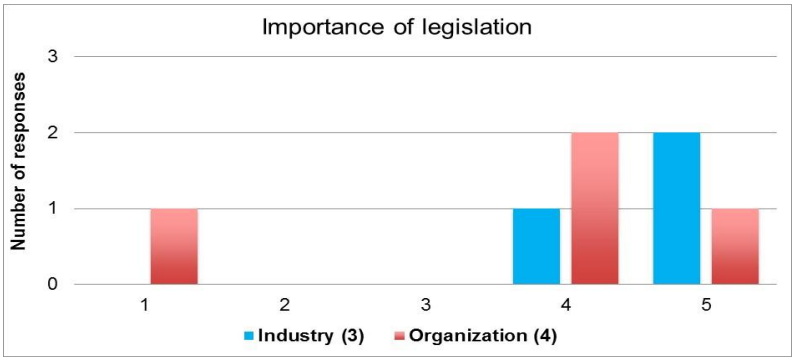


Figure 3 Example Question and Analysis of Responses to AquaSpace Questionnaire

This questionnaire returned responses to 48 questions[19] from the GFCM, non-GFCM and supra-national respondents and key outcomes from these were subsequently presented to participants attending the Workshop. For the GFCM, at least one response was received from each of the 21 surveyed countries in the Mediterranean and Black Sea region. In this region, there was a total of 37 respondents; 17 were experts from government institutions, 10 from the aquaculture industry and 10 from research institutions. Industry stakeholders included aquaculture farmers and representatives of aquaculture farmer organisations from finfish and shellfish sectors. Some respondents that were classified as researchers also act as experts working for government institutions.

For the non-GCFM, 24 responses from 10 different countries were received. Nine respondents were experts from government institutions, 10 from the aquaculture industry and five from research institutions. Industry stakeholders included aquaculture farmers and representatives of aquaculture farmer organisations, representing both finfish and shellfish aquaculture. There were seven responses from supranational groups.

3.5 Workshop on spatial planning for aquaculture

3.5.1 Technical background

As an introduction for workshop participants, several presentations were given covering:

a) CCRF compliance, considering social, economic and environmental aspects of a potential development location, where the planning process allows mitigation of both potential conflicts with other users and negative impacts on the ecosystem, which underlined the need for an appropriate regulatory system to support spatial planning for aquaculture activities Presented by FAO;
b) Aquaculture zoning, site selection and area management concepts in which the main steps were described and examples from 10 case studies given, soon to be presented in an FAO publication (FAO, in press). The importance of a relevant regulatory framework that considers national and local peculiarities and capacities to proceed with spatial planning was highlighted, along with the need for spatial planning for aquaculture to be pragmatic, systematic and flexible to achieve acceptance and implementation. Presented by FAO;
c) Allocated zones for aquaculture – a GFCM perspective, in which the experiences of GFCM partners were outlined. Presented by FAO.
d) Spatial perspectives on aquaculture management in Canada, and work in relation to marine spatial planning, covering a range of users, including aquaculture. The presentation noted that Zone Management and Biosecurity Area Management are going to be new required standards for the Best Aquaculture Practices Certification. Presented by Dalhousie University.
e) Presentation of results from the questionnaires in GFCM and non-GFCM countries (by FAO), supranational responses (Presented by UCC) and analysis.
f) Interpretation of results (Presented by FAO).

The summary of drivers and barriers showed that a legal framework for aquaculture planning was generally widespread although not necessarily yet broadly implemented; and that aquaculture zoning was the most applied of spatial planning tools in countries. Also, the results indicated that there was a general lack of incentives used to foster the implementation of aquaculture planning, at national and local levels; and that public perceptions of aquaculture vary greatly between countries and even within regions. In general, countries were found to use formal processes to consult stakeholders by means of public hearings and consultative meetings, although public hearings appeared as a default

[19] Responses to all question appear in the report sent to project partners under Milestone MS5.

mechanism, occurring even when other mechanisms are in place. A review was drafted based on the analysis of the questionnaire responses. The review provided an understanding of the main barriers that continue to occur which may limit future aquaculture development. These were:

- The bureaucracy in obtaining a licence.
- Conflicts for space use and resources.
- The negative perception of aquaculture.

The results of the survey also showed that the following elements were of concern to most stakeholders:

- better understanding and communication of socio-economic impacts and benefits of aquaculture activities.
- better known and definition of incentives for aquaculture and spatial planning development.
- crucial need for a leading body/institution to centralise and manage all aspects of aquaculture.
- critical need for stronger cooperation among countries to share better practices and lessons learned.

From the GFCM area, the five areas which received the lowest average scores, were considered as the main gaps/constraints. These areas were biosecurity, carrying capacity, coordination of competencies, opportunity-risk analysis and consultation with stakeholders. From the supra-national responses, central elements of agreement for further development of spatial planning were: the importance of existing legal frameworks specific to aquaculture, and development of a participatory approach for the establishment of potential zones/areas for aquaculture. Supranational organisations also highlighted that the terminology used and the lack of available and relevant scientific data on spatial planning for aquaculture were major obstacles to more general adoption.

2.3.3 Working Group Discussions

During the workshop, participants undertook two major exercises through working groups defined to 1) establish issues and solutions related to methods of spatial planning associated with zonation, site selection and area management and 2) to determine public perception constraints that impact local decision making on increasing spatial use for aquaculture in marine and freshwater environments.

1) Working Groups on methods for spatial planning: issues & solutions

Workshop participants were aggregated into three working groups (WGs) on i) zoning, ii) site selection and iii) management of aquaculture areas. Composition of the working groups was balanced per the background of participants, as follows:

i. WG on Aquaculture Zoning: 12 participants from 10 countries (3 from government, 6 from other industry and 3 from research);
ii. WG on Aquaculture Site Selection: 11 participants from 11 countries (5 from government, 3 from industry and 3 from research);
iii. WG on Aquaculture Management Areas: 12 participants from 8 countries (3 from government, 4 from industry and 5 from research);

Terms of reference were defined and each group was led by a chair, supported by a rapporteur. The working group process was defined and information captured using a template. Each group was tasked with identifying the main issues, gaps and barriers to aquaculture spatial planning and management and to prioritise these. They were further required to discuss potential practical solutions to these challenges. key elements from the discussions were shared and discussed during a plenary session with all participants.

i. Working group on aquaculture zoning:

In relation to policy norms, regulations and Institutional issues the group noted the following:

a) The existence of several EU Directives that impact zoning potential, such as the WFD and MSFD and felt implementation of these complicates the process of spatial planning.
b) There was a lack of coordination between national/regional and local levels of authority and occasionally an inability to include appropriate regulatory sectors in the planning/zoning process.
c) Development of aquaculture-only zones has with it an exclusivity risk that a zone defined for aquaculture of one species risks inhibiting development of new species or culture systems.
d) On land use, aquaculture implies the use of terrestrial infrastructures (building, storage etc.) that can be a challenge to obtain, even where "water space" has been allocated, which limits what can be done.
e) Licensing procedures are too long and difficult to obtain in many places, with the pre-licence investment needed to obtain licences being prohibitive for small farmers.
f) Zoning implies biosecurity risks, in which spatial requirements for biosecurity may be difference from zones defined for planning or biodiversity issues.

In relation to barriers for implementation (e.g. such as availability of tools, user rights) the group noted:

a) That increasing space for aquaculture requires new expertise that local govern and planning department often lack.
b) Aquaculture must be a part of an integrated management approach, not a distinct activity that ignores other users and use of space, to overcome potential conflicts.
c) There remains a need for scientific knowledge, particularly in relation to connectivity within and between zones (such as disease transmittance potential).
d) There are barriers to gaining information in relation to other prescribed uses of space (such as tourism) – which an integrated management approach may overcome.
e) Incentive are needed to encourage and reward communities that plan, zone and accept aquaculture. The example given was that of Norway where a percentage of the licence fee is given to local communities to develop projects. Similar schemes operate in other sectors, such as wind, in the UK for example.
f) Aquaculture technology is rapidly evolving and zoning needs to be flexible to accommodate innovation and the differing needs of various species (fish and shellfish, and to an extent algae), both for key species and for emerging species, and of aquaculture systems developed.

The group identified the need for authorities and specialised agencies to adopt a pragmatic approach, that has within it common guidelines and standardised procedures defined through appropriate authority guidelines and bound by research within European regions. The group recognised the need for a strong public engagement, in which local authorities play a key role in both promoting aquaculture zoning and public engagement. There was an over-arching need identified, to generally improve public perception and to ensure people understand and see aquaculture products as food and the role it plays in food security. Means to do this include more accurate estimation of seafood demand which translates into a better understanding of the number of "sites" needed to fulfil this requirement into the future, which will then determine how many zones need to be consolidated or established. There was an acknowledged link to the Galway Atlantic Declaration in ensuring policy makers build the political will to achieve aquaculture growth across the Atlantic countries, with, where possible, agreed standards on approaches to be implemented.

ii. Working group on aquaculture site selection:

In relation to policy norms, regulations and Institutional issues on site selection, the group noted the following:

a) The need for clearly defined guidance and policy development for aquaculture zoning
b) The need for guidance on implementation and competency of individuals and organisations implementing policy, with associated clear guidance on strategy for site selection.
c) Having a clearly defined lease period, providing exclusivity for long enough to encourage investment in sites.
d) Guidance is needed on the process of permitting and licensing, and some specification on duration of the stages in any procedure to provide clarity for all parties.
e) Identification of a mechanism for consultation for farm site selection, between private and public sectors.

In relation to barriers for implementation (e.g. such as availability of tools, user rights) the group noted:

a) The need for need for a participatory approach, that encompassed a number of stakeholders.
b) The undertaking of a compliance review would be useful to determine information on leasing periods, and technological, environmental and social compliance undertaken by industry.
c) Provision of guidance, based on best practice for the developer / investor

In terms of practical solutions, the group identified the need to be more transparent in siting decision making, and noted development of the Aquaculture Investor Index within *AquaSpace*, as a useful tool to improve this transparency across Europe. The group noted the work being undertaken in the case study activity within the project and perceived lessons could be learned from such as approach, both at national and regional levels. In siting decisions, it was important to identify areas that favoured aquaculture and also areas where aquaculture will be prohibitively difficult to establish. Having this national view of not only where aquaculture can be carried out, but also where it cannot, would save unnecessary investment in locations that would otherwise be off-limits. In this there was a need to ensure authorities and policy makers were not using aquaculture, as a means to gain data (e.g. through EIA) about particular locations that authorities had failed to collect directly, especially if the site was then never a possible location for aquaculture. In the long term the use of data paid for and collected via aquaculture companies (e.g. in achieving monitoring requirements) to improve our understanding of local environments was encouraged. In relation to the Atlantic Galway Declaration, sharing of best practices in site selection, and building capacity to enable grower groups to share information and provide cross boundary case studies (e.g. shellfish aquaculture potential for nutrient mitigation and nutrient trading).

iii. Working group on aquaculture area management:

In relation to policy norms, regulations and Institutional issues on site selection, the group noted the following:

a) Where they had been implemented, management frameworks on area management had been established after aquaculture development had taken place, so new proposals had to deal with both historical norms and legacy issues.
b) There is a definite need for adaptive management and a flexible approach to management of areas, with the ability to change after establishment as new information becomes available, with perhaps a regular review process instigated.

c) There was perceived to be a lack of understanding by government managing authorities concerning aquaculture operations and the changing nature of the marine environment, in particular; compared to the farmer and to some extent the research sector who have much more regular contact with local conditions.
d) Recognised the need for government managing authorities, farmers and research communities to work more closely in how areas are managed.
e) There is a lack of joined up thinking between parties, where a co-operative approach provides for a distinct market advantage.
f) There is a positive role for farmers' associations.
g) Blanket Decisions on closed areas – closed due to proximity rather than actual disease.
h) Lack of standard approach / clarity of approach / availability of facilitators.
i) There are too many regulations, and that these regulations are not always consistently implemented across regional and national boundaries, particularly where transboundary issues occur.
j) The economic benefit of aquaculture, and especially of ancillary industries including processing, is not recognized as a major benefit.

In relation to barriers for implementation in area management (e.g. such as availability of tools, user rights) the group noted:

a) Lack of consistent branding that promotes standards of compliance, that if adhered to can improve saleability, and to some extent farmers being "self-regulating" through for example, better application of shared costs of monitoring.
b) Objectors to aquaculture tended to constrict farmers to single sites, whereas from an environmental point of view it may be better farmers to achieve multiple location within a site to rotate location, and thus reduce the overall impact of multi-year culture in one location.
c) There is often a lack of compatible use (Tourism v Aquaculture) with other users whereby competition for space sees other sectors favoured over Aquaculture, for the lack of any integrated approach. The group noted that "aquaculture tourism" (to extend the example above) can work if organised in tandem with tourism development. The group noted, however, that biosecurity could be an issue, as a result of large numbers of tourists visiting sites, with a limited control over unhygienic practices.
d) Time lag between measurement and results by statutory agencies – lack of funding for statutory agencies – regulatory capacity.
e) Technology - Lack of data, capacity to utilize, limit of capabilities of GIS (or GIS not properly populated).
f) In relation to the use of areas for aquaculture that are offshore the group questioned whether it is really practical in a European context (*sic* deep water and unpredictable current and wind regimes), and whether using such space for aquaculture is economically viable! There was also some discussion over what is meant by "offshore" on open coasts, and there was no agreed definition forthcoming.
g) Within areas, it requires a different mode of area management when multiple companies are using the same space, compared to single large producers occupying all the space, not least in disease management for example. There is also potential for "large company influence" when one company dominates.

In addressing some of these issues the group felt the *AquaSpace* case studies through Workpackage 4 could provide exemplars and proactive approaches to resolving issues and highlighting enabling

conditions. Part of the reason for decline in production was a licensing issue and there needed to be some form of analysis (at national level) to identify the reasons why this was the case. The group understood the need to bring parties together and to work collaboratively, particularly industry and researchers, to influence policy decisions and to aid in the collation and assessment of available tools for area management evaluation. Like other groups, this group also highlighted the need for aquaculture, as an industry, to highlight the benefits of aquaculture production. One area where the Atlantic Galway Declaration could benefit is offshore aquaculture, with research to evaluate economic and ecological potential, as has been done recently for Integrated Multi-Trophic Aquaculture (through the FP7 IDREEM project[20] and partner projects in Canada for example).

2) Working Groups on public perception and civil society: issues & solutions

Based on the same distribution used for the first exercise, participants were divided into three WGs simulating specific categories of stakeholders; respectively i) consumers, retailers and the market in general; ii) NGOs and civil society organisations in defence of nature and social aspects; and iii) tourists and coastal home-owners. Composition of the working groups was balanced per the background of participants, as follows:

i. WG as consumers, retailers and market in general: 12 participants from 10 countries (3 from government, 6 from other industry and 3 from research)
ii. WG NGOs and civil society: 11 participants from 11 countries (5 from government, 3 from industry and 3 from research)
iii. WG as tourists and home owners: 12 participants from 8 countries (3 from government, 4 from industry and 5 from research)

Once again terms of reference were defined and each group was led by a chair, supported by a rapporteur. This working group process was defined and information captured using a template. Groups were tasked to adopt the role of a particular sector and consider, investigate and discuss, based on the perspective of this allocation, what they did not like about aquaculture and what the aquaculture sector could do about it and whom should lead the work. Key elements from the discussions were shared and discussed during a plenary session with all participants.

i. Working group as consumers, retailers and market in general:

In relation to what is not liked about aquaculture the working groups determined that there were four key elements that concerned consumers, retailers and the market, namely:

a) There is a lack of knowledge about what fish consume in their diets, referencing for example dioxins, which, some years ago, had a large public interest. There were issues related to Food safety antibiotics, colouring, GMO feeds and other chemicals Farmed fish shellfish are dangerous for your health and Farmed fish are GMOs.
b) Concern over nutritional values in the product, with aquaculture products perceived as being Less nutritious than wild counterparts.
c) Concern on environmental issues, with a general perception that consumers were under the impression that the farmed environment of some species is very contaminated and has large environmental impacts; that there were Impacts on food safety because of the perceived poor quality environment. It was also perceived that consumers were concerned about escapees and their impact, particularly on wild stocks, on chemicals used in the production process and, more generally, concern about the use of fish mean and fish oil, with implications on fisheries.

[20] See http://www.idreem.eu/cms/wp-content/uploads/2016/10/IDREEM_FINALREPORT_PRINT_710_web_2.pdf

d) Finally, there was a perception that aquaculture products are too expensive compared to other fish, despite the lack of ability to differentiate between farmed and wild fish. Working group members had also heard stories (anecdotal) that labour conditions were inappropriate and cheap labour was being used to keep costs down.

When asked to consider what the industry could do to overcome these perceptions, with an emphasis on spatial aspects in particular, the WG suggested the following solutions:

a) Provide more information to the consumers on food health, nutrition; used to inform consumers how are the fish farmed and what are they fed (possibly through labelling or certification); develop systems of traceability and provide basic information on this on all products, including clarification over point of origin; consider the implications of introducing aquaculture in to school programmes and educational materials for health care professionals; and finally, educate among other chefs (use of master chefs and food producers), Journalists, culinary schools, and policy makers on the virtues of farmed aquatic products.
b) Produce suitable posters covering the aquaculture species life cycle, including breeding and selection, and processing.
c) Introduce cameras in the cage and have a live show near the retailer post or market point of sale.
d) Use information technology; including APPs to offer information about the farming process.
e) Inform consumers that the farmed fish are produced following regulations, including for imported farmed fish.
f) Government provided or facilitated certification/fish watch.
g) Better promote positive stories about aquaculture, such as the ecosystem services provided by aquaculture.
h) Improve transparency.
i) Avoid negative propaganda to other farmed fish even if they are competing within local markets (one aquaculture image).
j) Increase the use of comparative “footprints” against other food products (e.g. better evaluation through life cycle analysis).
k) Get more information to the media.
l) More transparency in the value chains and explain the process and costs of the different steps
m) Encourage consumer to eat only farmed products that are properly labelled and or certified that define the environmental and social standards employed in producing the project.
n) Improve the image and joint benefits of all seafood, whether farmed or wild caught (culture and capture working together).

In a spatial context, the WG defined the idea of providing information from an ecosystems perspective, within which carrying capacity had been considered, and the application of area management agreements to collectively “steward” the local ecosystem through marine spatial and land planning. The spatial planning process should involve communities to create ownership and to improve aquaculture perception at a local level.

ii. Working group as NGOs and civil society:

In relation to what aspects of aquaculture the working group disliked with reference to NGO and civil society issues, the following concerns were raised:

a) Wild stocks.
b) Negative impact for small scale fisheries.
c) Escapees, genetic erosion to wild stock.
d) Micro plastics.

e) Fish meal.
f) Need for transparency with regards to information (e.g. labelling).
g) Transport of pathogens.
h) Social problems.
i) Ghost net from cages.
j) Too many birds.
k) No space for tourism.
l) No benefits from local communities.
m) No information about pathology and mortality rate.
n) Small aquaculture farmers destroyed by big companies.
o) Impact on the local food and local communities.
p) No communication with NGO and local communities.
q) Feed company control.
r) Food print climate impact.

Asked about what the industry could do to overcome these perceptions, again with an emphasis on spatial aspects, the WG on NGOs and civil society defined the following solutions:

a) Have high containments, stop fish escapees. Site control. Hydrodynamic modelling of connectivity among sites. Regional bio-security planning and research.
b) Specific implementation/regulation of management planning, to improve interaction with all stakeholders, with appropriate data collection and transparency of information sharing.
c) Facilitate the use of biodegradable plastics, where possible, in the aquaculture production process, particularly in marine and open water environments.
d) Focus on fish in/fish out values, to provide evidence of high nutritional quality of culture species, and contribution to improving public health.
e) All products to be labelled, per international standards; with the public educated and informed of this.
f) Monitoring system and surveillances for escapees, environmental footprint altogether.
g) Adoption of best management practices across the sector and auditing to review compliance.
h) Ecotourism campaign. Education. Evidence of positive impacts.
i) Any kind of incentive, tax or other, that could support the creation of local jobs.
j) Enforcement of reporting systems, including for example the application of antibiotics, showing how the regulation on antibiotic use are enforced and making this information available to consumers.
k) Improve the role of the small-scale farms in the local community in terms of communication.
l) Work is being undertaken on areas such as carbon footprint, with pilot scale trials being undertaken in marine fish production. Results have been good for shellfish production.
m) Transfer of research to farmers.
n) Improve role of farmer organisations.
o) Improve the visibility/impact of aquaculture sector within UN systems, including the FAO, and within international bodies, particularly the EU.
p) Participants recognised that National plans exist for each EU Member State, and felt appropriate action plans were needed to move the plan into positive action.
q) Guarantee funds to support development of aquaculture.
r) Role of research to be better defined and that role communicated to all.
s) Need to improve the science/policy interface.
t) Use of multi-stakeholder platforms at different levels including, regional, national, and local.
u) Local actions groups to help move from a strategy into action.

iii. Working group as tourists and home owners:

In relation to tourists and homeowners, of specific relevance to Mediterranean and North European countries respectively where planning applications are often rejected because of objections from the two primary groups, and what issues they have with aquaculture, the following was noted:

a) Visual pollution was an issue, with the perception that it impacts (reduces) property values.
b) Pollution issues, particularly at beaches, because of plastic debris, slimy beaches, and nutrients in the water from fish farms that was perceived as being not safe for swimming.
c) Genetic pollution was perceived to be an issue for sport-fishermen with the genetic influence on wild fish from escapees.
d) Disturbance issues, in relation to the need to maintain operations 24 hours a day, seven days a week, the associated noise pollution and perceived bad smells from sites.
e) There is often competition for space, particularly in navigation for sailors, and tourists in general.
f) There was a perception that home owners are concerned primarily about their "own backyard", but also the environment more generally.
g) There was recognition that home owners cannot avoid farms, whereas tourists can and that there may be some envy about farms "making lots of money" using common grounds.

When considering what the industry could do to overcome these concerns and perceptions, with regard to spatial aspects in particular, the WG on tourists and homeowners defined the following solutions:

a) Improve social acceptability in the local community.
b) Government has a clear role through clear spatial planning to reduce conflicts; Government endorsement; providing clear standards for operations but also emphasising the good quality and safety of farmed products.
c) Create synergy between aquaculture and tourism: open farm days, seafood festivals, sponsoring of good local causes (e.g. sport events).
d) Promote the consumption of locally and sustainably produced food.
e) (Eco-) labelling of farm products to certify sustainability.
f) Increase the direct benefits to the local community (through some form of tax revenue that comes back to the local community)
g) Communicate the socio-economic benefits (e.g. jobs) to the area.
h) Farmers make efforts to reduce impact of farm activity (particularly visual impact, noises and smells etc.) and communicate these actions to the community.

In a more spatial context, the group noted the need to educate local legislators on the contribution of spatial planning to prevent conflicts in the coastal zone; where the aim and purpose of spatial planning for aquaculture is clearly defined, and communicated; including the link to ICZM. There was recognition that spatial planning requires the input from locals, including home owners and tourist operators as directly affected stakeholders, but the question remained about how this could be implemented.

3) Overall conclusions of the workshop/questionnaire approach

The outcome from the questionnaire were utilised to stimulate debate and to thus inform the subsequent workshop working groups' session and Plenary discussions. The observations, discussion outcomes and outputs from the WGs sessions were presented in plenary by the Chairs of each WG. During the ensuing discussion, some participants shared their experiences of spatial planning and the importance of having a good legal system and governance structure for aquaculture to improve

development and performance of the sector was emphasised by many. The Norwegian participant stressed the importance of social acceptability and public awareness of the benefits provided by the aquaculture industry which, in turn, enhanced the development of the sector. In relation to spatial planning, the analysis of the questionnaire results showed that, for the most part, key elements dealt with the same global issues. Within the three WGs, barriers/obstacles referred to

a) A common lack of efficient implementation of existing policies on aquaculture, lack of a clear distribution of power and responsibilities.
b) Poor social acceptability.
c) Low technical knowledge and understanding of spatial planning concepts.
d) Lack of meaningful communication between relevant stakeholders and how they are involved in the planning process.

During the discussion, it appeared that some local specificities exist in both Northern and Southern Europe, particularly regarding the nature of conflicts of spatial use, primarily from property owners in Northern Europe and from tourism in the Mediterranean. In relation to public perception, results showed that perceptions of aquaculture activities differ by category (i.e., consumers, retailers and market; NGOs and civil society organisations; tourists and coastal home-owners). However, in general terms the concerns were globally related to the same main areas, on food safety and environmental impacts.

The agreed outcomes from the questionnaire and workshop approach were:

- In many countries, policy on aquaculture addresses the general principles enshrined in the CCRF, but not necessarily in the same manner. The preparation of common basic rules for licensing and certification processes is essential to harmonise practices and enhance coherence and legal predictability, to build a good environment for sustainable aquaculture development.
- The perception of aquaculture is a driver for development of the sector. Efforts should be undertaken to enhance promotion of aquaculture production and its significant benefits.
- The existence of relevant data on aquaculture production is at the heart of good governance. It allows the responsible authorities to monitor the progress accomplished and determine the next steps and development opportunities. A strong focus should be placed on stimulating countries and to provide relevant stakeholders with up to date and reliable data (including production information, ecological data, etc.).
- A high level of social acceptability would decrease the potential for conflict with other sectors. Based on this, participatory and cross-sectoral approaches should be progressively adopted throughout decision-making, planning and management processes.
- The implementation of management plans for aquaculture zones could be facilitated by the application of specific knowledge-based tools (e.g., GIS, guidelines, etc.). For the latter, technical assistance would be needed.

The agreed conclusion and recommendations resulting from the questionnaire and workshop approach were:

- A strong and predictable legal framework is essential to overcome the main constraints hampering the development of sustainable aquaculture, in which spatial planning is a key element.
- General orientations and recommendations provided by supranational bodies offer wide operational freedom to the countries that have responsibility for developing their own methodology. In this regard, there is a need to develop a common and solid foundation for licensing, to harmonise practices.

- One of the major barriers in the implementation of aquaculture policy is lack of knowledge and public awareness on aquaculture. For this reason, initiatives to better acknowledge aquaculture and the benefits it brings, including food security and positive interactions with the environment on which it relies, are essential to enhance social acceptability.
- A participatory approach should be as broad as possible, for the creation or allocation of new areas for aquaculture activities. Additionally, the acknowledgement of new aquaculture farms and their activities and production at a local level allows a better and earlier acceptability by the local population. Special attention should be paid to make the public aware that the aquaculture industry is mainly composed of small family farms and not big multi-national companies with a large production, although this varies from country to country and sector.
- There is a need to address the negative perception of aquaculture being commonly regarded as something ugly, smelly and polluting. Promotional efforts should be undertaken to raise awareness that aquaculture could be sustainable and visually pleasing and to incorporate advanced technologies to minimise different externalities.
- The socio-economic benefits to local communities need to be significantly increased, to enhance awareness and support to local people. Frequently, governments have forced local municipalities to consider aquaculture activities, but with no incentives given to encourage municipalities to put farms in place. A better sharing of profits and benefits between national and local levels and the creation of incentives would be a good solution.
- The principle of ecological borders, which are considered acceptable by science and on which production should be based, need to be identified and applied. Communication on this aspect is essential to enhance understanding and support from localities and to have good involvement of the aquaculture industry to comply with such measures. This aspect stresses that environmental externalities are not necessarily matched with national boundaries and multi-country solutions may be needed.
- The elements discussed during the workshop were generally more related to the governance aspects of aquaculture. A better understanding of how other sectors addressed these kinds of difficulties and the sharing of their success stories could help to determine next steps for aquaculture development.
- The development of aquaculture activities implies the availability of sufficient healthy environments and increased spatial use. For this reason, aquaculture farmers should pay attention to, and take care of, existing and future production areas.
- Any excessive rigidity in the spatial planning process and operational tools applied would constitute a great barrier for the adoption of spatial planning approaches. From a legal perspective, it appears problematic to have frequent changes of site, for example. In this light, aquaculture planning should adopt an adaptive management strategy through broad participatory consultation, to accommodate all potential future developments.

Workshop on Spatial Planning for Aquaculture - Key observations

- The questionnaire and workshop was a paired approach to ascertain Government, industry and researcher views about increased use of space for aquaculture and barriers and solutions to aquaculture stagnation in the EU.
- The FAO, through the Code of Conduct for Responsible Fisheries (1995), advocate that States produce and regularly update aquaculture development strategies and plans. This has now been taken forward through CFP reform and specifically the Strategic Guidelines for Aquaculture (EC, 2013a).
- The EEA is viewed as the main instrument in which the framework of aquaculture planning should be developed globally and there is compatibility between the current approaches of the EU and the more global approaches advocated by FAO but there remains a significant amount to do in terms of implementation and coherence.
- There is a legal framework for aquaculture planning in most countries but implementation of this varies, which has substantial consequences for growth of the industry.
- Aquaculture zoning is the most applied spatial planning approach in the countries represented at the workshop. Experiences with this approach should therefore inform the development of Maritime Spatial Plans and locally-relevant coastal plans under national legislation or equivalent.
- The workshop found that there is a general lack of incentives to foster the implementation of aquaculture planning, at national and local levels, and that this needs to be addressed.
- Participants at the workshop were of the opinion that public perceptions of aquaculture vary greatly between countries and within regions. Lack of knowledge and public awareness on aquaculture can have implications for development planning in both the short and longer term.
- The legal framework, and resultant consenting processes, should facilitate knowledge exchange on the benefits of aquaculture at the local/regional level (economic, socio-economic, environmental).
- On occasion, workshop participants stated the legal framework is excessively rigid and does not facilitate adaptive management processes which could assist in both environmental protection and sectoral growth.

4. Maritime Spatial Planning

4.1 Background

MSP is a relatively contemporary approach to planning when and where activities take place in sea spaces and to ensure that such activities are as efficient and sustainable as possible. Conceptually MSP seeks to balance economic, social and environmental objectives. MSP is a process that is ecosystem-based, integrated, adaptive, strategic and participatory. At EU level, the European Commission has been working on MSP since the launch of the EU's Integrated Maritime Policy in 2007 and subsequent Action Plan where MSP was advocated as one of a range of approaches and tools which could help achieve more integrated maritime governance. In 2008 the Commission published a Roadmap for MSP: Achieving Common Principles in the EU which contained key principles so as to help ensure a common approach to MSP in the EU (EC, 2008a). The principles are presented in Box 1. In 2009, five workshops on MSP were held with Member States, industry representatives, NGOs and other groups as a way of establishing whether the principles of the Roadmap were appropriate and how MSP could be progressed in the EU. A Communication on the achievements and future development of MSP recognised the need to focus on cross-border aspects of MSP as well as creating a more common framework for Member States MSP efforts (EC, 2010). This was taken forward through the carrying out of an Impact Assessment which sought to explore binding and non-binding options for both MSP and ICZM.

Box 1: Common principles for MSP according to the European Commission (COM(2008)791 final).

Principles of MSP

1. Using MSP according to area and type of activity
2. Defining objectives to guide MSP
3. Developing MSP in a transparent manner
4. Stakeholder participation
5. Coordination within Member States — Simplifying decision processes
6. Ensuring the legal effect of national MSP
7. Cross-border cooperation and consultation
8. Incorporating monitoring and evaluation in the planning process
9. Achieving coherence between terrestrial and maritime spatial planning — relation with ICZM
10. A strong data and knowledge base

A stakeholder consultation exercise, conducted as part of the impact assessment, found that 43% of respondents encountered 'many' conflicts of space between or within sectors with 55% expecting these incidences to increase significantly in the future.[21] A comparison of three possible options put forward by the Commission (EC, 2013b), to address conflicting claims on marine space and unbalanced uses of sea space, found that a framework Directive on MSP and ICZM was the most suitable option. The Commission published a draft Directive establishing a framework for MSP and Integrated Coastal Management (ICM) in March 2013 (EC, 2013c). The draft, as published, sought to oblige Member States to undertake MSP and ICM through processes that cover problem identification, information collection, planning, decision-making, management, monitoring of implementation, and stakeholder participation. Critically the draft Directive did not set any new sectoral targets but rather attempted

[21] See http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/msp/summary-results-of-msp-questionnaire_en.pdf

to achieve more integration between existing objectives and policies which was viewed as a way of contributing to more consistent, coherent and coordinated management across the sea basins. A final version of the Directive was adopted in July 2014 following significant amendments and debate across numerous EU organisations and Member States. The final version of the Directive saw the requirement to develop ICM strategies dropped as well as a number of other, more subtle changes in content. Some of these changes were a result of individual Member State concerns relating to the draft Directive going beyond what was necessary, thereby potentially breaching the subsidiarity principle, to achieve the over-arching aims and objectives.

4.2 Directive requirements

Directive 2014/89/EU establishing a framework for maritime spatial planning provides a framework for MSP in Europe by setting out a set of common minimum requirements. Article 1 of the Directive states that MSP is aimed at "promoting the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources". The provisions of the Directive apply to marine waters of Member States but not coastal waters if they come within a Member State's town and country, or land-based, planning system provided this is stated in the Plans developed. Marine waters have the same definition as that used in the MSFD (2008/56/EC) and include the seabed and subsoil from the baseline (low water mark or straight baseline) to the outermost limit where a Member State exercises jurisdiction, usually 200 nautical miles. Coastal waters, where applicable, has the same definition as used in the WFD, namely, "surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters". Member States are required under Article 4 to establish and implement MSP and in so doing, to take account of land-sea interactions and the particularities of their marine regions as well as the impacts of existing and future activities and uses on the environment. The Directive allows Member States to build on existing policies, regulations or other mechanisms so long as they conform with the requirements of the Directive.

The objectives of MSP are contained in Article 5. This states that Member States should consider the economic, social and environmental aspects necessary to support sustainable development and growth in maritime sectors, apply an ecosystem-based approach, and promote the coexistence of activities and uses. Member States do, however, retain the ability to decide how different objectives are reflected and weighted in the maritime spatial plans developed. Minimum requirements for MSP are contained in Article 6 and reiterate the need to take into account land-sea interactions and environmental, economic, social and safety aspects. Member States should also aim to promote coherence between MSP, the resulting plan(s) and other processes, such as Integrated Coastal Management or equivalent "formal or informal practices". This is one of only two instances where ICM is mentioned in the substantive articles of the Directive; the other being in Article 7 which focuses on land-sea interactions, the use of other processes to achieve coherence and the need to reflect this within any plan created. Article 6 continues by stating that Member States should ensure the involvement of stakeholders, organise the use of the best available data, ensure trans-boundary cooperation between Member States and promote cooperation with third countries. Maritime Spatial Plans developed by Member States must be reviewed at least every ten years (Article 6(3)).

When creating a Maritime Spatial Plan, under Article 8(1), Member States are to identify the spatial and temporal distribution of relevant existing and future activities and uses in their marine waters. The Directive lists aquaculture areas; fishing areas; installations/infrastructures for non-renewable and renewable energy resources, minerals and aggregates; maritime transport routes and traffic;

military training areas; species and habitat conservation sites and protected areas; raw material extraction areas; scientific research; submarine cable and pipeline routes; tourism; and underwater cultural heritage as possible activities and uses that may be included. Public participation in the MSP process is covered by Article 9, which prescribes that all interested parties, stakeholders, authorities and the public are informed and consulted "at an early stage" in plan development and in accordance with existing EU legislation on this matter. Stakeholders and authorities must also have access to the plans once they are finalised (Article 9(2)). Article 10 relates to data use and sharing which covers environmental, social and economic data as well as physical data about marine waters and how to share information necessary for MSP. Member States are requested to make use of existing instruments and tools to do this such as those operating under the Integrated Maritime Policy and/or the INSPIRE Directive (Infrastructure for Spatial Information in the European Community, 2007/2/EC). Coherent and coordinated planning across marine regions, that takes account of transnational issues, is the subject of Article 11. This highlights the possibility of using existing structures for regional institutional cooperation such as those formed as part of the Regional Sea Conventions, networks of competent authorities across different Member States or any other method that fulfils this purpose, perhaps those used in the context of sea-basin strategies, developed under the Integrated Maritime Policy. Article 12 extends this cooperation effort to third countries and their work on MSP.

Articles 13 and 14 cover the implementation phases of the Directive. Accordingly, a competent authority, or authorities, for implementation of this Directive must be designated by each Member State. This information must be communicated to the Commission along with information on the legal and administrative responsibilities of that authority in relation to the marine waters concerned, the other institutions it cooperates with and relationships established and a summary of any regional coordination mechanisms established to fulfil the cooperation requirements. Copies of any maritime spatial plans developed must be sent to the Commission and the Commission also has an obligation to report to the European Parliament and the Council on the progress made in implementation of the Directive one-year after the deadline for creation of maritime spatial plans and every four years thereafter. Member States are required to transpose the Directive by 18 September 2016. By the same deadline, the competent authorities must also be designated. The first maritime spatial plans must be created as soon as possible, according to Article 15(3), but at the latest by 31 March 2021.

4.3 Implementation status

From the overview of MSP Directive requirements in the previous section it will be apparent that Member States are very much in the process of beginning to implement the Directive. This varies by Member State, as some States had already commenced implementation of MSP before the Directive was adopted. For other Member States, allocation of competent authorities and transposition of implementing legislation is underway. Table 7 presents the status of MSP Directive implementation, correct at the time of writing.[22] Where the status of Directive implementation is unknown in a particular Member State, the respective cells are left blank.

[22] 14 September 2016.

Table 7: Implementation of the MSP Directive in all coastal Member States (Source: EUR-Lex, 2017). Countries with an asterisk are members of the AquaSpace consortium.

Member State	Transposing Mechanism	Competent Authority
Belgium	Royal Decree of 20 March 2014. Marine Environment Act, 20 July 2012. Royal Decree of 13 November 2012.	Health, Food chain safety and Environment (federal public service)
Bulgaria	Maritime Space, Inland Waterways and Ports of the Republic of Bulgaria Bill [proposed].	Ministry of Regional Development and Public Works
Croatia	Physical Planning Act 2013, as amended.	Ministry of Construction and Physical Planning
Cyprus	No information submitted to EC as yet.	Ministry of Transport, Communications and Works - Department of Merchant Shipping
Denmark	Lov nr. 615 af 8. juni 2016 om maritim fysisk planlægning [Law on Maritime Spatial Planning] adopted 19/5/16.	Danish Maritime Authority, Ministry of Business and Growth
Estonia	Planeerimisseadus [The Planning Act].	Estonian Ministry of the Finance
Finland	Laki maankäyttö- ja rakennuslain muuttamisesta [Law amending the Land Use and Building Act] (482/2016) 17/06/2016. Laki Suomen talousvyöhykkeestä annetun lain 3 §:n muuttamisesta [Law amending § 3 of the Act on the Finnish economic zone] (483/2016) 17/06/2016. Valtioneuvoston asetus merialuesuunnittelusta [Government Regulation on Maritime Spatial Planning] (816/2016) 15/09/2016.	Finnish Ministry of the Environment
France*	LOI n° 2016-1087 du 8 août 2016 pour la reconquête de la biodiversité, de la nature et des paysages (article 123) [Law on the re-conquest of biodiversity, nature and landscapes].	Decentralised structure
Germany*	National ordinance on the National Development Programme (LEP-LVO M-V) Number 11, 08/06/2016. Landesentwicklungsprogramm MV [Land Development Programme] Number 11, 08/06/2016. Also earlier legislation on MSP.	Federal Maritime and Hydrographic Agency (BSH) and Federal Ministry of Transport and Digital Infrastructure (BMVI) as well as coastal *Lander*
Greece*	No information submitted to EC as yet.	Ministry of the Environment and Energy
Ireland*	EU (Framework for Maritime Spatial Planning) Regulations 2016 (S.I. No. 352 of 2016).	Department of Housing, Planning, Community & Local Government plus the Marine Institute as technical and scientific advisors.
Italy*	Attuazione della direttiva 2014/89/UE che istituisce un quadro per la pianificazione dello spazio marittimo [implementation of Directive 2014/89/EU on MSP].	Cross-departmental remit / undecided
Latvia	Teritorijas attīstības plānošanas likums [Territorial Development Planning Law] 2011. Cabinet of Ministers Regulations No. 740 on Sea-plan development, implementation and monitoring procedures 30 October 2012.	Ministry of Environmental Protection and Regional Development
Lithuania	Government of the Republic of Lithuania in 2016. 8 June. Resolution No. 556 to implement the IMP. Lithuanian Minister of the Environment, 26 May 2016, Order No. D1-387 Rules for Integrated Territorial Planning Documents. Resolution No. 1097 on public information, consultation and participation in decision-making on spatial planning regulations, as amended.	Ministry of the Environment
Malta	Marine Spatial Planning Regulations, 2016 - Development Planning Act (Cap. 552 of the Laws of Malta) 18/10/2016.	Malta Environment and Planning Authority (MEPA)
Netherlands	Decree of February 19, 2016 amending the Water Decree in connection with the implementation of the Framework for Maritime Spatial Planning.	Ministry of Infrastructure and the Environment
Poland	The law of 5 August 2015 amending the Act on maritime areas of the Polish Republic and the Maritime Administration and other laws. Regulation of the Minister of Transport, Construction and Maritime Economy and the Minister of Regional Development of August 5, 2013 on zoning plans for Polish marine areas.	Ministry of Maritime Economy and Inland Navigation

Portugal*	Decree Law No. 38/2015 Ministry of Agriculture and the Sea Development, Law No. 17/2014, of April 10, which Establishes the Bases of the Policy of Management and Management of the National Maritime Space. Decree Law No. 139/2015 Ministry of Agriculture and the Sea: first amendment to Decree-Law no. 38/2015, of March 12, which develops Law no. 17/2014, of April 10, establishing the Bases of Ordinance Policy and Management of the National Maritime Space, and transposes Directive 2014/89/EU on MSP.	Directorate General of Natural Resources, Safety and Maritime Services (DGRM), Ministry of the Sea.
Romania	Government Ordinance no. 18/2016 on MSP.	Ministry of Regional Development and Public Administration
Slovenia	Spatial Planning Act 2007. Law Amending the Law on Spatial Planning, 27/07/12 and earlier legislation.	Slovenian Ministry of the Environment and Spatial Planning
Spain*	No information submitted to EC as yet.	Ministry of Agriculture, Food and Environment
Sweden	Act (2014: 861) amending the Environmental Code (1998: 808). Marine Planning Ordinance (2015: 400). Regulation (2015: 401) amending Regulation (1998: 896) on the management of land and water areas.	Swedish Agency for Marine and Water Management (SwAM).
United Kingdom[23]*	No information submitted to EC as yet. Marine and Coastal Access Act 2009 and related devolved legislation.	DEFRA and devolved administrations.

In countries where maritime spatial planning exists, the system that is currently operational is outlined in the next section though it is not known whether the Commission will deem this as fulfilling the requirements of the MSP Directive.

4.4 Analysis for *AquaSpace* partners

4.4.1 European Union Member States

France

France's national Sea and Coastline Strategy Framework (*Stratégie Nationale pour la Mer et le Littoral,* SNML) is currently being reviewed.[24] This strategy contains high level objectives for French marine waters out to 200 nautical miles. The six themes in the SNML are:

- Protection of the environment, resources, biological and ecological balances, and the preservation of sites, heritage and landscapes;
- Risk prevention and coastal management;
- Knowledge, research and innovation as well as training of maritime professionals;
- Sustainable development of maritime and coastal activities and the exploitation of natural biological, mineral and energy resources;
- French participation in the development and implementation of international and European policies for the protection and enhancement of maritime areas and activities;
- Governance of the strategy including its implementation, monitoring and evaluation.

The objectives of the strategy are taken forward in a decentralised manner through: 1) Sea Basin Strategy documents (*documents stratégiques de bassins maritimes*, DSBM) and 2) Maritime Front Strategy documents (*documents stratégiques de façades*, DSF). These documents specify the goals of the national strategy and define, at a sub-national level, the management objectives, the spatial organisation of maritime uses and environmental interests. Local maritime councils prepare the latter

[23] Though the UK voted to leave the EU in June 2016, it is still included in this report as no formal Article 50 process has yet commenced hence the legislation of the EU still has binding effect on the UK.
[24] See http://www.developpement-durable.gouv.fr/La-strategie-nationale-pour-la-mer.html

documents with the State through the Ministry of Environment, Energy and the Sea. The strategic documents are intended to implement the provisions of the MSP Directive and final versions are expected for publication in early 2017. Public consultation has already commenced so as to provide an initial assessment of the ecological status as well as current and future demands of maritime activities and uses in the French part of the North Atlantic-Western English Channel region.

Germany

MSP implementation in Germany was motivated significantly by the offshore wind energy and particularly the increasing demand for sea space in light of the growth of that sector (driven by policy shift away from nuclear power). MSP is now used as a decision-making tool for all activities in both the North and Baltic Sea, under the Federal Land Use Planning Act which was amended to extend its scope of application to the EEZ limit. The plans are both regulatory and enforceable. The Federal Ministry of Transport, Building and Urban Development (BMVBS, 2009a and 2009b) has agreed the targets and principles of spatial planning for the German Exclusive Economic Zone (EEZ) in the North and Baltic Sea which seek to deliver a number of objectives:

- Secure and strengthen marine traffic;
- Strengthen economic capacity through systematic spatial development and optimisation of spatial use;
- Promote offshore wind energy;
- Long-term protection of the use of special characteristics and potential in the EEZ through economic use of space and priority for marine-specific uses;
- Protect natural resources by avoiding disruptions to and pollution of the marine environment.

MSP covers surface waters, the water column and the seabed, and identifies specific zones for maritime activities. These are implemented through three different types of zoning allocation. In 'priority areas' only one use is permitted and is granted priority over all other uses. Priority uses can be for shipping, pipelines, etc. In 'reservation areas' one use is given special consideration in a comparative evaluation with other spatially significant planning tasks, measures and projects. The third zone covers 'marine protected areas' created to reduce environmental impacts and protect the marine environment. Spatial plans for the territorial sea are the responsibility of the *Länder* (Federal States). Two *länder,* Lower Saxony and Schleswig-Holstein, border the North Sea and two others, Schleswig Holstein and Mecklenburg–Western Pomerania adjoin the Baltic Sea. In 2016 Mecklenburg–Western Pomerania produced a new plan which included the territorial sea area. This creates priority and reservation areas for maritime transport, wind energy, coastal protection and fisheries. With respect to fisheries the Plan covers fishing grounds (catch) as well as spawning and nursery areas for commercially important species (Ministerium für Energie, Infrastruktur und Digitalisierung Mecklenburg-Vorpommern, 2016).

Greece

Greece has a complex system of nested plans ranging from strategic frameworks to regulatory urban plans and zoning, with higher level plans binding on those at a lower level. Papageorgiou (2016) states that these plans did not refer to the marine parts of the country and accordingly the Ministry for the Environment amended the Institutional Law for Spatial Planning (Law No 2742) in 2011 to address this gap, and provide for the development of spatial plans at national or regional level which included marine areas. No information on transposing measures for the MSP Directive have yet been submitted to the European Commission (EUR-Lex, 2017). It is expected that responsibility for MSP in Greece will be split between two key government departments: the Hellenic Ministry for Mercantile Marine

Affairs, which has responsibility for maritime surveillance and the Hellenic Ministry for the Environment, which is responsible for spatial planning. As a signatory to the Barcelona Convention, and associated protocol on Integrated Coastal Zone Management, Greece zoned its coastal zone for management, primarily to reduce the environmental impacts of development on the coastal environment and also to ensure that building in the coastal zone was appropriately controlled. These were included in the National Spatial Strategy published by the Hellenic Ministry for the Environment in 2010 but were never officially adopted (Papageorgiou, 2016). Currently the only area-based plans that apply to marine areas of the country cover protected areas. There is, however, a National Spatial Framework for aquaculture and mariculture, due to its relative economic importance to the country, which was adopted in 2011 (Official Gazette No. 2505/B/2011). In a similar situation to elsewhere, other sectoral activities are covered by national policies and strategic plans, developed and overseen by their responsible Ministry.

Ireland

Ireland has no maritime spatial planning system in place currently though a large amount of preparatory work has been undertaken through several Government initiatives as well as EU and nationally-funded research projects. Ireland has already transposed the MSP Directive through the European Union (Framework for Maritime Spatial Planning) Regulations 2016. The competent authority for MSP is the Department of Housing, Planning, Community and Local Government with technical and scientific assistance from the Marine Institute, the State agency responsible for marine research and development. In 2012, the Irish Government produced 'Harnessing Our Ocean Wealth – an Integrated Marine Plan for Ireland' (Government of Ireland, 2012). This outlines the Government's vision, high-level goals and key 'enabling' actions for the appropriate policy, governance and business climate necessary to deliver economic growth of the country's marine sectors. HOOW recognised the need for MSP in the country and in 2012 an Enablers Task Force (ETF) on Marine Spatial Planning (MSP) was created to recommend a framework for implementing MSP in Ireland. The ETF put forward several recommendations including the development of a national Marine Spatial Plan to cover all Ireland's marine waters at a broad strategic level, which could then be supplemented with more detailed plans at a sub-national level later, as required (ETF, 2015). The ETF also recommended that MSP be established in Ireland through primary legislation, along with a lead agency. While a competent authority has been designated, MSP is being taken forward based on secondary legislation reiterating the contents of the Directive text but with no further detail. Other recommendations from the Task Force included the carrying out of environmental assessments, early stakeholder consultation, addressing marine data gaps, maximising multiple uses and streamlining consenting processes (ETF, 2015).

The competent authority consulted on the draft Regulations to transpose the requirements of the MSP Directive in April and May of 2016. Submissions received on the Regulations (DHPCLG, 2016) noted several key points on:

- key areas specifically their wording.
- The need for additional objectives for MSP.
- Having a hierarchy of objectives.
- The inclusion of specific policies and legislation in the regulations.
- The interface of MSP with the land-based planning system.
- Stakeholder participation.
- Enforcement and compliance aspects.

Several sectoral organisations and representatives also submitted their views on MSP and how it would impact on their individual sector. This information has not been utilised in the re-drafting of the Regulations but has been retained by the competent authority for possible use during the design and implementation phase of MSP (DHPCLG, 2016). With respect to the relationship between MSP and terrestrial planning, the Department has stated that the procedural arrangements for how MSP and terrestrial planning processes will interact is a matter that will be examined in detail during the implementation process. The same competent authority is also in the process of reforming the foreshore consenting regime which covers the majority of marine and maritime activities in the Irish foreshore (mean high water out to 12 nautical miles). Aquaculture activities are also governed by the Foreshore Acts, 1933-2011 but their application to that activity is administered by a different competent authority, namely the Department of Agriculture, Food and the Marine (DAFM). All submissions received on the MSP consultation are available on the Department's website.[25]

Italy

Italy transposed the requirements of the MSP Directive into national law in November 2016 but the transposing instrument does not appear to allocate a competent authority. This may be explained by the fact that most coastal competences rest with the regional authorities and not the State per se. In general, territorial waters are managed at the State level, while planning has been decentralised to the regional level. Some regions (Liguria, Marche, Tuscany and Emilia-Romagna) have developed their own coastal plans, which include coastal protection, beach nourishment, marinas, coastal traffic issues and the development of public and tourist facilities in the coastal area (Policy Research Corporation, 2011). Likewise, different regions have different levels of autonomy which has the potential to create difficulties for implementation of MSP nationally. Italy is a signatory to the Barcelona Convention and signed the ICZM Protocol in 2008. This has resulted in several pilot ICZM projects in specific Italian regions, i.e. Emilia-Romagna; Marche; Liguria and Tuscany. Complex jurisdictional arrangements also persist in the Italian marine area, with the country having no EEZ and multiple bilateral agreements with neighbouring States. The Ministry of Foreign Affairs and International Cooperation deals with transboundary issues related to maritime space. The Ministry of Agriculture, Food and Forestry is responsible for the national planning of fisheries and aquaculture activities. Between 2013 and 2015, the EC's DG MARE funded a project called ADRIPLAN (ADRiatic Ionian maritime spatial PLANning) which sought to improve MSP development in the region, to encourage full participation of all neighbouring countries in the process and promote scientifically-based political decisions to provide a coherent transnational approach to MSP in the region (Barbanti et al., 2015a). The project focussed on two specific areas: one in the Northern Adriatic Sea and the other in Southern Adriatic Northern Ionian Sea. The conclusions and recommendations from the project are presented in a book (Barbanti et al., 2015b).

Portugal

Portugal has been at the forefront of MSP development and was the first EU country to transpose the requirements of the EU MSP Directive into national law in 2015. The Basic Law for Planning and Management of the National Maritime Space (LBOGEM) was enacted in April 2014 (Law No. 17/2014 of April 10) and covers the Portuguese maritime area from the baseline to the outer limit of the continental shelf beyond 200 nautical miles. The Basic Law is a framework instrument and accordingly does not specify how MSP will be implemented in practice. It contains provisions on two types of legally binding national instruments for MSP for private and public entities. Article 7 describes the

[25]See http://www.housing.gov.ie/planning/maritime-spatial-planning/consultation-draft-regulations-tranpose-msp-directive-irish-law

Situation Plan (*Planos de situação,* or national marine plan) and Allocation Plans (*Planos de afetação*), which can be used to amend or alter the Situation Plan. The Situation Plan identifies the protection of historical and archaeological sites, preservation of the marine environment/biodiversity, and the spatial and temporal distribution of current and future uses and resources. The Allocation Plan identifies and allocates areas for new uses, not included in the Situation Plan, but once approved the Allocation Plans are automatically integrated into the Situation Plan. The framework law was given further legal effect under Decree-Law No. 38/2015 in March 2015 with four main sections: the legal framework for national MSP instruments; the legal framework for private use of national maritime space and associated financial regime; monitoring and technical assessment instruments; and the legal framework for private use of transitional water resources for aquaculture (Article 1). The Situation Plan is still under development but will be based on a preliminary map of existing uses, which has already been compiled for the Portuguese coastal area.

Law No. 58/2005 established a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, including the granting of rights of use of the maritime space in the first nautical mile. Due to the entry into force of LBOGEM, Law No. 58/2005 had to be amended so that the first nautical mile of coastal waters is now included in what is defined as the national maritime space (Becker-Weinberg, 2015). There appears to be strong coherence between Portuguese legislation on MSP and that relating to land-based planning. One interesting feature of LBOGEM is that it includes, in Article 11, rules for conflict resolution particularly which use or activity should prevail in such instances. These criteria are only applicable if the uses and activities ensure Good Environmental Status of the marine environment and of coastal areas as required under the MSFD. This is a precondition for the development of new uses or activities in the national maritime space. LBOGEM distinguishes between private and common uses of the national maritime space. As the name would suggest, a private use corresponds to the reservation of an area of maritime space for use of that environment, its resources or its ecosystem services that might result in a greater benefit than that obtained from a common use. The Portuguese MSP legislation provides for the granting of three different types of rights (*título*, or titles) that may be granted:

1. Concession: where the use of the area is continuous (over the entire year) up to a maximum duration of 50 years (Articles 52–53);
2. Licence: for intermittent (or temporary/seasonal) use(s) of the marine area for periods of less than 1 year and up to a maximum of 25 years (Articles 54–56);
3. Authorisation: limited to scientific research projects and/or pilot-projects involving new technologies or non-commercial uses with a maximum duration of 10 years (Article 57).

Any such title obliges the holder to comply with wider legal requirements including the achievement of Good Environmental Status under the MSFD and Good Ecological Status for coastal and transitional waters under the WFD.

Spain

Currently no maritime spatial plans exist for Spanish waters. No details of a transposing mechanism for the MSP Directive has yet been submitted to the European Commission (EUR-Lex, 2017) though it is understood that the preparation of a specific Royal Decree is underway.[26] Responsibility for marine and coastal activities and uses are split between central and regional governments. The Spanish Marine Environment Protection Law (41/2010) transposed the provisions of the MSFD but also explicitly introduced maritime spatial planning through the preparation, adoption and

[26] See http://www.msp-platform.eu/countries/spain

implementation of marine strategies. Five such demarcation areas have been defined taking into account the hydrological, oceanographic and biogeographic particularities of each and each of these will have a dedicated marine strategy. The marine strategy will effectively become the planning instrument for each area and provide an overarching framework within which other sectoral policies and administrative actions must comply. Spain has been involved in the implementation of ICZM for many years and has adopted legislation for the coast specifically (Coastal Law No. 22 of 1988, Royal Decree 1471 of 1989) though this does not define the 'coastal zone'. The Coastal Law defines the public maritime-terrestrial domain, which comprises: 1) the seashore and the banks of estuaries, marshes and other wetlands, as well as beaches and dunes; 2) the territorial sea and inland waters, with their beds and subsoil; and 3) the natural resources of the economic zone and the continental shelf. Urban development and territorial plans may cover the coastal strip but seldom do they cover territorial waters (Suárez de Vivero and Atmane, 2011).

United Kingdom

The UK is comprised of England, Wales, Scotland, and Northern Ireland. The latter three are commonly referred to as 'devolved administrations' as each has its own government or executive branch and legislature. England is governed directly by the UK Government and Parliament on all issues. In Wales, Scotland, and Northern Ireland certain responsibilities, known as 'reserved matters', have been retained by the UK Government. These vary by administration: in Scotland "energy" is a reserved matter and in Northern Ireland the "foreshore, sea bed, and subsoil and their natural resources" are a reserved matter. In effect this means that for certain policy areas, the UK Government in Westminster makes the policy and/or legislation, which is then applied in the devolved administrations by their authorities. With respect to maritime spatial planning, in effect, this means that while there is over-arching UK legislation on the topic, the approach taken in the devolved administration may differ slightly. The UK Marine and Coastal Access Act (MCAA) in 2009 forms the legal basis for marine planning. In 2011 the UK Government published the Marine Policy Statement (MPS), which establishes the framework for preparing marine plans and conducting decision-making in the marine environment (HM Government, 2011). Both the MCAA and the MPS were enacted prior to the adoption of the EU's MSP Directive in 2014 and it is unclear currently whether the former instrument is sufficient to transpose the requirements of the Directive. Another important factor to consider is the fact that the UK voted in 2016 to leave the EU. Since the Article 50 exit procedure has not yet been initiated, however, EU law still applies to the UK. The European Commission has been informed that Gibraltar, a British Overseas Territory, has transposed the provisions of the Directive via the Environment (Maritime Spatial Planning) Regulations 2016 (EUR-Lex, 2017). No information was yet received for other parts of the UK.

England

The Marine and Coastal Access Act of 2009 (MCAA) provides the legal basis for marine planning and the creation of the Marine Management Organisation (MMO), which is responsible for marine planning in English inshore and offshore areas. As part of the UK, it is currently unclear as to whether existing legislation will fully transpose the provisions of the EU MSP Directive. Work on marine planning in England began officially in 2010, several years before the adoption of the EU Directive. The Department for Environment, Fisheries and Rural Affairs (Defra) has produced a detailed description of the marine planning system in England (Defra, 2011). Widespread stakeholder input resulted in deciding upon 11 plan areas and 10 marine plans (one marine plan covers both the inshore and offshore regions in the northwest). In each marine plan region, the priorities and directions for future development within the plan area are outlined and this information is used to inform marine users about the more suitable locations for their activities and where new developments may be located.

Sectoral consenting is linked to marine planning in that, when applying for a consent, a developer will need to show how the adopted marine plan and the MPS have been considered and how the plan supports the proposed activity (Defra, 2011). During plan development every effort is made to engage with local planning authorities to ensure that marine plans are coherent with land-based plans, in line with the 'duty to cooperate' enshrined in the National Planning Policy Framework (Department for Communities and Local Government, 2012). At present marine plans have been published for the East inshore and offshore regions and South marine plans, with work underway covering the north east, north west, south east and south west regions. The Plans take a long-term view of activities, usually a period of 20 years, and will be reviewed every three years.

Wales

A Welsh National Marine Plan (WNMP), which covers Welsh inshore and offshore waters in a single plan, is currently being developed by the Welsh Government. A draft for public consultation was published in November 2015 (Welsh Government, 2015). Two key aims of the WNMP are to promote suitable marine opportunities and to sustainably manage existing and future marine activities. The WNMP will provide an over-arching framework for informing marine licensing decisions. It covers both Welsh inshore waters (to 12 nautical miles) and offshore waters (beyond 12 nautical miles) in a single document. The landward extent of the plan is to mean high water Spring tides. Welsh Ministers have responsibility for most marine activities occurring in inshore waters (i.e. tourism, fisheries, small-scale renewable energy, nature conservation, and land-use planning). Non-devolved policy areas such as large scale renewable energy developments, offshore nature conservation and shipping remain the responsibility of the Westminster government but the Secretary of State (Defra) has agreed to these areas being included in the draft plan. The draft plan refers frequently to the EU MSP Directive and states that the plan was prepared "in accordance with, and gives consideration to the MSP Directive using the powers contained within MCAA" (Welsh Government, 2015). Under the MCAA, there is a requirement, when preparing a marine plan, to have regard to any other plan prepared by a public or local authority about the management or use of the sea or coast, or of marine or coastal resources in the area in, adjoining or adjacent to the marine plan area. This would include, for example, river basin management plans prepared to comply with the WFD; estuary management plans; management plans for European marine sites etc.

Scotland

The Marine (Scotland) Act was enacted in 2010 and is largely similar to the MCAA in that it provides for marine planning and licensing, marine conservation, seal conservation, and enforcement. It also led to the establishment of a new marine management authority for Scottish waters, Marine Scotland. A National Marine Plan (NMP) for Scotland was adopted on 25 March 2015 and laid before Parliament on 27 March 2015 (The Scottish Government, 2015a). It covers all current Scottish marine sectors and includes overarching environmental objectives, echoing those contained in the EU MSFD, for example. These objectives are to achieve a sustainable marine economy; to ensure a strong, healthy and just society; to live within environmental limits; to promote good governance; and use sound science responsibly (The Scottish Government, 2015b).

The NMP is complemented by regional marine plans covering 11 marine regions as far as the territorial sea limit (12M). These regional marine plans are developed by local Marine Planning Partnerships with representation from local authorities, fisheries groups and existing coastal partnerships. The Scottish Ministers have delegated powers to the Marine Planning Partnerships and it is intended that through this type of approach the plans developed can take significant account of local issues and needs in each respective region. At the time of writing, work is ongoing on the Shetland Isles and Clyde area

regional marine plans. These are also closely linked to existing land-use plans as well as other sectoral plans. Under the provisions of the Marine (Scotland) Act, offshore licensing is devolved to the Scottish Ministers in Scottish inshore waters (up to 12 nautical miles) and offshore waters (12–200 nautical miles). MS-LOT acts as a one-stop shop for all aspects of marine licensing. The number and type of consents required will depend on what is to be farmed i.e. whether it is a marine fin-fish, marine shellfish, algae or seaweed farm.

Northern Ireland

The Marine (Northern Ireland) Act entered into force in 2013 and covers the Northern Ireland inshore region, marine conservation zones, and reform of marine licensing for certain electricity work. In Northern Ireland, the 'inshore' region is defined as the territorial sea and the seabed adjacent to Northern Ireland out to 12 nautical miles, though jurisdictional issues in the border bays with the Republic of Ireland persist (Flannery et al., 2015). In those areas a separate North South Implementation Body, the Foyle Carlingford and Irish Lights Commission, has responsibility for promoting and developing both Loughs for commercial and recreational purposes related to marine, fishery, and aquaculture matters. The Department of Agriculture, Environment, and Rural Affairs (DAERA) is the competent authority for MSP and is in the final stages of preparing the Northern Ireland Marine Plan, currently undergoing a Sustainability Assessment. The plan covers the Northern Ireland inshore region and the offshore region (beyond 12 nautical miles) in a single document. Following the Sustainability Appraisal, it and the Plan will be available for public consultation, subject to Northern Ireland Executive and Secretary of State for the Environment approvals, because the draft marine plan includes reserved matters (DAERA, 2015). The Marine and Fisheries Division of DAERA carries out licensing and enforcement functions in Northern Ireland territorial waters, under Part 4 of the Marine and Coastal Access Act of 2009. This includes licensing of all types of fish farms except in the border bays areas. In Foyle and Carlingford, following the enactment of the relevant governing legislation, the development and licensing of aquaculture is conducted by the Loughs Agency, part of the Foyle, Carlingford and Irish Lights Commission (FCILC).

4.4.2 International

Internationally MSP is also at varying stages of implementation. There is no international instrument to govern MSP per se though integrated approaches to maritime governance are advocated by many international conventions, such as the UNCLOS, the UN Convention on Biological Diversity (CBD) etc. as well as overarching soft law instruments and policies. The need to protect marine biodiversity and related requirement to create Marine Protected Areas (MPA) was one of the initial drivers for implementation of MSP or ocean zoning, which is one way in which MSP can be applied at a practical level. Elsewhere conflicts between established uses and new users of marine space, led to the implementation of MSP. One example of this is the growth in offshore renewable energy development in countries such as Germany and the UK which stimulated new approaches to marine planning, management and licensing. The sections below provide a succinct status of MSP, or any equivalent processes, in those countries that are partners or affiliated to the *AquaSpace* project.

Australia

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) introduced the concept of marine bioregional plans to improve the way Australia's oceans are managed to ensure they remain healthy and productive. The plans cover the Commonwealth Marine Area, which extends from the outer edge of State/territory waters, usually 3 nautical miles, to the limit of the EEZ, in each marine region. There are five marine regions with bioregional plans in place for all but one region

(south-east)[27]. The Plans describe the marine environment and conservation values of each marine region, set out expansive biodiversity objectives, identify regional priorities and outline strategies and actions to address those priorities (Department of the Environment and Heritage, 2006). In this context, the impact of various sectors, including aquaculture, on the receiving environment are explored. Section 176 of the EPBC Act requires the Commonwealth Environment Minister to have regard to the bioregional plan when making any decision under the EPBC Act for which the plan has relevance. There is also some overlap between the marine bioregional plans and State/Territory coastal management and land-use plans to ensure the objectives are complementary. During Plan development there was extensive public consultation with key sectors, including fisheries, tourism and oil & gas, at various stages of the process. The division of competences between the Commonwealth, State and Territories may complicate the implementation of a common approach to MSP in Australian waters.

Canada

Canada has been progressive in adopting a comprehensive framework for oceans management through the Oceans Act (1997), complemented by Canada's Oceans Strategy in 2002 (Fisheries and Oceans Canada, 2002). Integrated Management (IM) that seeks to establish decision-making structures that consider both the conservation and protection of ecosystems, while at the same time providing opportunities for creating wealth in oceans-related economies and communities, and this is a fundamental principle of Canadian oceans management. The IM process is described in the Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada (Fisheries and Oceans Canada, 2002). This was taken forward through five Large Ocean Management Areas (LOMA) and associated plans and pilot-based approaches since 2005. The impacts of the plans were broadly similar to those of maritime spatial plans. Since then the plans have evolved to an approach that is based on nationally defined marine bio-regions also covering five areas: Placenta Bay and Grand Banks; the Scotian Shelf, Atlantic Coast and Bay of Fundy; the Gulf of St Lawrence; the Beaufort Sea; and the Pacific North Coast. The latest Scotian Shelf, Atlantic Coast and Bay of Fundy Plan, for example, consists of two related documents, a background and program description (Fisheries and Oceans Canada, 2014a) with an associated Implementation Priorities document, set for the period between 2014 and 2017 (Fisheries and Oceans Canada, 2014b). The Plan will be reviewed every three years to take account of changing circumstances and priorities. Generally, the Plans developed operate within existing jurisdictional contexts and different regulatory authorities are responsible for implementation of Plan goals through management policies and measures under their remit. Canada's maritime jurisdictional system is complex: provincial jurisdiction generally ends at the low water mark under the Constitution. In Newfoundland and Labrador provincial jurisdiction extends to the 3-mile territorial sea limit, and in British Columbia the waters between Vancouver Island and the mainland are considered provincial waters.

China

China's equivalent to MSP is Marine Functional Zoning (MFZ) and was proposed originally in 1988 when there was a nationwide study of China's coastal zone and tidal flat resources with the aim of developing a zoning plan for those areas in terms of their future utilisation. The zoning plan provides a basis for marine management and divides maritime spaces into different types of functional zones according to specific criteria (e.g. geographical and ecological features, natural resources, current use, socio-economic needs etc.). The Law on the Management of Sea Use 2011 prescribes that all uses of sea areas must comply with approved MFZ schemes (Fang et al., 2011). The MFZ covers planning of

[27] See https://www.environment.gov.au/marine/marine-bioregional-plans

marine developments, resource management and the creation of marine nature reserves in internal waters and the territorial sea of 11 provinces. The most recent round of MFZ took place in 2012, in accordance with the Sea Area Use Administration law, the Law on Marine Environmental Protection, and the Sea Island Protection Law. The associated Technical Guidelines list all the data and materials required for zoning and the methods used. Supplementary documents detail the area's socio-economic characteristics and existing marine activities along with an assessment of the physical environment, possible future uses of that sea space, environmental protection requirements, etc. to provide a detailed basis for future zoning (O'Hagan, in press). One of the main purposes of MFZ is to assign the most suitable sea areas to specific activities and hence avoid conflicting activities. All applications for a specific use of the sea must be assessed and approved by both the provincial and national government, removing local government from the process. While all sectors are included in MFZ, participation is limited to consultation with other relevant ministries.

Norway

Norway has no explicit legislation for MSP but the Norwegian Marine Resources Act of 2009 (*Havressursloven*) provides for the creation of Integrated Management Plans, supplemented by a series of Government declarations and parliamentary reports, which apply from one nautical mile to the limit of the EEZ. This legislation was intended to protect against biodiversity loss and consequently, planning and management decisions are made with this central objective in mind. The Ministry of Climate and Environment has lead authority for national goals, management systems, and performance monitoring and also plays a key role in coordinating the efforts of other entities that have marine remits (Norwegian Ministry of the Environment, 2009). Currently three plans are operational: the Barents Sea - Lofoten Plan (revised in 2011), the Norwegian Sea plan (2009) and the North Sea and Skagerrak plan (2013) and cover all economic sectors operating in those seas. These are advisory and do not prescribe how marine activities should be managed. Sectoral ministries and other regulatory agencies retain their competences but management must be consistent with the overarching plan. Sectoral interactions and conflicts are systematically included in each of the three plans. Sector-specific scientific reports are also produced as part of the plan-making process and may also guide local planning and management decisions. Stakeholders comprising industry representatives, NGOs, government representatives and the public are encouraged to participate in the plan-making process. In inshore waters, the Planning and Building Act governs planning to one nautical mile from the baseline (low water mark or straight baseline). Under this legislation local, inter-municipal, and regional plans for these areas can be prepared though in most circumstances these plans tend to cover only land-based activities. The governing legislation contains the rules for public participation in this plan-making process which can include public hearings, written contributions and meetings.

United States of America

In 2010, a National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes was created. This is supported by a National Ocean Policy Implementation Plan which consists of specific actions that federal agencies will take to address key ocean challenges, provide more prospects for State, local, and tribal engagement in marine planning decisions, streamline federal processes and promote economic growth (National Ocean Council, 2013). Marine planning is identified in the National Ocean Policy as one of nine priority implementation objectives to address conservation, economic activity, user conflicts and sustainable use of marine spaces. Given the diverse range of political barriers, jurisdictional complexities coupled with the sector-specific nature of jurisdictions over marine space, a national and prescriptive approach to MSP is unrealistic and unfeasible. For these reasons, the National Ocean Policy foresees the implementation of MSP to be regional in scope,

developed cooperatively between federal, State, tribal and local authorities along with considerable stakeholder input. There are nine marine planning regions with associated Regional Planning Bodies (RPBs) in various stages of implementing marine planning.[28] These bodies are supported in each region by staff from the National Oceanic and Atmospheric Administration (NOAA) to ensure that science is placed at the centre of marine planning processes and consequent decision-making. The RPBs have no regulatory authority with legal responsibilities being retained by the State and federal authorities. Usually States have jurisdiction to the 3-mile limit, beyond this, in US parlance, is the Outer Continental Shelf which extends to the 200-mile limit. The US is not a party to UNCLOS hence the maritime jurisdictional zones in use are different to most of the rest of the world. The Northeast RPB is responsible for preparing the ocean plan for the New England region, noting that within this region the States of Massachusetts and Rhode Island already have ocean plans for their State waters. The Massachusetts Plan, for example, already has areas zoned for multi-use, specific uses such as renewable energy and prohibited areas, in line with the provisions of the Ocean Sanctuaries Act (Commonwealth of Massachusetts, 2015).

[28] See https://cmsp.noaa.gov/activities/index.html

Maritime Spatial Planning - Key observations

- In theory, MSP should be complementary to the EAA as it reflects many of the same key principles: integrated, adaptive, participatory and coordinated.
- The MSP Directive applies to marine waters of Member States but not to coastal waters if they come within a Member State's town and country, or land-based, planning system. This has huge potential consequences for future planning of aquaculture particularly since most marine aquaculture currently takes place in inshore waters.
- Under the provisions of the MSP Directive, maritime spatial plans must "take account of" land-sea interactions and the particularities of their marine regions as well as the impacts of existing and future activities and uses on the environment. The way in which MSP will be implemented at Member State level, and particularly at local level, is therefore critical. This applies not only to the plans per se but to the governance structures in place, how different sectors are involved in plan development and how stakeholders input to the process as well as to longer-term plan evaluation and amendment.
- Scale is an issue for MSP implementation. The Directive foresees regional level implementation and coordination which may restrict its value for site level / sectoral planning, however, it is acknowledged that this is totally dependent on the approach taken to implementation in a particular Member State.
- Member States are just beginning to implement the Directive. Most EU Member States have enacted their transposing measures and designated their competent authorities but there are few plans operational at the time of writing.
- Information on MSP from the EU *AquaSpace* partner countries demonstrate that in most countries the issues surrounding MSP are the same: governance structure has the potential to hinder implementation and effectiveness; interaction between marine and land-based planning is a challenge that has yet to be fully dealt with.
- There is limited implementation of ICZM and less recognition of this as a key management approach: only Greece and Spain have dedicated coastal management legislation. Elsewhere coastal planning is likely to be subsumed into land-based planning processes.
- Portugal as a country advanced in MSP preparation has explicit conflict resolutions mechanisms built into its MSP process, which could be a learning opportunity for other Member States.
- Internationally, there is no one legal instrument covering MSP but almost all international environmental law advocated integrated approaches to maritime governance.
- In the selected international examples, MSP (or equivalent) appears to be driven by environmental protection not economic growth. In all the study countries, the policies suggest high levels of coherence between sectoral planning and consenting processes and the objectives of the over-arching planning framework, but achieving implementation is critical.

5. Planning for freshwater aquaculture

As is evident from the preceding sections, complex jurisdictional arrangements can lead to divisions of statutory and sectoral responsibilities between different jurisdictional zones. When land-based planning was first conceived, it was intended to regulate land-use, enable development and reflect different needs in different areas, primarily according to whether an area was urban or rural in character. It did not utilise the strict zoning regime which customarily applies to marine spaces, deriving from international law. Over time the scope of land-based planning has evolved to incorporate wider and more strategic objectives that reflect economic, social and environmental policies. The term 'spatial planning' has consequently been adopted since the mid-1990s to refer to the broader concept which integrates policy, social, cultural, economic and environmental management with spatial development and land use to ensure sustainable development. At EU level, there is no commonly agreed definition of land-based planning, or indeed spatial planning. This can be attributed to many factors. Land-based planning is not an EU competence with powers for land-based based planning residing with Member States and their internal government structures. The main actor at EU level is the European Commission, represented by the Directorate General on Regional Policy (DG REGIO). Policies in this space are aimed at supporting job creation, business competitiveness, economic growth, sustainable development, and improve citizens' quality of life rather than regulation of when and where specific activities can occur. At national, sub-national and local levels, land-use planning can result in areas being zoned for different uses such as residential, commercial, agricultural etc. Depending on the governance system in operation in a particular country, land-based planning can include either freshwater aquaculture only or coastal/marine aquaculture depending on how far planning jurisdiction extends in that particular country (Table 8).

Table 8: Summary by country of MSP and land-planning implementation and scope.

Country	MSP	Scope	Land-based planning	Scope
Australia	Partially	State and EEZ (?)	Yes	Variable
Canada	Yes	State and EEZ	Yes	Variable
France	No	n/a	Yes	Variable
Germany	Yes	EEZ	Yes	TS limit
Greece	No	n/a	Yes	Variable
Hungary	n/a	n/a	Yes	?
Ireland	Not yet	Unknown	Yes	Ends at HWM
Italy	No	n/a	Yes	Variable
Portugal	Yes	CS limit	Yes	Variable
Spain	No	n/a	Yes	Variable
UK				
England	Yes	Inshore & Offshore waters	Yes	Ends at MLW
Wales	Draft	Inshore & Offshore waters	Yes	Ends at MLW
Scotland	Yes	Inshore & Offshore waters	Yes	MLWMOST[29]
N. Ireland	Under development	Inshore & Offshore waters	Yes	Ends at LWM
USA	Partially	State and OCS limits	Yes	State 3M usually

The following sections provides examples in a freshwater aquaculture context, as indicative examples of spatial planning issues that are at the forefront for the freshwater production industry as a whole.

[29] Planning extends to most but not all of intertidal area (not to Lowest Astronomical Tide)

It covers Hungary, Poland and the Czech Republic, which produce the majority of carp species through pond aquaculture within the EU; with international examples of freshwater spatial planning from Australia and Canada. The freshwater case study in section 11. Case studies), provides additional details on the context for the development and spatial planning requirements for pond culture.

5.1 Regulation of freshwater aquaculture in Hungary, the Czech Republic and Poland

5.1.1 Legal frameworks

National legislation covers authorisation for the construction of fish pond systems, pond aquaculture management, the use and protection of the water resource, and the protection of the environment and nature (Table 9).

The water used for filling fish ponds is subject to authorisation. The surface water, as opposed to borehole water, used for aquaculture is free of charge in the Czech Republic and Poland, while Hungarian farmers must pay for it (price subject to geographical location, time of year and other factors). Halasi-Kovács et al (2012) calculated that on average it cost €6.76 /thousand m^3.

The drainage of water from fish ponds is also subject to authorisation; which is free of charge in the Czech Republic, whereas in Hungary it can either be free of charge or a water load fee paid, depending on the decision of the local water authority.

Table 9: National legislation related to spatial development of pond aquaculture.

Topic of regulation	Poland	Czech Republic	Hungary
Fisheries	Act of 18 April 1985 on inland fisheries Regulation of the Minister of Agriculture and Rural Development of 12 November 2001 on fisheries and conditions of rearing, breeding and harvesting of other organisms living in water Regulation of the Minister of Agriculture and Rural Development of 8 June 2010 on detailed conditions of recognition of marginal, local, and restricted activity	The Fishing Act No. 99/2004 Coll. Implementing Decree No. 197/2004 Coll. Act No. 154/2000 Coll. Farm registration Act No. 166/1999 Coll.; Decree No. 290/2008 Coll Authorisation of an aquaculture production organisation and a farm registration	Act CII of 2013 on fisheries and the protection of fish Order 133/2013. (XII. 29.) MoRD on the determination of some rules of fisheries and fish protection Act XVII of 2007 on several issues of the procedure connected to agricultural, rural development and fisheries subsidies and other provisions Order 18/1996. MoTCW (VI. 13.) on the application necessary for the water rights authorisation procedure and its enclosures
Water protection	Act of 18 July 2001 Water law	The Water Act No. 254/2001 Coll.	Act LVII of 1995 on water management Order 13/2015. (III. 31.) MoI on the administrative service charges of water and water protection public proceedings
Environment	Act of 27 April 2001 Environmental protection law		Act LIII of 1995 on the general rules of the protection of environment Act LXXXIX of 2003 on the environmental load charge Decree 219/2004. (VII. 21.) on the protection of subsurface waters Decree 220/2004 (VII.21.) on the rules of protecting the quality of surface waters Decree 27/2006. (II. 7.) on the protection of waters against nitrate pollution of agricultural origin Decree 314/2005. (XII.25.) on the process of the authorisation of environmental impact assessment and uniform environmental use Order 28/2004. (XII. 25.) MoEW on the permitted limit related to the emission of water polluting materials and the rules of using the formers

			Order 27/2005 (XII.6.) MoEW on the detailed regulation related to the control of the emission of used and waste waters Order 6/2009. (IV. 14.) MoEW-MoH-MoARD on the permitted limits necessary for the protection of the geological compartments and subsurface waters against pollution and on the measurement of the pollution Order 10/2010. (VIII. 18.) MoRD on the permitted water pollution limits of surface waters and the rules of their application
Nature conservation	Act of 16 April 2004 On nature protection Act of 21 August 1997 on the protection of animals Regulation of the Minister of the Environment of 07 October 2014 on the species protection of animals	The Act on Protection of Nature and the Landscape No. 114/1992 Coll.	Act LIII of 1996 on Protection of nature Decree 275/2004. (X.8.) on the nature protection areas of European Community relevance Order 13/2001 (V.9.) MoE on the protected and critically endangered plant and animal species, the protected caves and the publication of plant and animal species significant from the respect of nature protection in the European Community Order 14/2010. (V. 11.) MoEW on the areas of land concerned by nature protection areas of European Community relevance

In Poland, the fee for drainage of aquaculture ponds is paid if the yield is higher than 1500 kg per hectare, at a rate of €4.5 for each 100 kg of fish over 1,500 kg. Drainage of fish ponds in Central Europe is governed under environmental protection rules, although in the Czech Republic drained water is not considered as "waste water", while the contrary is true in Hungary and Poland. The quality of the drained water must conform to water quality thresholds, derived from the WFD, in the Czech Republic and Hungary. If the water being drained has higher levels than those legally permitted standards then a penalty must be paid, under a form of polluter-pays principle.

The similarities and differences between regulation of pond aquaculture in the three countries are presented in Table 10. This indicates that the construction of new fish ponds is usually subject to authorisation, however, differences can be observed in relation to time taken to obtain the necessary licences. These timeframes vary from is 1-2 months in Poland, while in Hungary it can take between 6-12 months. It is also normal that no additional/special permissions are needed for farming operations in licensed aquaculture sites. Although it is not prohibited by law, it is general practice in Hungary that authorisation for fish ponds construction cannot be obtained for ponds within Natura 2000 sites.

Table 10: Similarities and differences in the content of national legislation in the selected countries.

Regulation topic	Poland	Czech Republic	Hungary
Construction of fish ponds	Licence needed Period of licensing: 1-2 months	Licence needed	Licence needed Period of licensing: 6-12 months Critical to get licence in Natura 2000 areas
Management of fish ponds	No special licence needed	No special licence needed	No special licence needed
Water supply	Licence needed Free of charge	Licence needed Free of charge	Licence needed Fee required
Water drainage	Licence needed Fee payable if fish yield is above 1500 kg/ha	Licence needed Free of charge	Licence needed Mostly free of charge, in some cases fee is payable depending on the decision of the local water authority
Rules of environmental protection	Drained water is categorised as wastewater Water output is not connected to water quality threshold	Drained water is not categorised as waste water Water output is connected to water quality threshold	Drained water is categorised as waste water Water output is not connected to water quality threshold
Technological interventions	Regulated in the interest of water protection	Regulated in the interest of water protection	Regulated in the interest of water protection

Rules on nature protection	Local regulation Restrictions only in the case of significant nature conservation effect Loss of income due to restriction is compensated by the government	Local regulation Higher restriction of production from the respect of nature protection Loss of income due to restriction is partially compensated	Local regulation Lower restriction of production from the respect of nature protection Loss of income due to restriction is not compensated

Pond aquaculture is regulated from the aspect of surface water protection in the Czech Republic and Hungary, but with respect to the protection of groundwater resources in Poland. However, technological restrictions are basically connected to nature protection regulations. Aquaculture practice in ponds operating in national parks or Natura 2000 sites, cannot contradict the nature protection objectives and/or the Natura 2000 operational plan for the given area. In Poland limitations in fish pond areas are only introduced if significant negative effects on nature arise. In these cases, the losses caused by any limitations imposed are compensated by the State. In protected areas, typical measures imposed include restrictions on:

- Water management through limitations on pond filling or drainage when protected birds are present during their reproductive period.
- The quantity of fish that can be stocked.
- Input of feed and/or manure.
- Reed cutting.
- The use of scarecrows and firearms as a means of predator control.

When imposed payment of compensation for loss of production has not been resolved in either Hungary or the Czech Republic.

Results from interviews carried out for the *AquaSpace* project suggest that nature conservation restrictions do not directly cause significant production losses, though indirect consequences can be observed in farms larger than 100 ha, especially evident in Hungary. Nature conservation restrictions that make production uneconomic are antagonistic because it underplays the role pond aquaculture has in mainlining the wetland habitat, which is significant compared to other forms of intervention. In this way pond aquaculture supports conservation efforts.

5.1.2 Governance and administrative frameworks

Responsibilities for freshwater aquaculture policy and resultant administrative frameworks are managed by the following government departments:

- The Ministry of Agriculture Department of Angling and Fisheries Management (Hungary)
- The Ministry of Agriculture and Nutrition Department of the Civil Service of Forest, Game Management and Fishery (Czech Republic)
- The Ministry of Maritime Economy and Inland Navigation Fisheries Department (Poland)

These entities oversee the legal framework as well as provide overall administrative control of aquaculture and fisheries activity. The main policy and administrative tasks relate to controlling the operation of fish breeding farms and licensing of new fish varieties and hybrids. They also have a duty to ensure that over-arching EU legislation such, as the CFP and its associated Regulations are applied within the domestic context. This includes developing, managing and coordinating the implementation of the Operational Programmes under the EMFF. In Hungary, these tasks were transferred to the State Secretariat for Agricultural and Rural Development in the Prime Minister's Office in 2014. Policy, strategy development as well as new or amended legislation also falls under the remit of the central government departments in all three countries. Depending on the topic this

involves development of specific guidelines and implementation programmes for State policy relating to marine fisheries, inland fisheries, aquaculture and fish trading and marketing. The collection of statistical data on both fisheries and aquaculture is coordinated by the overseeing government departments. While the responsible entities are tasked with developing freshwater aquaculture they also oversee the management, protection and utilisation of marine and inland water organisms, as well as the protection of natural fish assemblages. In developing aquaculture policy, the government departments collaborate with the fisheries industry (farmers, research institutes, etc.) and other stakeholders, but in an informal way.

Together with central governmental authorities, regional and local level authorities are also involved in aquaculture licensing, such as local water use (abstraction and drainage) issues and fees. The regional water department decides on the plans submitted, based on the water demands, considering the available water volume during low flow season in the requested water catchment area. Spatial planning is realized through regional and local spatial development plans and the siting of aquaculture ponds is dependent on the adequacy of surface water resources.

5.1.3 River Basin Management Plans under the WFD

Refer to section 6.3.

5.2 Regulation in other nations

5.2.1 Australia

Australia's freshwater aquaculture sector varies from intensive tank rearing systems to automatic systems to pond and dam systems. Due to the governance regime in place, State and territory governments regulate aquaculture in Australia. The State, Territory and local governments each have a different level of control in relation to planning, development and management of aquaculture within their jurisdiction. Generally, Australian Government legislation aims to protect matters of national environmental significance, promote sustainable development, and maintain certain standards in food safety, aquatic animal health, quarantine, trade and taxation. Information on industry support, licensing and permit arrangements and the regulatory arrangements that apply to each jurisdiction are available on State-level government websites.[30] In 2005 the federal Government published a report on a best practice framework of regulatory arrangements for aquaculture in Australia which covers both marine and freshwater aquaculture (Department of Agriculture, Fisheries and Forestry, 2005). In some ways, this could be described as similar to the EC's Strategic Guidelines (2013a) as the aim of the framework was to compare and contrast the systems in place across the various jurisdictions, assess the appropriateness, effectiveness and efficiency of the current system and consider alternative regulatory arrangements so as to facilitate growth of the sector.

In 2009, the State Government of New South Wales (NSW) with industry involvement produced a NSW Land-based Sustainable Aquaculture Strategy (Industry and Investment NSW, 2009). The Strategy is composed of two interlinked sections: one which covers best management practices and a second section which covers integrated approvals. In the context of the Strategy land-based aquaculture refers to pond aquaculture systems using estuarine, marine, saline groundwater or fresh water for growing species and tank-based aquaculture systems using estuarine, marine, saline groundwater or fresh water for growing species. At the centre of the Strategy is 'ecologically sustainable development' (ESD) which has a basis in the Fisheries Management Act 1994. ESD requires the effective integration of economic and environmental considerations in decision-making processes. A fundamental part of

[30] See http://www.agriculture.gov.au/fisheries/aquaculture/publications and http://www.agriculture.gov.au/fisheries/aquaculture/starting

the Strategy is the Aquaculture Industry Development Plan (AIDP), which seeks to put the environment at the centre of aquaculture planning, development and management. The AIDP covers five elements of farm operation, namely, business planning; species selection; site selection; planning and designing the farm; and operating the farm. In relation to site selection, the Strategy identifies each of the factors to be considered and identifies the preferred location and tips for each. This also alerts potential developers to other legal requirements including those related to designated conservation sites, where there may be native title claims, heritage considerations and amenity issues. The Strategy could be described as a sign-posting document in that it directs developers to the appropriate regulatory authority as well as providing additional information on every aspect of farm operation. The regime applicable to different categories of aquaculture is explained in detail. This includes the licensing process as well as the environmental assessment procedures which may be applicable depending on the scale and nature of the operation. Land based aquaculture is permissible if it complies with minimum site locational (including zoning provisions) and operational criteria listed in the Project Profile Analysis (PPA), detailed in the Strategy. The PPA provides a matrix ranking of the level of environmental risk associated with the locational and operational attributes of the aquaculture project site. There are three levels of risk: low, medium and high. The consent authority has to take into consideration the AIDP when making their decision. The Strategy also outlines the other permits which may be required under separate pieces of legislation and who to liaise with in relation to these.

Victoria is the largest producer of freshwater trout (82%) and farmed abalone (51%) in Australia and a significant producer of mussels (29%), barramundi and goldfish (Savage, 2015). A draft Victorian Aquaculture Strategy 2016-2021 was published in 2016 (Department of Economic Development, Jobs, Transport and Resources, 2016). This recognises the future potential of both marine and freshwater aquaculture in the State and contains targets relating to development as well as improvement of the regulatory environment. In relation to the latter, one of the objectives is to standardise inland licensing requirements. The state of Victoria also has Planning Guidelines for Land Based Aquaculture designed to assist local government in understanding aquaculture and how it relates to Victoria's planning provisions (Department of Primary Industries, 2005). It also assists developers and planners in operating their farms and assessing aquaculture applications, respectively. A key function of the guidelines is to educate the public about aquaculture and its environmental and amenity impacts. They cover only land-based and marine onshore aquaculture systems. Under the Victorian planning provisions, aquaculture is a ‘permit required’ use in most zones with the exception of those areas zoned as a Farming Zone (FZ) and Rural Activity Zone (RAZ). It is currently not ‘prohibited’ use in any zone. Any associated works would require an additional permit, such as for buildings, water discharge etc. Whilst the guidelines elucidate the processes in place, a range of regulatory authorities are responsible for different parts of the permitting process including local councils, State agencies, local water authority, Environmental Protection Agency etc. When a permit is issued, it may contain conditions that limit or control the use and/or development permitted for the site or the requirements of one of the other responsible authorities. Aquaculture licences vary according to whether the land is private land or Crown land and also by species.

5.2.2 Canada

Canada’s aquaculture industry has grown significantly in the last decade (Statistics Canada, 2015). This is primarily attributable to salmon farming but trout farms can be found in six of ten provinces. The 2011 National Aquaculture Strategic Action Plan Initiative (NASAPI) set out a cooperative framework for federal, provincial, and Yukon partners to collaborate to develop Canada’s aquaculture in five aquaculture sub-sectors: East and West Coast marine finfish, East and West Coast shellfish, and freshwater; across the three thematic areas of governance; social licence and reporting; and

productivity and competitiveness (DFO, 2010a). The freshwater section of this initiative contained actions relating to environmental management of cage systems; the establishment of habitat protocols; and streamlining and harmonising the site application and review process for all freshwater aquaculture (DFO, 2010b). The requirement to gain approval under the Navigable Water Protection Act was recognised as a barrier as it can trigger a federal environmental assessment under the Canadian Environmental Assessment Act if the project is considered likely to cause substantial navigational interference. This was identified as an area which needed to be addressed through greater standardisation of the process and production of guidelines (DFO, 2010b). A number of other governance and regulatory issues were identified as requiring work. Specifically, this included the ability to licence multiple species in a single licence; and farmers' rights and obligations in private waters.

Whilst progress was made to an extent in each of the five sub-sector areas, the need for continued effort was recognised and subsequently an Aquaculture Development Strategy 2016-2019 was published (Fisheries and Oceans Canada, 2016). This has three identified work-streams which apply to various extents across the aquaculture sub-sectors and provinces. The focus areas are: an improved federal/provincial/ territorial regulatory framework; improved coordination of aquaculture fish health management; and improved support for regional economic growth through aquaculture. For each theme, strategic objectives and actions needed to achieve the objectives are specified (Fisheries and Oceans Canada, 2016). The Strategy applies to all forms of aquaculture but no specific actions are identified for the freshwater sector.

Land-based Planning and Freshwater Aquaculture - Key observations

- At EU level, there is no commonly agreed definition of land-based planning, or spatial planning.
- Land-based planning is not an EU competence, with powers for land-based based planning residing with Member States and their internal government structures.
- At Member State level, the effect of land-based planning on aquaculture varies by country: in some countries land-based planning systems extend to coastal/nearshore waters.
- There is a strong need to ensure marine and land-based planning systems are coherent and do not contradict each other. ICZM plans could have a harmonising role in this regard.
- Within Member States, competences for land-based planning can be split between central, regional and local government levels which can lead to unclear policy and procedures.
- Freshwater aquaculture is therefore governed by national legislation more comprehensively than by the EU though but certain EU legal instruments, e.g. EIA, WFD and the Birds and Habitats Directives, will have implications for the sector in terms of achieving of GES, for example.
- Experiences from Central Europe show that the WFD and nature conservation legislation have substantial impacts on the regulation of pond aquaculture.
- Beyond the EU, State practice also varies with some countries identifying the need for a more strategic approach to aquaculture planning at central government level but implementing this, through decentralised structures, can be challenging.
- There is a need for clarity on the rights and responsibilities of farmers in waters that are owned or managed by different entities (private waters, public waters).
- Aquaculture policy tends to cover all forms of aquaculture and may not be wholly reflective of the needs of the freshwater sector.

6. Other relevant EU instruments

6.1 Context

A number of other EU laws and policies have relevance to the spatial planning and management of aquaculture. In terms of legislation the principal instruments are the Birds and Habitats Directives, the WFD and the MSFD. The CFP, though referred to as a policy in EU terms, has a strong legal basis and has many implications for the spatial planning and management of aquaculture such as the prevention and management of the introduction and spread of invasive alien species (Regulation (EU) No. 1143/2014), though the latter is not related to spatial management *per se*. Most recently in the reform package this has included the Strategic Guidelines for the Sustainable Development of EU Aquaculture (COM(2013)229). Other policies of relevance are many but only a few critical ones are included here. The EC's Integrated Maritime Policy has resulted in a new awareness of maritime sectors and consequently the development of sea basin strategies each with dedicated action plans. The Blue Growth strategy, seeks to support sustainable growth in the marine and maritime sectors as a whole, and specifically focuses on the aquaculture sector.

6.2 Birds and Habitats Directives

The Birds and Habitats Directives, or the nature conservation Directives, seek to deliver on EU and international biodiversity targets through the protection of key species and habitats. Primarily this is achieved through the designation of Special Protection Areas (SPA) and Special Areas of Conservation (SAC) respectively which together form the Natura 2000 network. In cases where a development or activity may have a significant adverse effect on the integrity of a designated habitat or species for which a site has been designated, a specific type of assessment, known as an Appropriate Assessment, will have to be conducted. This must focus on the conservation objectives of the site and derives from Article 6 of the Habitats Directive. The EC has previous produced guidance on the aquaculture activities in the Natura 2000 Network (EC, 2012a) which covers both marine and freshwater aquaculture. The guidance advocates the development and application of spatial planning, including MSP and ICM saying both approaches can facilitate the allocation of appropriate aquaculture sites, with the correct water quality. The guidance goes on to state that the potential environmental impacts of aquaculture can be managed, minimised or enhanced through appropriate siting and management of farms (EC, 2012a).

6.3 Water Framework Directive (2000/60/EC)

The main purpose of the WFD, which was adopted in 2000, is to prevent the deterioration of ecological quality and the restoration of polluted surface and groundwater by the end of 2015. A range of environmental objectives are contained in Article 4 to help achieve this aim. 'Good' status is defined with reference to a wide range of physico-chemical and ecological indicators set out in Annex V. Member States are required to adopt RBMP under Article 13. These provide details on how the objectives set for river basins etc. (ecological status, quantitative status, chemical status and protected area objectives) are to be reached within a required timescale. It also includes an analysis of the river basin's characteristics, a review of the impact of human activities on the status of waters in the basin, estimation of the effect of existing legislation and the gap associated with meeting the objectives coupled with measures to address those gaps. The first series of RBMPs ran from 2009 to 2015, and Member States are now in the second phase of river basin management planning. The WFD covers surface waters, groundwater, inland waters, rivers, lakes, transitional waters and coastal waters. For ecological status, coastal waters extend to one nautical mile out to sea. Chemical status, however, applies also to territorial waters extending out to 12 nautical miles. Coastal waters are defined in Article 2(7) as "surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth

of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters". Adjoining coastal waters must be identified and assigned to the nearest or most appropriate river basin district or districts. Under Article 13(5) RBMPs "may be supplemented" with more detailed programmes and management plans for sub-basins, sectors, issues or water types, to deal with particular aspects of water management.

The WFD repealed the Directive on the quality required of shellfish waters (79/923/EEC) and the Directive on the quality of fresh waters needing protection or improvement in order to support fish life (78/659/EEC). The WFD seeks to provide the same, if not better, protection of areas used for shellfish production. Under the WFD, Member States are required to create a register of protected areas including shellfish protected areas where specific monitoring programmes will be designed and implemented. These areas should then be reflected in the associated RBMP. During the first cycle of RBMPs (2009-2015) aquaculture was identified as a sector which exerted pressure on the receiving water bodies. The pressures identified were use of water resources; point source of pollution; localised reductions in benthic biodiversity; significant dredging of water bodies and physical modification of land; changes in flow regimes; introduction of alien species (EC, 2016b). The objectives of the WFD are complementary to those contained in the MSFD and consequently both should deliver better protection of all water bodies.

6.4 Marine Strategy Framework Directive (2008/56/EC)

The MSFD requires Member States to put in place measures to achieve Good Environmental Status (GES) in their marine waters by 2020. Marine waters are defined as "(a) waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outmost reach of the area where a Member State has and/or exercises jurisdictional rights… (b) coastal waters as defined by Directive 2000/60/EC, their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation" (Article 3(1)). The latter sub-paragraph therefore addresses the potential for overlap with the WFD. Effectively the definition of marine waters means that in practice the Directive applies to the 200M limit of the EEZ. To help Member States interpret what GES means in practice, the Directive sets out, in Annex I, eleven descriptors which describe what marine waters will look like when GES has been achieved. There are several stages to be completed before GES can be achieved, including the carrying out of an initial assessment of the current status of the marine waters, the establishment of specific environmental objectives; implementing monitoring programmes and management measures. The Directive requires Member States to develop a marine strategy for their marine waters to achieve GES. Where a marine region is shared by several Member States, those Member States must cooperate to ensure the strategies are complementary and coherent. Article 13 provides that a programme of measures be designed to achieve or maintain GES by 2015, entering operation by 2016. According to Article 13(4), the programme of measures should include "spatial protection measures contributing to coherent and representative networks" of MPAs, SACs and SPAs.

6.5 Integrated Maritime Policy and Sea-basin strategies

In 2007, the EC published an Integrated Maritime Policy (IMP) for the European Union (COM(2007) 575). This explicitly recognises that "all matters relating to Europe's oceans and seas are interlinked, and that sea-related policies must develop in a joined-up way if we are to reap the desired results" (EC, 2007: 2). In light of this, sectoral management is no longer appropriate. The IMP sought to instigate more integrated maritime governance with the necessary cross-sectoral tools for implementation. One of the cross-sectoral tools identified was MSP. The IMP concentrated on:

1. Maximising the sustainable use of the oceans and seas;

2. Building a knowledge and innovation base for the maritime policy;
3. Delivering the highest quality of life in coastal regions;
4. Promoting Europe's leadership in international maritime affairs; and
5. Raising the visibility of maritime Europe.

Subsequent actions at EC level have tended to focus on the above themes. The IMP also has a number of cross-cutting policies within it including those on integrated maritime surveillance; marine data and knowledge; sea basin strategies and Blue Growth. To date six sea basin strategies have been developed, covering the Baltic Sea, Black Sea, Mediterranean Sea, North Sea, the Atlantic and the Arctic Ocean. These specific strategies exploit the strengths and address the weaknesses of each large sea region in the EU. In the Atlantic Area, for example, the Strategy (COM(2011) 782) grouped the challenges and opportunities into five themes: implementation of the ecosystem approach; reduction of Europe's carbon footprint; sustainable exploitation of seafloor natural resources; emergency response; and socially inclusive growth (EC, 2011). A subsequent Action Plan was adopted in May 2013 (COM(2013) 279) which seeks to deliver the over-arching objectives of the strategy as well as contribute to Blue Growth in France, Ireland, Portugal, Spain and the United Kingdom. This has four priority areas: promote entrepreneurship and innovation; protect, secure and develop the potential of the Atlantic marine and coastal environment; improve accessibility and connectivity; and create a socially inclusive and sustainable model of regional development (EC, 2013d). The Action Plan recognises aquaculture under priority 1 in relation to improving skills in the industry and supporting the reform of the CFP, which was underway at that time.

6.6 Blue Growth

A Communication on Blue Growth was published in 2012 exploring the opportunities for marine and maritime sustainable growth (COM(2012)494). This recognised that the marine environment is a key driver to many economies in the EU and that recent advances in technology are now enabling work further offshore. The Communication therefore sought to further "harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth" (EC, 2012b: 2). In order to stimulate this growth, the strategy identifies specific areas where dedicated action could provide added incentive. These areas are ocean energy; aquaculture; maritime, coastal and cruise tourism; marine mineral resources and blue biotechnology. The Communication recognises that "lack of available maritime space for aquaculture activities, competition in the global market and administrative constraints in particular concerning licensing procedures are amongst the challenges to growth" (EC, 2012b:8). In certain instances, the Commission has published further Communications and calls to action for the sectors identified in the Blue Growth strategy, e.g. in relation to ocean energy. With respect to aquaculture, however, the Commission is progressing work on this through the revised CFP and specifically the Strategic Guidelines for the sustainable development of EU aquaculture (COM(2013)229).

6.7 Strategic Guidelines for the sustainable development of EU aquaculture

The Strategic Guidelines for the sustainable development of EU aquaculture are intended to encourage growth in the EU aquaculture sector by identifying common priorities and objectives at EU level, which can then be progressed nationally (EC, 2013a). Through a consultation process with sectoral stakeholders, four priority areas were identified namely, administrative procedures; coordinated spatial planning; competitiveness and a level playing field (COM(2013)229). The Guidelines set out targets for the Commission, for Member States and for the Aquaculture Advisory Council. In relation to coordinated spatial planning, for example, the target for Member States is to put in place coordinated spatial planning, including MSP, so that the potential needs of the aquaculture sector can be considered when planning and allocating spaces for marine uses and activities. Member States are required to produce a multi-annual plan to promote aquaculture in their

country. A template for the multi-annual plan was included in the guidelines (see Box 2) and the plans developed cover the period 2014-2020, with a mid-term review in 2017. All 27 Member States of the EU have produced their multi-annual plans.

Box 2: Template for multi-annual national plan for the development of sustainable aquaculture (COM(2013)229)

1. National context and link with main national objectives
   - National situation and strategic approach towards the EU main objectives
   - Quantified national growth objective (2014-2020)

2. Response to the strategic guidelines

(a) Simplify administrative procedures:

(1) Assessment of the national situation:
   a. Qualitative description of the administrative set-up
   b. Quantitative data and explanations
(2) Main elements of the intended policy response: planned actions to reduce the administrative burden
(3) If applicable, corresponding quantified targets and indicators

(b) Coordinated Spatial Planning:

(1) Assessment of the national situation
(2) Main elements of the intended policy response
(3) Where applicable, corresponding quantified targets and indicators

(c) Competitiveness:

(1) Assessment of the national situation
(2) Main elements of the intended policy response
(3) Where applicable, the corresponding quantified targets and indicators

(d) Level playing field:

(1) Assessment of the national situation
(2) Main elements of the intended policy response (2014-2020)
(3) Where applicable, corresponding quantified targets and indicators

3. Governance and partnership

- Key contributions from the main actors involved (regional and/or local authorities, industry, stakeholders and NGOs)
- Link with the EMFF priorities and financial allocations
- Name and contact details of the National Contact Point for the promotion of sustainable aquaculture

4. Best practices

- Identification and presentation of three national best practices

6.7.1 National implementation of the Strategic Guidelines

Only the multi-annual national plans for aquaculture from *AquaSpace* project partner countries are considered here with specific reference to two of the priority areas: administrative procedures and coordinated spatial planning. The relevant parts of the Strategic Plans were translated and synthesised for the purposes of this review. It should be noted that within the other priority areas (competitiveness and level-playing field) there may be measures and activities identified within the national strategic aquaculture plans which would also impact upon future aquaculture site selection, planning and management. These have not been considered in this document. Where necessary, other sources of information have also been consulted and referenced.

<u>France</u>

Responsibility for aquaculture policy and regulation resides with the Directorate of Marine Fisheries and Aquaculture (DPMA), within the Ministry for Environment, Energy and the Sea. The Directorate

has a decentralised structure with representatives at the Préfet (Prefecture) level. At the regional Préfet level there are schemes for the development of marine aquaculture, which include site selection. It is intended that these schemes will be incorporated into the strategies associated with MSFD implementation[31]. The National Strategic Plan for Aquaculture identifies three key issues which impact upon French aquaculture (Ministère de L'écologie, du Développement Durable et de L'énergie, 2014). These relate to:

1. Increasing effective linkages between those from the industry and the administrations in relation to licensing;
2. Increasing the supply of aquaculture products to a buoyant market and despite strong constraints;
3. Being able to encourage sustainable aquaculture activities with territories; and
4. Removing the main development challenges faced by the Outermost Regions.

The Plan goes on to identify key objectives to address the identified issues. In relation to licensing, for example, there are objectives to improve the clarity of the administrative structure; promote collaboration between the industry and administrations; and to better utilise spatial planning to allow access to suitable sites. This will include the establishment of a 'reference group' at regional level where specific expertise on aquaculture would be concentrated. At national level, an aquaculture inter-ministerial expert group (*CNIDEXaqua*), comprised of experts from the different State departments and public institutions, will be established and have links to existing national initiatives on all forms of aquaculture (Ministère de L'écologie, du Développement Durable et de L'énergie, 2014). France also proposes to consolidate existing legislation into a unifying Aquaculture Code (*Op. cit*., p.72) and adopt a one-stop shop approach to consenting (Objective 3 in the Plan) which would incorporate a single authorisation for aquaculture along with a special authorisation for experimental developments. The possibility of authorities and private stakeholders signing Memoranda of Understanding (MoUs) to support collaborative aquaculture developments is also included in the plan (Objective 5). A separate section of the Plan deals with spatial planning for the sector. This calls for the determination of the Best Possible Aquaculture Sites (MEAP) in pre-existing planning or management schemes and includes targets for specific types of aquaculture using findings from DSR and DPSIR models. The use of the 'MEAP' approach also enables the consideration of other aspects such as data collection, information systems and public participation, which the Plan notes will have to be considered in the future implementation of the MSP Directive. Information on the animal health status will also be integrated into the MEAP approach.

Germany

The German National Strategic Plan for Aquaculture (Bundesministerium für Ernährung und Landwirtschaft [BMEL], 2014) follows the template provided by the Commission and correspondingly the Plan is structured around the following objectives:

- Identification and designation of relevant development constraints for German aquaculture, detailing the current situation;
- Identification of fundamental and comprehensive strategic long-term objectives, determining specific sectoral growth targets for the medium-term period (strategic planning); and
- Identification of measures necessary to achieve the strategic objectives.

[31] See http://www.fao.org/fishery/legalframework/nalo_france/fr

Like elsewhere in the EU, German aquaculture is characterised by stagnation which is linked to a number of interrelated constraints such as complex legal frameworks and licensing practices, insufficiencies in education and training, damage to the environment caused by predators in pond aquaculture locations and public perception of aquaculture. Opportunities have, however, also been identified such as the ability to increase fish production from cage systems in lakes and ponds at former mining sites and aquaponics. A number of measures are proposed to implement the objectives of the Plan, which are addressed to specific stakeholder groups in order to encourage implementation. For those measures that concern administrative procedures, the Plan states that these should be dealt with through a centralised process. This is complicated by parallel responsibilities of different authorities, their hierarchies or in sub-areas (e.g. coast) of State and federal authorities, where simplification would not currently be possible. As a result, simplification of administrative procedures is being supported indirectly in the short and medium term, while the simplification of the legal process to facilitate improved authorisation procedures in aquaculture remains a long-term objective. Measures to simplify administrative procedures are outlined in Table 11.

Table 11: Measures to simplify administrative procedures in the German Strategic Aquaculture Plan (BMEL, 2014).

Measure	Description	Actors
Further development of legal framework	Complete evaluation of legal framework including proposals for further development of relevant national and federal laws to simplify authorisation procedures for aquaculture.	Coordinated by federal and State fisheries associations.
Development Privilege	Review of the current rules on the development privilege of aquaculture projects; including initiatives to adapt.	Coordinated cooperation of State and federal fisheries associations with relevant ministries.
Approval Coordinators	Appointment of coordinators for licensing procedures at federal level (e.g. for economic development organisations, chambers, etc., if not already available).	State fisheries associations and the economic promotion bodies at federal level.
Alternative proceedings	Implementation of concrete approval procedures by contractors and subsequent licensing to private investors.	Associations, private investors as service providers
Approval information	Development of guidelines on the approval / expansion of aquaculture companies for licensing authorities	State fisheries associations
Training licensing authorities	Organisation of further training for licensing authorities aimed at expediting and standardising licensing practice.	State fisheries associations

Measures for coordinated spatial planning and site security for aquaculture projects are also addressed in the Plan. This is divided into spatial planning for inland aquaculture and marine aquaculture, however the latter is not covered in much detail in the Plan. Spatial planning competencies for inland aquaculture are split between the States and the federal level, therefore, there is no binding plan for the entire federal territory. This means that designating new areas for aquaculture is not possible through regional spatial planning legislation but could be achieved through spatial planning principles in policy for inland aquaculture. Such principles only become binding if the law, which is the basis of the approval decision (e.g. the Building Code (BauGB); Land Building Regulations (LBO); Federal Natura Conservation Act (BNatSchG), National Nature Conservation Act (LNatSchG), etc.), contains a regulation which gives the spatial order validity. State authorities do have the power to designate special area under urban planning legislation. The Plan does not cover marine waters substantively. It does state that in the German part of the Wadden Sea, due to its protected status, only existing shellfish aquaculture is permitted with no plans to expand aquaculture activity in this area. Measures relating to coordinated spatial planning in coastal areas of the German Baltic Sea are given in Table 12.

Table 12: Coordinated spatial planning measures specified for coastal areas of the German Baltic Sea (BMEL, 2014).

Measure	Description	Actors
Concept for Baltic sea mussels	Establishment of a development concept for the sustainable production of mussels	Ministry of Energy, Agriculture, Environment and Rural Areas in Schleswig Holstein (MELUR SH)
Areas of suitability in the Baltic Sea	Identification of priority areas for integrated multi-trophic aquaculture plants or mussel and / or algae crops in spatial planning and land plans	Highest spatial planning authorities in the States Schleswig Holstein (SH) and Mecklenburg Vorpommern (MV) in cooperation with relevant State fisheries associations

Greece

In Greece licensing of land and marine waters for aquaculture activities was transferred to the local fisheries services of decentralised administrations of the country (non-elected regions) through legislation enacted in 2014 (Development of Aquaculture and Other Provisions law no. 4282/2014). The national Strategic Plan for aquaculture states that as a result of EU legislation, the process for obtaining aquaculture licences has become more complicated, costly and time-consuming (Ministry of Rural Development and Food, Directorate-General for Fisheries Management, Aquaculture and Inland Waters, 2014). The Aquaculture Development Law partly simplifies the licensing procedure by responding to industry needs (lengthening the lease agreement period; reactivating inactive licences etc.) and clarifying the administrative framework. The legislation also introduced a one-stop shop approach to licensing, which reduced both the number of licences required and the number of authorities involved. The legislation also sought to make the sector more investment-friendly in recognition that most operators are small, family-owned businesses or SMEs. Dedicated Ministerial Orders are required under Greek law to give full effect to the Aquaculture Development framework law and consequently this is included as an action in the national aquaculture Plan. The Plan foresees the establishment of a National Aquaculture Council who will advise the Ministry of Rural Development and Food on aquaculture policy matters such as required reforms, financial support mechanisms etc. Consolidating and amending the legal instruments that cover environmental aspects of aquaculture licensing is explicitly targeted in the Plan. To assist developers a licensing handbook outlining the procedures in place is to be published and a digital platform with applicable information will also be launched. Timelines for each of the proposed actions are presented in the Plan (Ministry of Rural Development and Food, Directorate-General for Fisheries Management, Aquaculture and Inland Waters, 2014: 20).

The existing legal framework includes a framework for spatial planning and sustainable development for certain areas or sectors of productive activities of national importance. This enabled the approval, at national level, of a Special Framework for Spatial Planning and Sustainable Development for Aquaculture (EPCHSAAF) and associated strategic environmental assessment which should facilitate the development of guidance on certain aspects of aquaculture activity such as licensing, coexistence with other activities and environmental protection. Two types of Aquaculture Development Zones (ADA) may be allocated depending on who is involved in their allocation: ZICU are Zones of Informal Concentration of (aquaculture) Units containing up to five farms, with a total spatial extent not exceeding 10 ha (100,000m^2) and a distance of 500m - 2km from each other. ZICU are considered the transitional stage before the ZODA is enacted. ZODA are Zones of Organised Development of Aquaculture Farms. Outside ADAs the installation of single units is permitted only for pilot units that meet certain requirements; where there is combined planning of tourist facilities or diving parks with (small capacity) aquaculture units in the context of agro-tourism; and in uninhabited islands mainly close to the borders or remote areas. Marine aquaculture farms are not permitted in areas used by the military, in navigation channels or where there are cables, structures or pipes for energy distribution; or in areas where the seabed is covered by protected species (*Posidonia oceanica,*

Cymodocea nodosa, Zostera marina and Zostera noltii) or species listed in EU/national legislation (Anagnopoulos, 2016).

The national strategic Plan therefore seeks to expedite and deliver the implementation of the aforementioned spatial planning framework for aquaculture. Currently an area of only 8 km^2 is leased for marine fish farms (Ministry of Rural Development and Food, Directorate-General for Fisheries Management, Aquaculture and Inland Waters, 2014: 21). The EPCHSAAF provides national level guidance for the siting of both marine and freshwater aquaculture installations. Problems in implementing this approach are identified in the national Plan and include a complex and time consuming legal framework governing the allocation of sites; high costs; the fragmentation of representative bodies and a cost-benefit analysis of whether the definition of allocated zones is advantageous. The Plan seeks to address these identified short-comings of the EPCHSAAF and its implementation to date. This will involve clarifying legislation on the process and the institutions involved; awareness raising across all stakeholders; determining criteria for the carrying capacity of the allocated zones; expediting the process for allocating the different types of aquaculture zone; and developing a monitoring and evaluation framework.

Ireland

In Ireland, the National Strategic Plan for Sustainable Aquaculture Development was published by the Department of Agriculture, Food and the Marine in 2015 after public consultation on a draft version earlier in the year (DAFM, 2015). Chapters 7 and 8 of the Plan deal specifically with coordinated spatial planning and aquaculture licensing respectively. With respect to spatial planning the vision for 2020 is that "aquaculture [is] incorporated into an effective and equitable marine spatial planning system". Four actions are identified to achieve this, namely:

1. Develop opportunities and constraints mapping for aquaculture taking specific account of environmental issues, Natura 2000 sites and inshore fisheries;
2. Identify marine tourism opportunities from aquaculture;
3. Study on integrated multi-trophic aquaculture and possible synergies with offshore wind farms or other marine renewable energy;
4. Study on how aquaculture contributes to communities in rural areas.

Constraints may be economic, social and environmental in nature and the proposed study will assess the spatial constraints and opportunities culminating in the production of maps showing where specific aquaculture activities are suitable and where there are constraints to particular aquaculture activities. The opportunities associated with tourism are intended not only to build on a long tradition of seafood related festivals in the country but also to help improve both public understanding of the sector and its perception. In relation to coexistence of marine activities, a consideration in both MSP and perhaps for Blue Growth, a study into possible synergies between marine renewable energy and aquaculture activities is proposed and would also contribute useful inputs to the MSP process.

Following a similar structure to the chapter on coordinated spatial planning, the chapter on aquaculture licensing contains four actions on how a streamlined and efficient licensing system can be achieved:

1. Progressively remove the current aquaculture licensing backlog;
2. Review and revision of the aquaculture licensing process, including the applicable legal framework;
3. In the context of a reviewed process and revised legal framework, consider the phased introduction of appropriate timescales for licence determination; and

4. Develop a data management and information system, with online aquaculture licence application and tracking functionality, and spatial mapping of aquaculture sites.

Marine aquaculture is currently licensed under several legal instruments, some of which date from the 1930s. Freshwater aquaculture is licensed under the Planning and Development Acts, 2000-2016 for land-based operations. A recognised obstacle to aquaculture development in Ireland is the licensing process and specifically the challenges presented by environmental legislation such as the Birds and Habitats Directives and the associated Appropriate Assessment process. Ireland has faced infraction proceedings[32] in this regard previously and is in the process of retrospectively conducting AA for all existing licensed sites. This stymied the processing of any aquaculture licence applications in the country significantly. Licence determinations farms in or near to for Natura 2000 areas are dealt with on a bay-by-bay basis and 13 AAs had been completed by October 2015 (DAFM, 2015). According to the Plan, it is expected that the remaining AAs will be completed by 2016 and this in turn will expedite the processing of licensing applications. As a result of this situation a new Monitoring and Compliance Unit was created within DAFM but with representatives from other government departments and State agencies which have a marine remit. The purpose of the Unit is to enhance monitoring and regulatory standards, practices and procedures and includes a process for the systematic audit of licence conditions.

An independent review of the aquaculture licensing process was launched in January 2017.[33] The aim of this review is to identify changes required to the aquaculture licensing process and associated legal framework that will:

- Deliver licence determinations in a timely manner;
- Support achievement of the actions and priorities in related national policies;
- Facilitate enhanced transparency in the licensing process for all stakeholders; and
- Ensure legally robust licence determinations having regard to EU and national law.

Stakeholders are being asked to submit their views by early February and the Review Group appointed then has four months to report to the Minister with recommendations on suggested actions. The review covers all stages of the licensing process from pre-application stage to the determination stage and all types of licence.

Italy

The Italian National Strategic Plan for Aquaculture proposes to strengthen institutional capacity and administrative simplification between 2014 and 2020 (Ministero delle Politiche Agricole Alimentari e Forestali (MiPAAF), 2014). This begins with a process to ensure a single, consistent regulatory framework for Italian aquaculture, to reduce and/or remove administrative and bureaucratic constraints for aquaculture businesses and deliver a more efficient and transparent system which in turn will boost entrepreneurship and development. Amendment of the Italian Constitution (Title V) resulted in regulatory responsibilities for aquaculture being transferred to the regions exclusively, with the State having competences for national programmes and coordination of regional policies. This has implications for requirements relating to the development of aquaculture, licensing and granting of State concessions, renewals, extensions and other authorisations. In relation to aquaculture installations that are located more than one kilometre from the shore, an application must also be made to the central Ministry of Agriculture (MiPAAF, 2014). This sometimes results not only in

[32] Commission of the European Communities v Ireland, C418/04.
[33] See http://www.fishingnet.ie/independentaquaculturelicensingreview-publicconsultation2017/

competing jurisdictions but multiple legal arrangements that vary from region to region. For developers this causes lengthy administrative procedures. Strategic actions in the National Plan to simplify procedures includes the adoption of a single piece of legislation for for aquaculture; the creation of an "Aquaculture Platform" which will host information to support both developers and decision-makers; and the creation of a 'one-stop-shop' at central level to support regional offices in responding to stakeholder needs. There is also an action dedicated to upgrading the national statistical system and data collection with a view to assisting strategic planning, in response to changes in trends at regional level.

With respect to coordinated spatial planning, the Italian Strategic Plan contains a useful overview of the repercussions of many key EU legal instruments, e.g. WFD, MSFD, Natura 2000 and EIA; as well as GFCM initiatives such as the ecosystem approach to aquaculture (EAA) and Allocated Zones for Aquaculture (AZA), have for Italian aquaculture. Critical issues identified are: how poorly the aquaculture sector is reflected in existing spatial planning and integrated coastal zone management initiatives; poor implementation of the Allocated Zones for Aquaculture (AZA) in line with EAA; a lack of criteria for the allocation of areas; poor coordination between central, regional and local institutions; data availability and more specific implications that could derive from the WFD, the MSFD and Natura 2000 sites (MiPAAF, 2014 list on p.128). Six strategic actions are put forward to address coordinated spatial planning, shown in Table 13, along with the expected outcomes of the action. For each action, the Plan presents a synthesis of the issue, types of aquaculture effected, responsible bodies, steps involved in achieving the action, the timeframe and expected results.

Table 13: Strategic Actions on coordinated spatial planning and expected outcomes (based on MiPAAF, 2014).

Strategic Action	Expected outcomes
Better use of marine space and development of knowledge and tools for defining Allocated Zones for Aquaculture (AZA);	Creation of a Working Group. Publication of Guidelines for AZA Development of database and GIS systems for AZA Establishment of environmental monitoring protocols for AZA Development of sustainability indicators
Regional development of plans for Allocated Zones for Aquaculture	Increase in the number of AZAs
Protected Areas for Shellfish	Improving the environmental quality (microbiological parameters) in shellfish production areas Geodatabase on environmental and health quality of shellfish production areas Alert system for entities responsible for production and harvesting of bivalve molluscs
Improve Environmental Impact Assessment in Aquaculture	Publication of Guidelines on EIA for inland, shellfish and marine aquaculture
Improving aquaculture within Natura 2000 sites	Guidelines on Aquaculture Development in Natura 2000 sites (including AA, changes in population, compensatory measures etc.) Geodatabase of all aquaculture sites located in Natura 2000 areas
Ensuring the availability and quality of water resources for inland aquaculture	Guidelines for increased water and energy efficiency in inland aquaculture areas

The Working Group will concentrate on defining criteria and tools to implement AZA for marine and shellfish aquaculture, taking the MSP Directive and GFCM Resolution 36/2012/1 on guidelines for AZA into account. The latter Guidelines are to be implemented at regional level and it is intended to integrate such zones into regional spatial plans for the coastal and marine space. The Plan and the progress made in implementing the strategic objectives will be reviewed and evaluated in 2017.

Portugal

The Portuguese Directorate-General for Natural Resources, Security and Maritime Services (DGRM) published the final version of the national strategic action plan for aquaculture in 2014, following a public consultation on an initial version earlier that year (DGRM, 2014). The Plan does not strictly

follow the template put forward by the European Commission in the Strategic Guidelines for Aquaculture though most of the topics are included in the Plan implicitly. There are three central objectives of the Plan: reduction and simplification of administrative procedures (in line with the Guidelines); identification of water resources and allocation of areas with the greatest potential for aquaculture (related to spatial planning) and increase, diversify and enhance national aquaculture production, which satisfies the other work areas contained in the Strategic Guidelines (COM/2013/229). In relation to simplifying administrative procedures three actions are stipulated (DGRM, 2014):

1. Amendment of the legislation governing the licensing of the use of the water domain and authorisation of aquaculture installations
2. Simplification of procedures that relate to the documents to be submitted by economic operators and
3. Creation of an online platform for the submission, analysis and processing of licence applications.

In Portugal aquaculture requires a licence for occupation of the sea space and a licence for conducting the aquaculture activity, each of which is a separate process administered by a different authority. Simplification will therefore enable the simultaneous processing of applications for each type of consent. This practice already exists in the dedicated Aquaculture Production Areas (APAs) but as most aquaculture sites are planned in an *ad hoc* manner a more strategic approach to processing of licensing applications should be helpful. To facilitate simplification, the Plan states that prior to licensing there will be an evaluation and definition of the baseline conditions including those relating to the environment. This has already been taken forward to an extent through the LBOGEM framework in 2014 (see preceding section Portugal) and enabling Decree-Law No. 38/2015 that amends the regime applicable to private use of transitional water resources for aquaculture. The next action relates to documents to be submitted by developers and seeks to define standard procedures and the minimum information required, including the availability of online models, consistent with the type of establishment being proposed. Associated with this action is the creation and/or updating of technical support guides and manuals to expedite the licensing process. An online platform for submission, analysis and processing will be developed as part of this action and will be interoperable with other systems in use by the competent authorities. The online system is a virtual one-stop shop where a manager can follow each step in the process from application through to operation. The online system will also be accessible to other regulatory authorities so that they can follow the process/application. It is intended that the introduction of this system will reduce the time taken to obtain a licence to 120 working days, excluding the time allocated for tendering, consultation etc. (DGRM, 2014: 49).

Portuguese land and marine territory is already covered by several plans, sometimes pertaining to the same spatial area, but each with different objectives and responsible authorities. The national aquaculture Plan implies that this is a weak point for the aquaculture sector, which requires better coordination and alignment of objectives, particularly in relation to environmental quality and associated parameters. Decree-Regulation No. 9/2008 already enables the zoning of aquaculture production areas in open waters. The pilot zone of Armona, in the Algarve, is one example that is already in operation. Under the Plan, it is intended that new zones will be identified which are suitable for aquaculture, are of lower environmental sensitivity and are compatible with other uses. Once those areas are identified they will be released for operation through a public tender process. The creation of new zones requires legislation and data collection. The latter will involve bringing together a range of spatial information held in different bodies, along with mapping of all active and inactive farms, and overlaid with other spatially relevant data such as designated sites, prohibited areas, safety constraints. This will enable the selection of new zone which will then be subject to a characterisation

exercise involving the environmental conditions and possible technologies that could be sited there. Following these steps a legal process to designate a zone can begin. According to the Plan, this will occur during 2016-2018 (DGRM, 2014).

Spain

The Ministerio de Agricultura, Alimentación y Medio Ambiente published the Spanish Strategic Aquaculture Plan in 2014 (MAGRAMA, 2014). This complements a number of pre-existing national efforts to promote aquaculture in the country including a White Paper on Spanish Aquaculture (MAGRAMA, 2001), the Spanish Strategy for the Sustainable Development of Aquaculture (FOESA, 2013) and Regional Strategic Plans at regional level. The Strategic Plan was developed in cooperation with the Autonomous Communities (AC), NGOs and the main producer organisations. According to the Plan, the vision for Spanish aquaculture by 2030 is to be a sustainable, strong economic and competitive sector, which creates wealth for society and quality employment. To achieve this planning and management of the sector, particularly the legal and administrative framework upon which it is based, must be improved so that is can respond weaknesses identified by companies in the sector.

Table 14: Strategic objectives and actions in the Spanish multi-annual Strategic Aquaculture Plan (MAGRAMA, 2014).

Strategic Objective	Strategic Actions
Simplify and standardise the legal and administrative framework and reinforce the representativeness of the sector (nationally, regionally and within the industry).	A1.1. Coordinate the process of simplification of the administrative procedures for the authorisation of aquaculture in the Autonomous Communities; A1.2. Coordinate the process of homogenisation of standards related to EIA and associated criteria and parameters; A1.3. Reform the Law on Marine Cultivation (*Ley de Cultivos Marinas*) to provide JACUMAR[34] and JACUCON[35] with more power; A1.4. Standardise the criteria for facility operation. Design and propose standard criteria for royalties; A1.5. Analyse the potential for offshore aquaculture; A1.6 Improve the information system for aquaculture to support the planning, management and monitoring of the activity.
To increase Spanish aquaculture production by improving sectoral planning within the framework of integrated coastal zone management and selecting new Aquaculture Interest Zones (AIZs) and support and promote inland aquaculture in national hydrological planning.	A2.1. Establish common criteria for the selection of AIZs and coordinate the selection process and declaration of AIZs by the Autonomous Communities; A2.2. Reinforce positive interactions of aquaculture in the Natura 2000 network; A2.3. Plan access to water for inland aquaculture and reuse of defunct facilities; A2.4. Develop and improve crop technologies focused on better use of space; A2.5. Support investment in new sites and the creation of new aquaculture enterprises; A2.6. Develop a GIS tool for spatial planning of Spanish aquaculture.
Note: under the priority area relating to 'competitiveness', strategic actions relating to the strengthening of environmental aspects are included but they have not been included in this section.	

Work on the legal and administrative systems in place seek to provide greater legal certainty to aquaculture developers and greater transparency to potential investors and consumers. The governance structure in Spain is complex with the Autonomous Communities having exclusive competence for aquaculture. The Plan states that in theory 17 different maritime management plans could apply to aquaculture. Almost all the AC already have strategic plans for aquaculture. A key function of the national Plan is therefore to ensure the necessary and timely coordination mechanisms between central government and the AC are in place (MAGRAMA, 2014: 23).

Declines in inland aquaculture are attributed to deteriorating environmental quality of inland waters, Spanish hydrological planning and uptake of Recirculation Aquaculture Systems (RAS), where water

[34] JACUMAR (*Junta Nacional Asesora de Cultivos Marinos*) National Advisory Board for Marine Cultivation.
[35] JACUCON (*Junta Nacional Asesora de Acuicultura Continental*) National Advisory Board for Inland Aquaculture.

consumption is substantially reduced. The Strategic Plan contains 37 national strategic actions, which complement each other as far as practicable. Table 14 shows the strategic objectives with the supporting required strategic actions for the two priority themes of interest to this report: simplification of administrative procedures and coordinated spatial planning.

A key challenge in the Spanish Plan is to reconcile national objectives and actions with strategic planning work that is already underway in the AC. The national Plan has endeavoured, with the agreement of the AC, to incorporate these in one of three ways:

1. Where one of the AC has a pre-existing plan, its provisions are integrated into the National Strategic Plan. These strategic plans are annexed to the national Plan as a Regional Strategic Planning document.[36] [9 AC are in this position], or
2. In AC that do not have a strategic plan but have defined certain strategic actions these are also included in the Regional Strategic Planning document. [3 AC fall into this category], or
3. The Autonomous Communities can adhere to the strategic actions proposed at national and regional level.

Each of the national strategic actions in the national Plan are detailed with information on the priority theme to which it relates, supporting information for the SWOT analysis conducted, the type of aquaculture to which it relates, a description of the context, how it will be financed, its relationship to any related Autonomous Strategic Actions, the timeframe and indicators for its implementation.

United Kingdom

In the UK responsibility for aquaculture policy is a devolved matter, meaning the separate administrations of England, Scotland, Wales, and Northern Ireland largely determine how it operates in that area. Scotland is the major aquaculture producer of the UK with both marine (salmon) and freshwater aquaculture. In England, Wales and Northern Ireland the focus is on shellfish and trout production. The Department for Environment, Food and Rural Affairs (Defra) published the UK's multiannual national plan for the development of sustainable aquaculture in October 2015 (Defra, 2015). The Plan outlines the different regulatory requirements which apply in each of the devolved administrations. In relation to simplifying administrative procedures, the Plan states that the foremost challenge across all the devolved administrations is the expertise available within the regulatory organisations and the surety needed to take sometimes controversial decisions. On occasion this is compounded by a lack of scientific evidence on the impacts of aquaculture as well as the public perception of aquaculture which can lead to objections towards proposed developments and/or expansion of existing operations. Due to the governance system in the UK, the Plan does not contain quantified targets for the simplification of administrative procedures as such decisions are up to the governments within the devolved administrations. The plan does, however, highlight the measures contained in the EU EMFF Regulation (No. 508/2014) that could potentially assist in addressing the administrative shortcomings. Specifically, those referenced are Article 47 relating to a better understanding of the science behind environmental interactions; Articles 47, 50 and 56 which seek to improve the industry's relationship with stakeholders and regulators; and Articles 49-50 relating to sharing of best practice, specifically in relation to building capacity at the decision-making level.

In relation to spatial planning, the UK is at the forefront of implementing marine planning in the EU, commencing their planning process before the adoption of the EU Directive on MSP. In a similar

[36] See http://www.mapama.gob.es/es/pesca/temas/acuicultura/315_PLANES_AUTONOMICOS_PEAE_MAR_2015_tcm7-367648.pdf

situation to that of aquaculture, marine planning is also a devolved activity with each administration at a different stage of implementation, as outlined above, and consequently targets for the UK in relation to this are not presented in the Plan. Findings from the EMFF SWOT Analysis and Needs Assessment found that 'opening up commercially viable new productive areas' for UK aquaculture was desirable. Accordingly, this process will have to interact with the over-arching marine planning process in each marine region and/or devolved administration. The published marine plan for the East Inshore region states that the region hosts about 40% of English shellfish production and over 50% of English mussel production according to 2010 figures (Defra, 2014). During the preparation of the East Inshore Marine Plan, a first assessment of the spatial potential for aquaculture in the East and South Marine Plan Areas was conducted (MMO, 2013). This identifies the spatial potential at a plan area level and incorporates a rudimentary, high level cost-benefit analysis on the possible economic return for each type of aquaculture. In the subsequent Marine Plan, and within aquaculture sites, Policy AQ1 provides that proposals should demonstrate:

a. that they will avoid adverse impacts on future aquaculture development by altering the sea bed or water column in ways which would cause adverse impacts to aquaculture productivity or potential;
b. how, if there are adverse impacts on aquaculture development, they can be minimised;
c. how, if the adverse impacts cannot be minimised they will be mitigated; and
d. the case for proceeding with the proposal if it is not possible to minimise or mitigate the adverse impacts (Defra, 2014).

Through this type of approach, the Plan seeks to facilitate future aquaculture development and does not preclude other developments or activities but applies national policy in the sense that consideration must be given to how other proposals may impact access to, and use of, areas suitable for future aquaculture development. Stakeholders are involved throughout the marine plan development process and the aquaculture sector is represented through the responsible government bodies, industry organisations and individual operators.

Eastern European nations

Poland, Hungary and the Czech Republic have recently updated their aquaculture policy strategies, all with a similar focus upon improving environmental sustainability in the aquaculture sector; and there is considerable emphasis on environmental services provided by aquaculture sites. All multiannual national strategies[37] involve a plan for:

- maintaining the current pond area for extensive aquaculture and strengthening its ecological functions (habitat provision, microclimatic effects, landscape formation),
- modernization of existing production units (development and purchase of new technologies),
- diversification of the aquaculture sector in terms of produced species (with high market potential) and activities (multi-functionality, angling, ecotourism),
- knowledge transfer and exchange of best practices at the national level and also between Member States,
- development of the post-harvest value chain and boosting the local population's demand for freshwater products.

Thus, spatial expansion of pond aquaculture is not envisaged (or is envisaged to a limited extent) by the national aquaculture strategies, and no financial incentives are available to build new ponds.

[37] http://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans/index_en.htm

However, the quality of the space currently devoted to fish farming will be improved with respect to utilisation and environmental services.

Other Relevant EU Instruments - Key observations

Regarding legal instruments:

- Guidance from the EU is available on the interaction of various pieces of legislation with aquaculture but often this is too vague to have practical effects.
- Certain legal instruments appear to overlap in terms of objectives as well as geographic scope. The most pertinent example of this is between the WFD and MSFD. Good environmental status in the MSFD, for example, is not exactly the same as good ecological/chemical status in the WFD which can create challenges for implementation. This can be attributed to the differences in geographical scale of their respective application and consequent criteria. The MSFD operates at a much larger scale (region) and for the purposes of GES takes in a wider range of parameters.
- There needs to be workable and visible mechanisms to link high level environmental objectives with site-level operation: MSFD/WFD GES with EIA findings and licensing of farms. These mechanisms, if they exist, are not currently obvious.
- Neither the WFD or MSFD Directive mentions aquaculture specifically though operators have to comply with national legislation implement both. Management measures deriving from both which improve water quality or the marine environment more broadly should therefore be a positive development for the aquaculture industry.
- In terms of impacts from aquaculture, neither the WFD or MSFD Directive can fully take account of such impacts though these are specifically included within the Impact Assessment Directives (EIA and SEA). As such there needs to be clear links between these processes regardless of the scale of operation.
- Targeted objectives and measures for areas of aquaculture production need to be fully integrated into the second round of RBMPs so that the possible impacts of the sector and its future requirements can be considered in the context of the whole river basin.
- As sectors grow, and particularly in light of Integrated Maritime Policy, sea-basin strategies and Blue Growth objectives, so too does the need for an operational approach to the assessment of cumulative effects. Evidence from experience with the EIA Directive suggests that cumulative impacts are still the most ignored aspect of impact assessment. Strategic management approaches such as MSP will need to address this gap.
- Development of guidance on licensing aquaculture developments at national level so as to see how consenting meets with broader legal requirements.

Other Relevant EU Instruments - Key observations

Regarding National Strategic Aquaculture Plans:

- Almost all of the Plans examined identify the need to amend legislation governing aquaculture to make licensing process more effective. This could be difficult given the governance systems in various Member States, particularly where there is a separation of powers between central and regional/provincial/local authorities.
- Some Member States have created Inter-Ministerial Working Groups, committees or council so as to bring all parties with a marine remit into one place and work collaboratively on issues of common concern.
- With respect to licensing almost all countries have proposed the creation, or updating, of manuals or guidance documents so as to clarify applicable procedures for developers. This could be combined with over-arching EU guidance on WFD, MSFD, Natura 2000 and EIA requirements as a way of making that more meaningful for site operations.
- Complicated licensing procedures are also being addressed through the adoption of the one-stop shop approach to consenting.
- Technology is also being advocated as a way of improving consenting and licensing processes by mapping constraints, making information more readily accessible and providing useful data.
- The Italian National Strategic Aquaculture Plan is the only plan of all those examined that refers to the FAO EAA and zoning. Other countries utilise zoning to a certain degree but this is identified as an area that needs more work and greater implementation.
- In some countries there are legal barriers to zoning specific areas for future aquaculture development. This is a problem that can only be addressed within Member State systems.
- Compliance with environmental legislation such as the Birds and Habitats Directives and water quality Directives would appear to have had detrimental impacts on licensing processes particularly in terms of the time taken to obtain licences and the level of information needed to supplement licence applications.
- Very few of the national plans mention MSP or ICZM. In relation to MSP, this could be explained by the fact that the Strategic Guidelines and associated Plans came into being just as the MSP Directive was enacted and entering into force.
- The UK marine planning process specifically links with the aquaculture sector (and other maritime Sectors) in the regional plan development process.

7. Linkages between spatial planning and ecosystem approach

7.1 Background

There are numerous definitions of the ecosystem approach deriving from international, regional, EU and national legislation and policy documents, as well as other sub-regional bodies that have a marine environmental management role.

There is not one commonly accepted and agreed definition of the ecosystem approach, because it is, in essence, a management principle, and therefore open to interpretation depending on how it is being applied. A common definition is "*the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity*"[38] Within this context the CBD defines twelve principles of the ecosystem approach[39], whereas the FAO's definition for the ecosystem approach to aquaculture has three; but both fit within what Maltby (2000) describes as "*….not a static model but is a holistic process for integrating and delivering….*". Across all definitions, a number of common elements appear therein, which could be said to characterise an ecosystem approach. These are:

- An integrated management approach;
- Conservation of ecosystems;
- Sustainable use of ecosystem goods and services.

7.2 Ecosystem Approach to Aquaculture

The best application of an ecosystem approach for aquaculture is developed out of the FAO CCRF (FAO, 1995) which embeds sustainability in the planning and management of aquaculture. Out of this concept FAO's strategy is the ecosystem approach to aquaculture or EAA (FAO, 2010), which defines three principles that govern implementation, namely:

i. Aquaculture should be developed in the context of ecosystem functions and services (including biodiversity) with no degradation of these beyond their resilience.
ii. Aquaculture should improve human-wellbeing with equity (e.g. access rights, and fair share of incomes) for all relevant stakeholders.
iii. Aquaculture should be developed in the context of other sectors, policies and goals as appropriate.

The EAA provides a planning and management framework to integrate aquaculture into local planning and prescribes clear mechanisms for engaging with producers, government and other sectors and stakeholders, to effect sustainable management of aquaculture operations. The EAA encapsulates the spirit and need to define a suitable definition and format to engage with the ecosystem approach within Europe, as outlined above, ensuring local and national environmental, social, economic and governance objectives in the pursuit of good spatial planning. A recent development is the application of aquaculture spatial planning under the ecosystem approach and FAO will shortly publish a guidance document which summarises the main steps in the process to define suitable zones, sites and management areas for aquaculture development (Aguilar-Manjarrez et al., in press).

In this context FAO and World Bank (2015) define a number of common problems that result in a lack of spatial planning for aquaculture under the ecosystem approach, which much of the industry will

[38] http://www.ospar.org/about/principles/ecosystem-approach
[39] https://www.cbd.int/ecosystem/principles.shtml

recognise as issues for the development of aquaculture within Europe, including fish disease, environmental issues, production issues, social conflicts and lack of resilience, among others.

What the EAA has done in practical terms is enhance the development of appropriate tools and models (Corner and Aguilar-Manjarrez, in press; Nunes et al., 2011) that aid our understanding of aquaculture, its effects and mitigation actions that can be taken in order to ensure aquaculture is developed sustainably (Nunes et al., 2011). In practice there remains significant scope to develop better management systems, improved technical understanding and better control (e.g. disease) to aid development, including the best use of available space.

There is, however, uncertainty in applying the ecosystem approach as a concept in relation to EU policy development, because of the failure in Treaties of the EU to mention the ecosystem approach explicitly, which results in mixed messages in terms of how it can be implemented.

7.3 Ecosystem approach within EU policy

At EU level, while the Treaties governing the establishment and functioning of the EU do not explicitly mention the ecosystem approach, it is referred to implicitly and can be implemented through a number of policies and legal instruments. At policy level, for example, this includes the IMP, where the Commission has recommended that national policies should be guided by the principles of subsidiarity, competitiveness, sustainable economic development, stakeholder participation, and the ecosystems approach (COM(2008) 395 final). Legally the ecosystems approach has a basis in both the MSFD and the CFP.

The MSFD seeks to implement the environmental aspects of the IMP and consequently a key focus of that legislation is to manage human activities that impact upon marine ecosystem, to protect and conserve biodiversity and ensure sustainable development of marine resources. The MSFD also refers to adaptive management to facilitate a more flexible approach to managing activities that may impact on the quality of the marine environment and growing evidence from both science and impacts experienced. In practice, and according to the Preamble of the Directive, this means by applying an ecosystem-based approach, priority should be given to “achieving or maintaining good environmental status in the Community’s marine environment, to continuing its protection and preservation, and to preventing subsequent deterioration” (Recital 8). Article 1(3) reiterates this by providing that the marine strategies put forward by Member States will apply an ecosystem-based approach to the management of human activities, “ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status.” This links to Annex VI of the MSFD and specifically the spatial and temporal distribution controls, to be included in Member States’ programme of measures, that influence where and when an activity is allowed to occur. Other EU legal instruments, in particular the nature conservation legislation (i.e. the Birds and Habitats Directives), that enable the creation of protected sites will also contribute to implementing the ecosystems approach as envisaged by the MSFD.

In the context of the CFP, in 2008 the Commission published a Communication on the role of the CFP in implementing an ecosystem approach to marine management (COM(2008) 187). This does not mention aquaculture explicitly, but the Communication explains the Commission’s position in relation to the ecosystem approach by stating that it seeks to ensure goods and services from living aquatic resources for present and future generations within meaningful ecological boundaries (EC, 2008b: 3). This means in practice that aquaculture, and fisheries management should not be detrimental to future functioning, diversity and integrity of marine ecosystems. The Communication stresses that an ecosystem approach to managing marine waters “cannot and should not be implemented in a specific sector alone, but must be cross-sectoral”, referring to the aforementioned instruments (IMP, MSFD,

Habitats Directive) in assisting with implementation. Reform of the CFP aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food and focuses on four policy areas: fisheries management, international policy, market and trade policy; and funding of the policy through the EMFF, (Regulation (EU) No 508/2014). Each of these policy areas can contribute to the implementation of an ecosystem approach. Fisheries management measures, for example, deal with catch limits between 2015 and 2020 and aim to sustain fish stocks in the long term. This also contains measures relating to making fishing fleets more selective in what they catch and to phase out the practice of discarding unwanted fish and in that way recognises the impact of fishing activity on all components of the ecosystem. In an aquaculture context, explicit responses to the ecosystem approach are not so clear-cut, but are implied by the application of EIA, for example. Under EIA applicants for an aquaculture site licence should undergo a process of investigation and data collection to determine possible environmental (and social) risks associated with the aquaculture development (including local cumulative effects), and provide mitigation or means to offset possible impacts, prior to an application being approved. There is consideration of local ecosystems on a site-by-site basis (or perhaps within a small-scale area) but at present little over-arching strategy that promotes integrated thinking at the zonal or area management scale that is fundamental to the ecosystem approach.

7.4 Implementation in the EU

The EMFF defines the funding mechanisms for the implementation of the CFP reform package, relevant measures from UNCLOS, the sustainable development of fisheries and aquaculture areas and inland fishing; and the IMP (Article 1, Reg. No 508/2014). As such the funding supports implementation of spatial planning tools such as ICM and MSP, stating that both contribute to the aims of ecosystems-based management.

There is, however, no single and defined way to implement the ecosystem approach. This very much depends on the measures that are in place to conserve and maintain ecosystem integrity. Accordingly, implementation is inherently linked to every marine sector, its management and responsible institutions and how they interact and cooperate.

A number of the law and policy instruments which seek to achieve better maritime governance and protection of the marine environment have yet to be evaluated. The latest progress report on the IMP for example, dates from 2012 (COM(2012) 491) and acknowledges the growing contribution of maritime sectors to Europe's economy, status of implementation of the MSFD at that time and the challenges of implementing Natura 2000 in the offshore environment (EC, 2012c). With respect to the MSFD, the Commission is not due to publish a first evaluation report on the implementation of the Directive until 2019, at the latest (Article 20(1), MSFD). Article 17 of the Habitats Directive requires Member States to report every six years about the progress made in implementing the Habitats Directive, which focuses on how Favourable Conservation Status of specific habitat types and species is being maintained or restored.

The latest state of nature in the EU report, covering the period 2007-2012, covers assessments of both species and habitats for terrestrial and marine regions (EC, 2015). The proportion of unknown species assessments is much higher in all five marine regions, with the Baltic Sea region having the worst status where 60% of the assessments were deemed unfavourable-bad, followed by 33% in the Black Sea Region (COM(2015)219). The Communication states that most of the bad status/deteriorating trends are found in species associated with aquatic environments and that this corresponds with the finding that freshwater habitats mostly have an unfavourable-inadequate conservation status. The conservation status of, and trends for, habitats are worse than for species. Member States also must include information on the main pressures and threats that are impacting on species and habitats

when reporting to the Commission. The results for marine species and habitats are shown in Figure 4, which indicates that 'use of living resources' is the largest pressure on bird and non-bird species. The Commission interprets this as coming primarily from fishing and harvesting of aquatic resources and aquaculture. Pollution contributes most to pressures on habitats.

An analysis of the governance structures to implement the ecosystem approach is much more difficult due to the range of sectors and institutions it involves. This is further complicated by the division of competences between the EC and internal Member State structures. At the sub-national level, local decision-making may or may not align with the national policy perspective. Thus, to implement the ecosystem approach in marine waters is one challenge but to analyse the governance structure and associated tools adds another layer of complication.

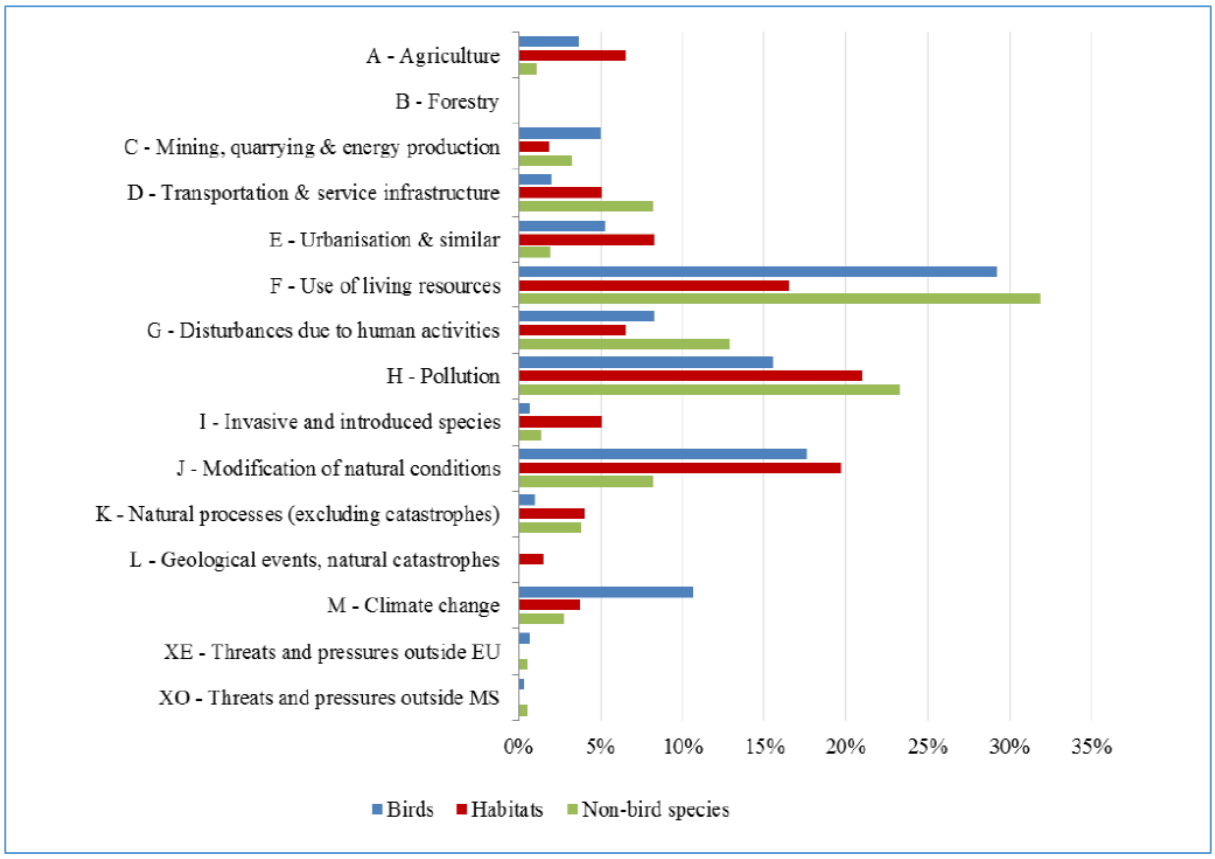


Figure 4: Frequency (%) of high ranked level 1 pressures and threats together for marine regions (from COM(2015) 219).

7.3 Spatial planning and the Ecosystem Approach

The purpose of spatial planning as originally conceived is to balance development and conservation and minimise long-term environmental damage by providing mechanisms, strategies and tools to maintain and/or restore assets and ecosystems. Both ICZM and MSP are intended as integrated spatial planning tools. Gee et al (2011) state that MSP aims to optimise sea use and ensure the integrity of the ecosystem simultaneously. In theory, the maritime spatial plans developed to comply with the MSP Directive should assist in delivering an ecosystem approach to future management of marine waters. This is, however, almost totally dependent on how such plans will be implemented and enforced. The ecosystem approach presents many challenges for existing maritime sectors as well as the associated management frameworks. At the most basic level, the ecosystem approach does not align with existing maritime jurisdictional zones, political boundaries and the institutional bodies

created to operate in those areas. The result is that the rights and duties of multiple users and actors varies across the ecosystem and there is no one body with ultimate authority or decision-making ability. It is highly unlikely that implementation of MSP will address these issues as evidence to date would appear to suggest that maritime spatial plans in existence are more focused on future sectoral development in a defined space, and not coordinated management of multiple activities. A second challenge presented by the ecosystem approach relates to the evidence base. From the various progress reports submitted to the Commission it is clearly acknowledged that there is still a huge amount of uncertainty in the marine environment from a fundamental science perspective but also in relation to impacts from both established and newer marine activities. There are substantial efforts at national and EU level in relation to data acquisition and monitoring but how this informs management in terms of actions at a practical level or better policy is currently unclear. This will be compounded as the environment changes. Adaptive management has a strong policy basis in EU law but there is uncertainty around what this means, being another undefined term in EU law. It could be argued that the ecosystem approach as a concept is weakened by the lack of a clear definition at EU level: without this it could be misunderstood or deemed as too difficult to implement.

As the Communication on the role of the CFP in implementing an ecosystem approach to marine management (COM(2008) 187) recognises the ecosystem approach to marine management implies that multiple and often conflicting interests need to be reconciled in a process. There are currently many tools, policies and instruments that can be used to begin implementation. There is however a critical need to provide integrated institutional structures at national and EU level which can conduct the range of activities necessary to fully implement the approach. These activities relate not only to pure management functions but to monitor, enforce and coordinate actions in a cross-sectoral and transboundary manner that are responsive to changing circumstance, be they social, environmental or economic. In conclusion, there are strong potential linkages between the ecosystem approach and spatial planning, with both being strengthened by the fact that they are 'integrated' in their perspective but to date it would appear they are equally weakened by being regarded as separate technical processes. The conceptual basis of the ecosystems approach must be capable of being translated into practical actions for spatial planning. More recent policy instruments like MSFD and to an extent MSP as conceived have enormous potential but ultimately it depends on how they are implemented, monitored and amended – which is currently too early to determine.

Guidance issued by the EC in 2016 states that planning is a key issue in relation to the strategic development of the marine aquaculture sector (EC, 2016b). The Commission believes a strategic view is important to ensure that aquaculture develops in the most suitable areas and that MSP is the mechanism that can link strategic planning with other marine sectors and uses to ultimately enable coexistence and reduce the potential for conflict. In this regard allocation of zones for aquaculture development is viewed as being complementary to the ecosystem approach.

Spatial Planning and Ecosystem Approach - Key observations

- There are a number of definitions of ecosystem approach, but all include three basic elements; an integrated management approach; conservation of ecosystems; and Sustainable use of ecosystem goods and services.
- The ecosystem approach to aquaculture has been developed by the FAO as a means to enhance aquaculture production in an environmentally and socially acceptable way that takes account of multiple uses of space.
- Legally the ecosystems approach has a basis in both the MSDF and the CFP but nowhere in EU is the concept defined, which could have implications for how it is, and if it is, implemented. The conceptual basis of the ecosystems approach must be capable of being translated into practical actions for spatial planning.
- Adaptive management also has a legal basis in EU law but is undefined, with the potential to lead to the same complications as above.
- A previous Commission Communication on the ecosystem approach and fisheries acknowledges that the ecosystem approach "cannot and should not be implemented in a specific sector alone, but must be cross-sectoral". This is the challenge for future spatial planning approaches and specifically for MSP.
- There is no single and defined way to implement the ecosystem approach. Implementation is inherently linked to every marine sector, its management and responsible institutions and how they interact and cooperate.
- An analysis of the governance structures to implement the ecosystem approach is much more difficult due to the range of sectors and institutions it involves. This is complicated by the division of competences between the EU and internal Member State structures.
- The ecosystem approach does not align with existing maritime jurisdictional zones, political boundaries and the institutional bodies created to operate in those areas.
- With respect to the evidence base, there is still a huge amount of uncertainty in the marine environment from a fundamental science perspective which may make it difficult to 'sell' the ecosystem approach to national governments/implementation bodies.
- Spatial planning supports the ecosystem approach but this requires a governance framework that incorporates monitoring, enforcement and coordination in a cross-sectoral and transboundary manner which is also responsive to changing contexts.
- There are strong potential linkages between the ecosystem approach and spatial planning, both being strengthened by the fact that they are 'integrated' in their perspective but to date it would appear they are equally weakened by being regarded as separate technical processes.
- FAO's linked activities related to the EAA and spatial planning to be published in 2017 may provide a suitable approach for Member States to consider.

8. Spatial planning for aquaculture and other uses

8.1 Introduction

The presence of an aquaculture site can affect other activities in the vicinity and result in inter-sectoral interactions. Interactions between aquaculture and other activities may be either synergistic (resulting in benefits for both activities) or antagonistic where the activities of one sector have costs or negative consequences for another activity. Table 15 shows a matrix of interactions between aquaculture and a range of marine sectors under a number of defined categories, with specifics expanded in Table 16.

From Table 15 and Table 16 it is clear, depending on the sector concerned, that interactions may be relatively simple or very complex. For example, aggregate extraction can have negative consequences for aquaculture in terms of smothering and siltation. In this case, there is a clear need to make the two activities spatially discrete to avoid losses to the aquaculture industry. In general, however, interactions between aquaculture and other maritime sectors are not simple. Both synergistic and antagonistic effects can occur simultaneously and most commonly these effects are not readily predictable, and may be cumulative. For example, with respect to coastal development, aquaculture (shellfish or finfish) could have positive effects in terms of job creation and nutrient assimilation while simultaneously resulting in loss of visual amenity and potentially contributing to nutrient pollution (depending on the specific type of aquaculture).

Similar multiple positive and negative interactions between fishing and aquaculture can occur, for example, fishing provides essential inputs to aquaculture, as a raw ingredient in feed and as a source of stock (e.g. in the tuna ranching industry), conversely aquaculture may compete with fisheries for space and may have adverse effects on wild stocks, which can affect not only the fishing industry but can also have knock on effects in terms of recreational angling. It is beyond the scope of this section to detail the numerous case-specific interactions, the sectoral interactions matrix does highlight a number of key issues that should be considered when planning for aquaculture, and these are summarised below.

Of the 20 maritime sectors considered above, nutrients (N) clearly play a major role in maritime aquaculture sectoral interactions and this is reflected in the abundant academic literature on the role of nutrients management in aquaculture activities (e.g. Ferreira et al., 2009). Sectoral interactions involving nutrients may be either synergistic or antagonistic, for example aquaculture may assimilate nutrients (generally from diffuse sources) which enter the marine environment as a result of agricultural activities, by contrast oversupply of nutrients (either as a result of agricultural or aquaculture production) can result in eutrophication, the growth of undesirable levels of plant material which can lead to hypoxia and anoxia in marine environments. Nutrients should also play a key role in planning for coastal development, and waste water treatment, as they may impact positively or negatively on harvesting of wild shellfish, as well as on recreation and tourism.

Table 15 also illustrates the importance of contamination (C) effects which may either be caused by or experienced by the aquaculture industry. Contamination effects may be either biological or chemical. Chemical contamination caused by aquaculture may be the result of chemical treatments such as the use of antibiotics or pesticides. Biological contamination may be caused by the introduction of non-indigenous, or invasive species, or through overstocking and the potential for farmed animals to become vectors of pests to wild populations.

Table 15: Matrix of marine aquaculture inter-sectoral effects (N=Nutrient related effects, SS=Smothering and Siltation, C=Chemical or biological contamination, ECO=Economic effects, VIS=effects on visual amenity, W=Wild-fish interactions, S=spatial competition, MPS=multi-purpose structures, FAD-Fish Aggregating Devices, O=Other).

	Aggregates	Agriculture	Aquaculture	Coastal Development	Desalination	Fishing	Harvesting/Collecting	Land based industry	Military	Navigational dredging	Nuclear	Oil and gas	Renewable energy	Research	Shipping	Telecoms	Tourism and Recreation	Waste Water Treatment	Conservation/ MPAS
Synergistic		N	N	N ECO		FAD O	O N	N		O	O	M PS	M PS	O			N FAD		FAD
Antagonistic	SS	N	C	VIS N	C O	W W	W	C	S C	S	C	C		O	C S	S	VIS S C W	N	C

Table 16: Matrix of synergistic and antagonistic cross-sectoral effects

Use	Synergistic			Antagonistic	
Aggregates				Smothering / siltation	
Agriculture	Nutrients for shellfish			Eutrophication and hypoxia/ anoxia - red tides and associated toxins	
Aquaculture	Integrated Multi-Trophic Aquaculture			High densities can lead/act as a vector to the spread of sea lice and water exchange	Eutrophication (mainly for fed aquaculture)
Coastal Development	Increased local market size	Waste treatment potential of shellfish	Jobs	Visual amenity impacts	Eutrophication and hypoxia /anoxia - red tides and associated toxins
Desalination				Hyper-salinity	Potential introduction of non-indigenous species (e.g. Zebra mussels)
Fishing	Tuna Ranching	Supply of food for farmed carnivores	Fish aggregating Devices	Competition for space.	Reductions in harvested wild fish populations
Harvesting/ Collecting	Farmed Shellfish may spread beyond the farmed area (e.g. *Crassostrea gigas*)	Effluent may promote enhanced shellfish growth outside farmed area		Reduction in wild fish populations reduced take of wild salmon	
Land based industry	Water Quality effects of shellfish			Potential for contamination	
Military				Congestion	Potential contamination
Navigational dredging		Provides access to aquaculture sites		Smothering/ siltation	
Nuclear	Shellfish growth in warmer water				Nuclear contamination
Oil and gas	Multi-purpose Structures				Chemical Contamination
Renewable energy	Multi-purpose Structures				
Research	Provides topic for research			Makes ecosystems less pristine	
Shipping				Contamination through spills	Congestion
Telecoms					Congestion
Tourism and Recreation	Water quality effects		Fish Aggregating Devices	Reduced recreational catches	Visual amenity impacts
Waste Water Treatment	Enhanced shellfish growth				
Nature Conservation/ MPAS	Fish Aggregating Devices			Non-indigenous species	

Similarly, other industries, nuclear, military, oil and gas, shipping etc. may cause contamination in aquaculture products, which may result either from catastrophic events (Garza-Gil et al., 2006) or from background contamination.

In the drive for Blue Growth, the development of offshore structures also has potentially beneficial or adverse effects for the aquaculture industry, new structures may be used as Multi-Purpose Structures

(MPS) which can facilitate the development of offshore aquaculture, by contrast, if new structures are not multi-purpose they can lead to spatial competition with aquaculture.

The array of potential interactions combined with the huge variety of environmental (physical and chemical oceanographic) as well as social and economic conditions within Europe's seas and their adjacent communities means that individual aquaculture development sites will each experience their own complex mixture of synergistic and antagonistic sectoral interactions which may, in turn, affect their ability to operate.

As maritime industries continue to develop and competition for marine space continues to increase it is becoming increasingly clear that inclusive processes incorporating public and multi-sectoral participation have the potential to overcome potential public goods conflicts before they arise and become entrenched (Lange et al., 2016). Participatory mapping approaches are increasingly identified as a pragmatic mechanism to incorporate multi-sectoral perspectives and to identify and overcome conflicts before they arise. Alexander et al. (2012) applied a technique combining participatory mapping with spatial multi-criteria analysis to identify trade-offs between inshore fishing sectors and potential locations for the deployment of marine renewable energy devices. Similarly, Potts et al. (2014) use "touch tables" to map conflict zones between fishers and the oil industry in the Moray Firth and to identify areas where oil and gas support infrastructure could be located to minimise conflicts with fisheries.

In practice, many of the potential conflicts between aquaculture and other sectors have not yet been fully realised, or are avoided by existing planning and application processes. At present, constrained by technology as well as physical conditions and economic considerations, most aquaculture is limited to a narrow band close to the shore. Under these circumstances concerns over visual amenity are often of primary public concern and the Not In My Back Yard (NIMBY) attitude may take centre stage. The following section gives a detailed treatment of one approach to objective quantification of potential interactions between coastal and aquaculture development in Scotland and is a part excerpt from O'Higgins et al. (submitted).

8.2 Spatial planning using viewshed analysis to assist in aquaculture – other use conflicts

Scotland is one of Europe's major aquaculture producers, Atlantic salmon (*Salmo salar*) being by far the largest marine species cultured. The annual salmon production was estimated at around 186 kT in 2015, the size of the industry has more than doubled over the past two decades and is continuing to expand (Marine Scotland, 2014), encouraged by ambitious government targets for further development. Other major species cultivated in Scottish marine waters include the rainbow trout (*Oncorhynchus mykiss*) blue mussel (*Mytilus edulis*) and the Pacific oyster (*Crassostrea gigas*). Activities are essentially confined to the west coast of mainland Scotland as well as the northern island groups of Orkney and Shetland by regulation (Marine Scotland, 2016). Figure 5 illustrates the marine regions as well as the locations of marine aquaculture sites in Scotland. Tourism is another major industry in many parts of Western Scotland (Visit Scotland, 2014) and landscape and scenic impacts are an important consideration of aquaculture impacts in the licence application process, and there is potential conflict between further development of the aquaculture industry and tourism as well as passive use values enjoyed by local residents.

In order to explore the relative visibility of Scotland's coastal marine areas a viewshed analysis was performed in Arc GIS 10.2. Refractivity was set to 0.13 (the default) and the curved Earth option was used. Elevation data from the EU-DEM (Digital Elevation Model) was obtained from the European

Environment Agency,[40] the data have a 1 arc second (approximately 30m) resolution (Figure 6). The UK Ordinance Survey Open Data buildings layer,[41] provides polygons for every building in the UK. Data were extracted for the whole of Scotland and converted to point data resulting in a total of 1.26M locations (Figure 6). In order to achieve manageable analysis times, given the large size of the data sets and large amount of processing required, data were further subdivided into blocks based along lines of latitude and longitude. A buffer of 50km was constructed around each block, the 'extract by mask' tool was used to extract the buffered areas from the DEM and the analysis for each block was conducted using these buffered subsets (Figure 6). As a final step the buffered viewshed areas were combined using the weighted sum tool in the Spatial Analyst toolbox, with a weight of '1' being assigned to each raster. Areas of missing data were filled using nearest neighbours' interpolation.

The resulting product was a layer with approximately 30m resolution containing spatial information on the visibility of marine locations, expressed in terms of the number of buildings with a view of any given location. Throughout the analysis, the numerical units for the term 'visibility' represent the number of buildings with a view of a particular location, or number of views. Data for the location of aquaculture sites were taken from active fish farming leases.[42] The NEAR tool in ArcGIS 10.2 was used to measure the distance of each farm from the coast.

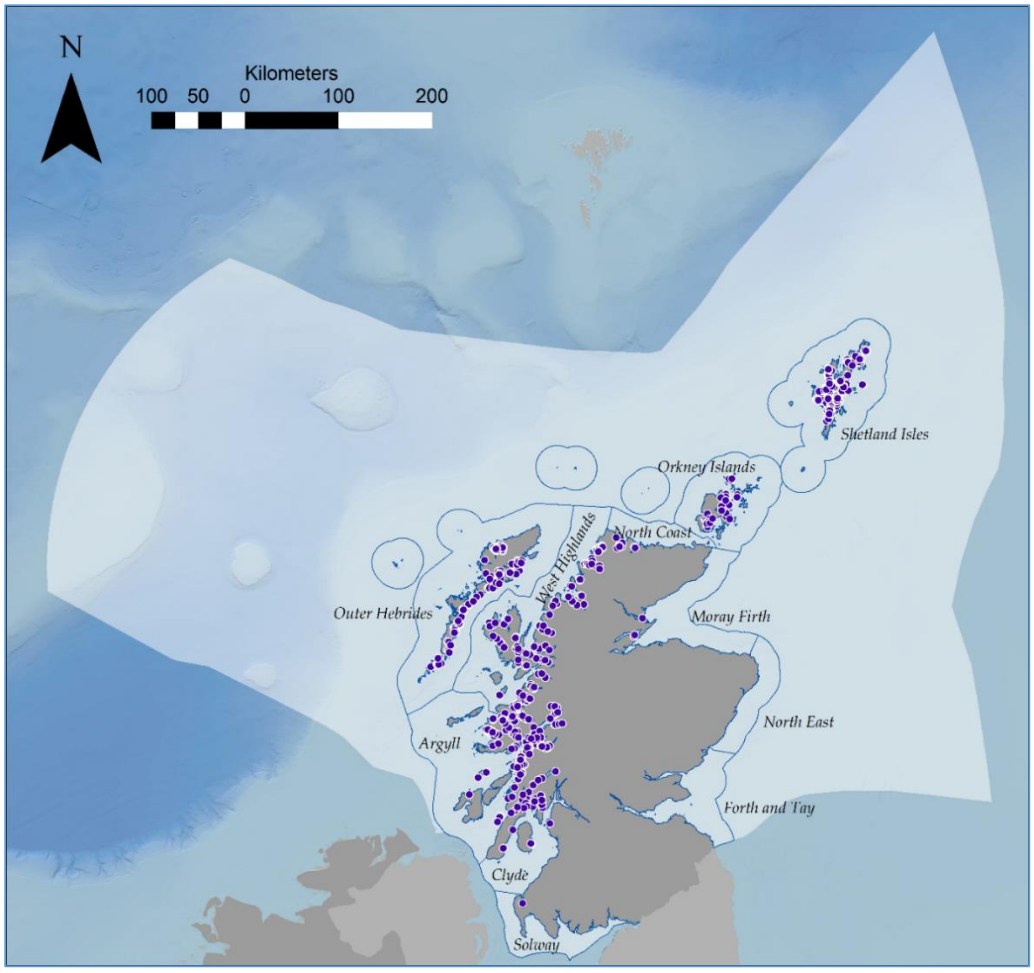


Figure 5: Scotland's marine territory (white) with marine regions (blue lines) and aquaculture sites.

[40] http://www.eea.europa.eu/data-and-aps/data/eu-dem
[41] https://www.ordnancesurvey.co.uk/business-and-government/products/opendata-products-grid.html
[42] http://aquaculture.scotland.gov.uk/

Figure 6: The Digital Elevation Model for Scotland (top left), the buildings layer from the Ordnance survey (top right) and example of division of the buildings layer by latitude and longitude and the generation of overlapping viewshed models (bottom).

Figure 7 illustrates the results of the viewshed analysis showing the overall national picture as well as a detailed map for a subset of the region. The Scottish EEZ covers an area of 470,641 km^2 of which 103,108 km^2 (20%) is visible from one or more building. Eighty-three percent (241,653 km^2) of Scotland's visible coastal area can be viewed from less than 100 buildings with 1% (2,914 km^2) of the visible area being viewed from 4,800 or more buildings.

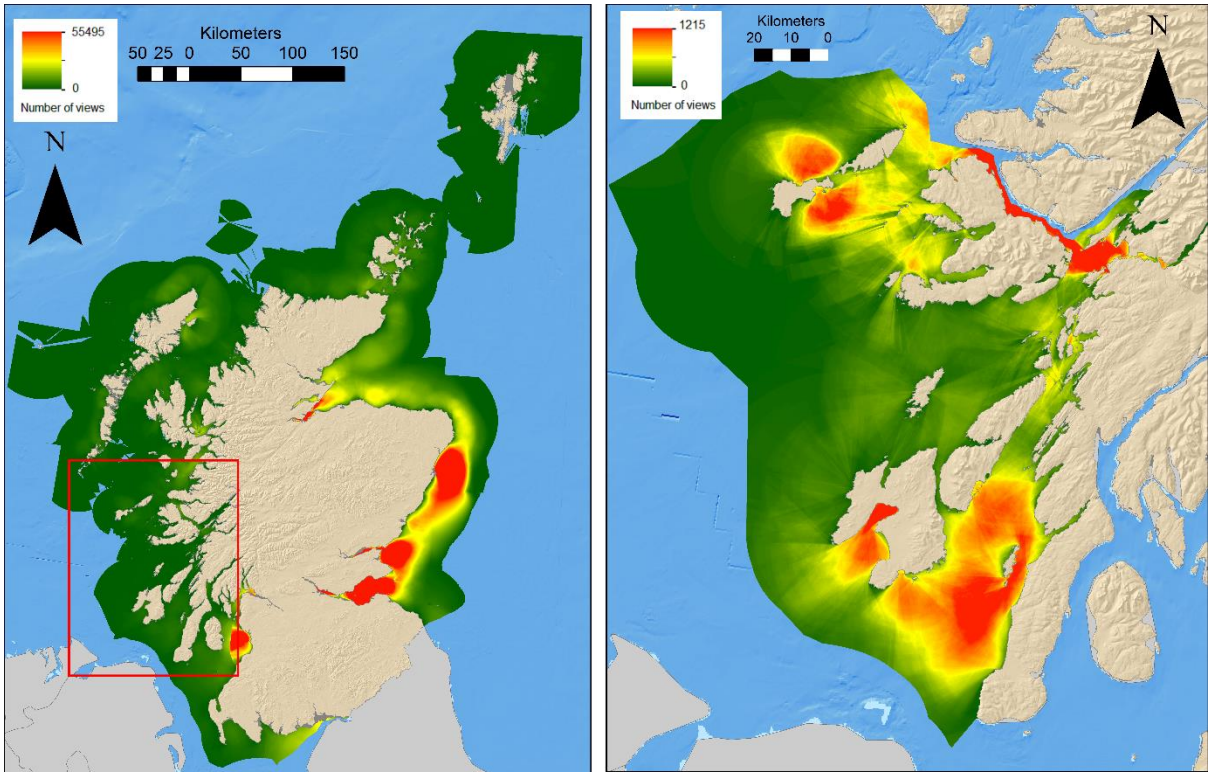


Figure 7: Viewshed map showing non-zero values for the coast of Scotland (Left), with red bounding box showing the location of the Argyll marine region sub region (Right) in Western Scotland. (Note the colour scales are based on standard deviations and a different scale is used for each map).

Table 17: Inter-comparison of the visibility of marine regions and the prevalence of aquaculture.

	Area (km^2)	Max (views)	Mean (views)	St Dev	Number of aquaculture sites
Forth and Tay	4485	29109	4701	5008	0
North East	3153	14068	3565	3552	0
Moray Firth	5870	7664	1293	866	3
Clyde	4273	34583	955	1499	30
Solway	12310	2557	549	579	1
North Coast	2444	1262	303	246	12
West Highlands	10410	1757	188	233	149
Orkney	9256	1646	180	217	30
Outer Hebrides	20850	1707	109	192	129
Argyll	12050	1215	84	101	119
Shetland	3721	188	27	29	247

Table 17 summarises the characteristics of the visibility and the number of marine aquaculture sites for each marine region. There was a clear spatial pattern in differences in visibility of the marine locations related to the distribution of the density of building (see Figure 6, bottom). The regions in the East had the highest mean number of views (>1000) while those in the West and North had visibility (<1000), a single region in the west, the Clyde (near the city of Glasgow, Scotland's largest

city), has the highest maximum number of views, from 34,583 buildings. There is a general pattern of higher fish farm density in the areas regions with lower mean visibility.

Figure 8 (left) shows a histogram of the visibility characteristics of fish farms. The distribution of the sites is highly left skewed with a median value of 36 views, the 99th and 95th %iles for visibility were 877 views and 365 views respectively. In total 14% of the area visible from Scotland is more visible than 95% of aquaculture sites while 25% of visible waters are more visible than 99% of aquaculture sites. Therefore, considering visibility only as a factor, 75%-86% of visible Scottish waters are suitable for aquaculture development. Figure 8 (right) shows the distribution of coastal waters with the visibility characteristics of shellfish and finfish aquaculture sites based on the 99 and 95%ile levels above.

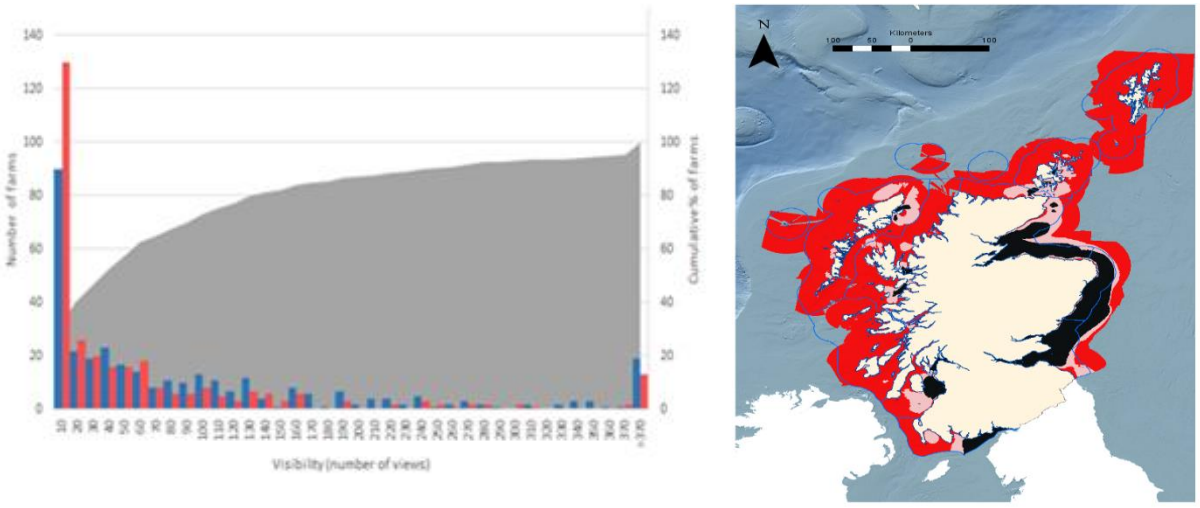


Figure 8: Histogram of the visibility characteristics of aquaculture farms (left) and the distribution of coastal waters with the visibility characteristics of shellfish and finfish aquaculture sites based on the 99 and 95%ile levels above (right)

For operational reasons both finfish and shellfish aquaculture is constrained to a narrow coastal band. Figure 9 shows the percentage distribution of aquaculture activities with distance from the coast. 99% of aquaculture occurs at sites within 836m from the coast and 95% occurs within 433m.

In Figure 9, the number for each bar indicates the percentage area of the marine region where visibility exceeds the 95%ile for aquaculture sites. The total area of the bands where 95% and 99% of aquaculture occurs are 4,641km^2 and 7,931km^2, making up 5.2% and 8.9% of the total area covered by the marine regions. Figure 10 illustrates the proportion of the coastal strip suitable for aquaculture (≥95%ile visibility) for each marine region. From Figure 10, the total area suitable for aquaculture within the narrow (433m) coastal strip is 3772km^2. A typical salmon farm is in the order of 5 hectares (0.05km^2) and there are about 650 marine aquaculture sites in the country covering approximately 30km^2. Aquaculture therefore occupies less than 1% of the 433m coastal strip with suitable visibility characteristics.

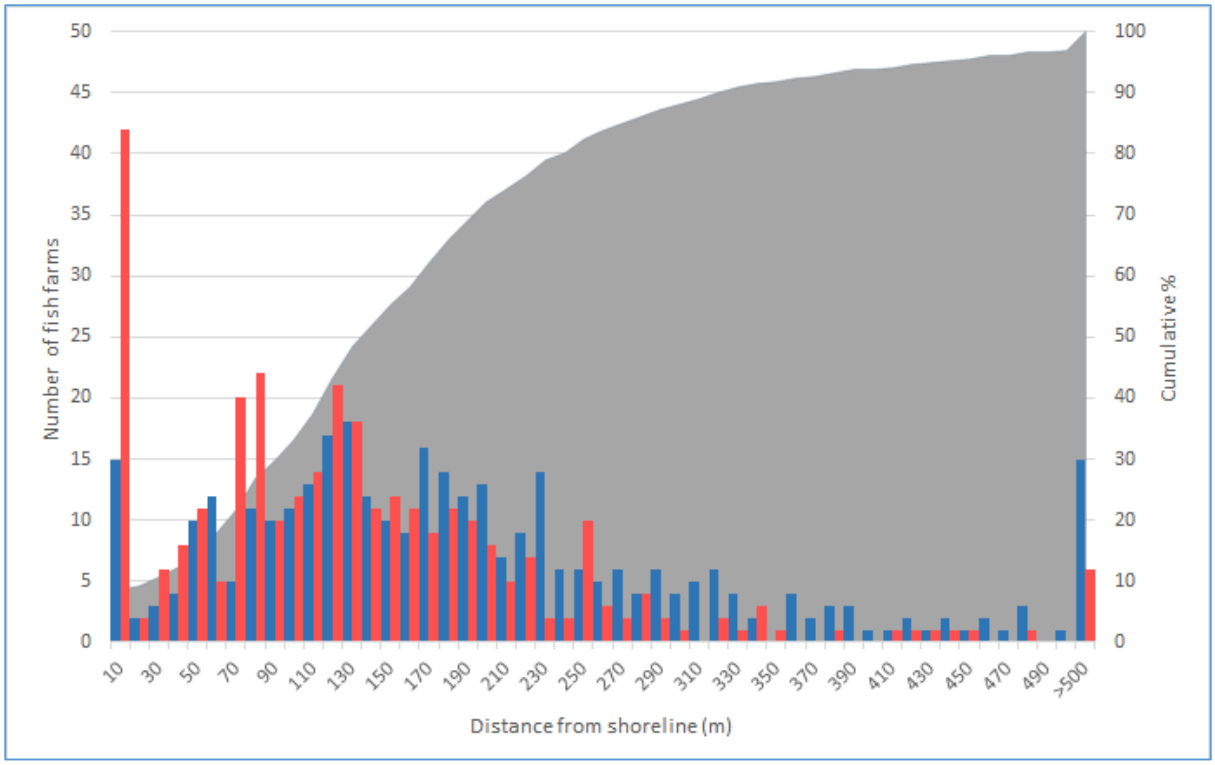


Figure 9: Histogram of finfish (blue) and shellfish (red) farm abundance with distance from shoreline and cumulative percentage of farms (grey).

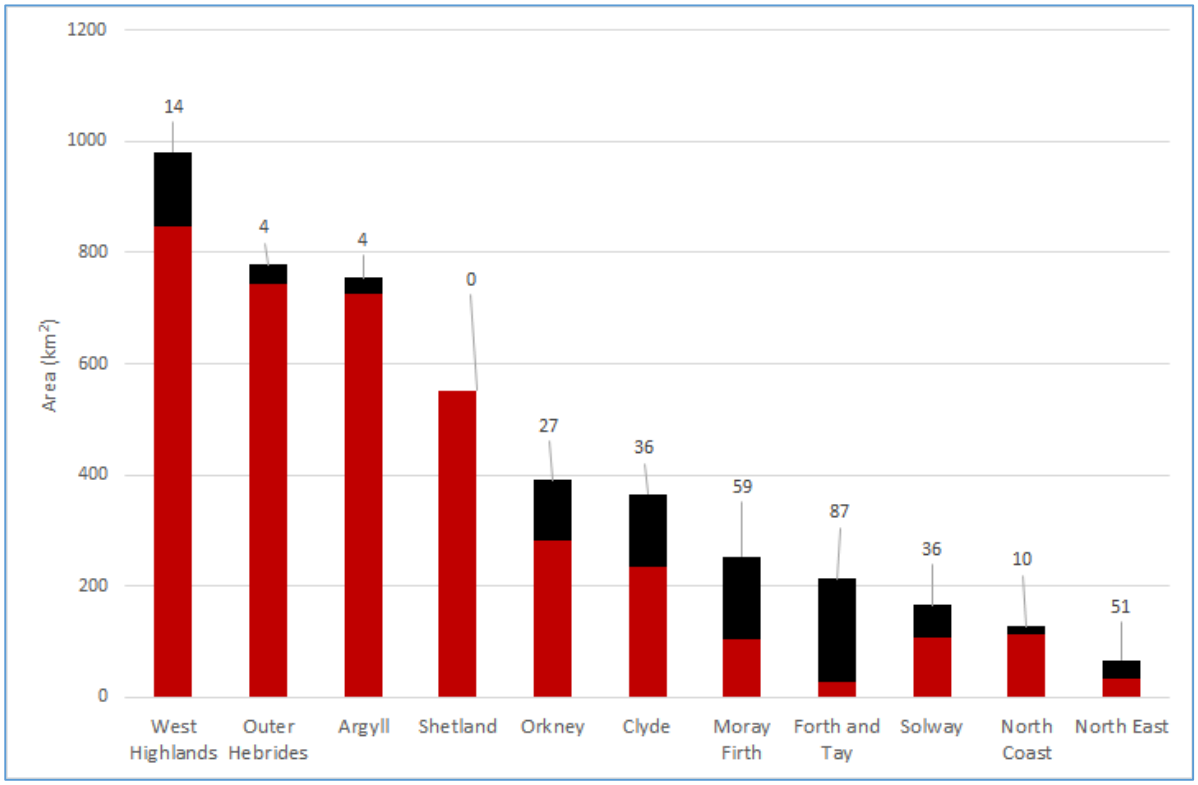


Figure 10: Areas suitable (red) and unsuitable (black) for aquaculture in each marine regional based on 95%ile of visibility within the coastal strip of 433m where 95% of aquaculture occurs.

At the national scale the map of visual amenity may provide a useful basis for strategic planning. The dataset gives a clear and intuitive picture of the visibility of different parts of Scotland's marine territory. Given the current obligations for EU Member States under the MSP Directive as well as the Scottish Government's desire to ensure the continuation of Blue Growth, understanding the distribution of views may provide a useful tool in prioritising areas for conservation or for development. Similarly, at the local level, visual impacts are generally a major concern surrounding developments in the marine environment. Current EIA processes often mandate a visual impact survey for development of new aquaculture facilities. While the analysis conducted here will not obviate entirely the need to conduct such surveys it may provide a useful tool for fish farmers seeking suitable sites for new facilities.

Based on existing patterns in aquaculture development and their visual impacts, the analysis suggests that there is considerable potential for further development of aquaculture sites on the West coast of Scotland without adverse congestion of seascapes. With the potential for development of offshore aquaculture, the spatial distribution for aquaculture sites stands to change considerably in the future. The analysis could also inform the planning and development of offshore aquaculture in Scottish waters.

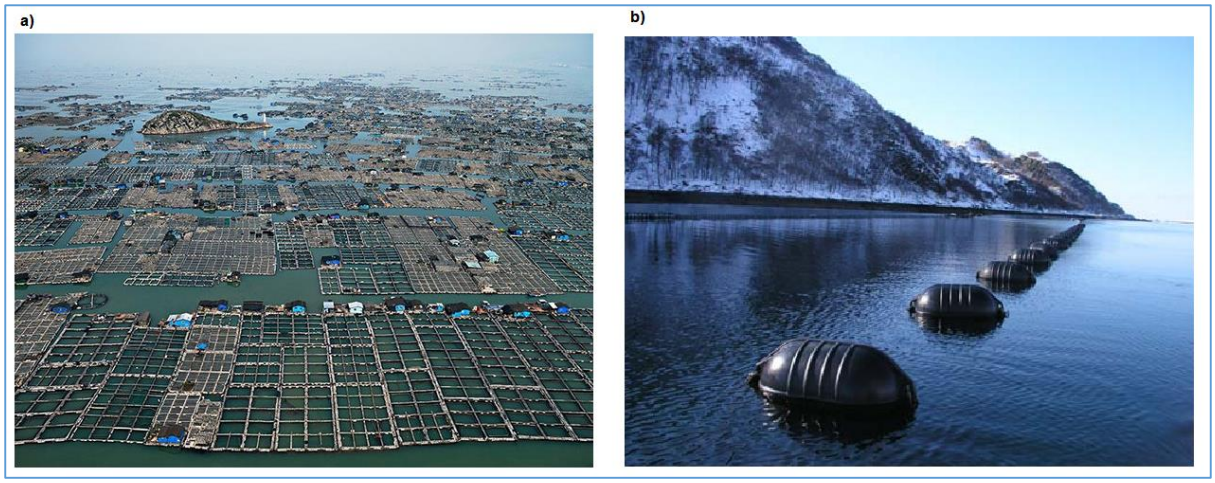


Figure 11: Cumulative visual impact of intensive aquaculture in China (©Edward Burtynsky) compared to low density aquaculture on Scotland (b).

However, in the viewshed approach used here, visibility (or visible impact) is considered as the sum of views from buildings. Human perception of visual impact is in reality much subtler. While lines of sight from buildings may perhaps act as an indicator of the number of individual properties whose view is potentially directly affected by development of a particular location, measuring a "NIMBY" factor, public reaction to aquaculture development and visual amenity of a seascape may not vary simply with the number of views from buildings.

For example, the cumulative impact of many aquaculture sites may differ greatly from the individual impact of one or two sites, and these impacts are by their very nature, subjective human perceptions, varying with the attitudes and values of individuals both toward seascapes and towards aquaculture. Given the prevalence of nature tourism and recreation in Western Scotland, visual amenity may be an important aspect of many recreational activities, these are not considered in the above analysis. Further, thresholds for visual amenity may be lower for those involved in nature tourism than for those experiencing the positive economic consequences of aquaculture development. Figure 11 illustrates the cumulative visual impact of an intensively developed marine aquaculture site contrasted with a sparsely developed one.

While the level of visibility from buildings may indicate the likelihood of objections to aquaculture development on aesthetic grounds, the analysis does not account for human factors which may determine the strength and persistence of objections nor does this analysis explore the socio-cultural context of specific marine regions. The viewshed layer generated here could be used as an objective basis to provide a rationale for planning decisions or to explore specific cases of conflict at highly localised scales and could also inform further research on cumulative visual impacts on public attitudes toward aquaculture.

All the datasets used in this study were publicly available for download and analysis. While the EU DEM covers the entire area of Europe, the buildings data for the UK have only recently been made publicly available for open use through the Ordnance Survey OpenData Initiative (Lilley, 2011). At the EU level, public availability of data varies from country to country. Extending this analysis to the area of the Irish Sea, for example, would require data from both multiple jurisdictions of the UK and the Republic of Ireland, with the same type of data requiring sometimes significant financial outlay. There is a legal responsibility on the part of all EU nations to develop coherent approaches to MSP and environmental protection on a regional basis (MSFD, MSP Directives) and a mandate to make environmental data publicly available and to develop coherent spatial data infrastructure under the Aarhus Convention and the INSPIRE Directive. However, spatial data infrastructure and differences in national spatial data policies currently remain an obstacle to implementing this approach at the larger regional spatial scales foreseen by these EU Directives.

This study has a strictly limited scope, it only considered the views from buildings. In reality, the visual amenity of a site is not simply composed of the number of views from individual homes, or buildings. Many individuals may actively seek out remote and scenic views and this may be particularly true on the West Coast of Scotland. Falconer et al. (2013) took a similar approach to this analysis but also incorporated sites with high recreational amenity value. In terms of MSP, and the ecosystem approach to management, the data developed in this study represent a single layer of socially relevant data at the national scale for incorporation into GIS. This layer adds to the number of criteria available on which to base planning decisions. This study can inform planning decisions through explicit recognition of the spatial qualities of one component of the ecosystem services provided by visual amenity and can complement localised spatial techniques designed to inform specific local planning problems.

Spatial Planning for Aquaculture and Other Use issues - Key Observations

- Interactions between aquaculture and other activities may be either synergistic or antagonistic but these effects are not always predictable and may be cumulative.
- Planning processes need to ensure that cumulative effects can be taken into account in the forward planning and decision-making processes.
- Successful and more effective planning for aquaculture must incorporate participatory approaches so as to foster trust and minimise objection at later stages in the planning process.
- Conflicts between aquaculture and other sectors and uses are not yet fully realised but their potential impacts should be considered in current planning processes that will impact on forward planning.
- Perceptions can differ from reality but strongly held perceptions can have the ability to stymie specific developments.
- Viewshed analysis can assist in future strategic planning and more local level maritime planning processes, as exemplified by the Scottish example.
- Viewshed analysis may also have a role in addressing NIMBY-type objections by providing evidence based on real data.
- Viewshed analysis can also inform planning decisions through explicit recognition of the spatial qualities of one component of the ecosystem services provided by visual amenity.

9. Relationship between spatial planning for aquaculture and the environment

9.1 Spatial management for aquaculture

The relationship between aquaculture spatial planning and the environment is a complex mix of appropriate zoning, site selection and area management (Aguilar-Manjarrez et al., in press), evaluation of carrying capacity at site-specific and regional scales (Ferreira et al., 2008), EIA, and consideration and measurement of impacts assessed against defined standards through monitoring, most often defined through developed best practices. Not all aquaculture is the same, in terms of the ecosystem services it provides (Northern Economics, 2009; Ferreira and Bricker, 2016) or the impacts it has (Osmundsen et al., 2017).

For aquaculture, best practices have typically been developed by the industry for itself, coincident with Member State development of appropriate methods of assessment and related standards (e.g. water quality standards). Such activity occurred prior to development of more encompassing EU regulatory instruments, to ensure developed aquaculture was not having undue impacts.

One of the earlier Directives affecting aquaculture directly was the EIA Directive (85/337/EEC) introduced in 1985 (and revised since), transposed through national legislation (Telfer et al., 2009) and now widely applied to aquaculture throughout the EU. Aquaculture is an Annex II activity, meaning the decision to conduct an EIA is at the discretion of the Member State. The term used in the Directive is “intensive fish-farming” and an aquaculture development will therefore need to be evaluated (or screened) to determine whether an EIA will be required or not. The circumstances under which aquaculture requires an EIA varies between species, and has a locational component depending on the perceived risks in different environments. So, the extent to which EIA is applied in Europe is variable for different types and scales of aquaculture development (Telfer et al., 2009).

Aquaculture, in common with virtually all commercial enterprise, is not a zero-impact activity and development in the EU over the last 40 years has been mirrored with an improved understanding of the impacts that are caused (Bardach et al., 1972; Gowen and Bradbury, 1987; Findlay and Watling, 1997; Osmundsen et al., 2017), and Member States have responded accordingly with increased management and control. Improved understanding is one of the reasons that many of the small Atlantic salmon farms (in Scotland and elsewhere) permitted initially in poor locations are now no longer present, shifting to locations with more suitable hydrodynamic and water quality conditions; that has also allowed farm size and production to increase. Freshwater pond aquaculture has a long history and developed over many years (See case study 1) and pond structures have been built on suitably sloping land with an adequate water supply, and impacts are relatively stable, so changes of location, once built, are relatively rare. Poor locations are generally abandoned, rather than moved.

Evaluation of environmental and spatial management in aquaculture is not new and Member States, and countries internationally, have recognised the need to ensure ecological systems are not overloaded, and environments impacted unnecessarily. Globally, however, this is not always apparent (Figure 11). Shifts in knowledge have also resulted in new locations being developed, often without organised spatial planning as part of the process of selection. There comes a point, however, when many of the “good” sites are taken, and remaining sites conflict with other uses or are environmentally less suitable, so further development requires a much more pragmatic and inclusive approach, much as defined in the MSP Directive.

Across the EU spatial planning for aquaculture has already been undertaken but often not for specific aquaculture spatial planning needs. An outbreak of the disease, infectious salmon anaemia (ISA), in

salmon in 1989/1990 led Scotland to develop location guidelines and developed a spatial management strategy aimed at limiting spread of the disease. There was a necessity to avoid large losses, by limiting movement of stock across areas to remove cross-infection potential. The result was development of zoning called Disease Management Areas (DMAs). These management areas do not overlap and restriction of movement of stock meant farms not affected could not impacted by the spread of the disease. Although control of ISA was regained, the zonation remained and has since been extended. Industry also defined Farm Management Areas (FMAs), as a means for companies to coordinate stocking, disease treatment and harvesting, for example. FMAs and DMAs are often the same, and more recently FMAs are often managed by the same company as the industry has consolidated. As part of the strategy, large areas of Scotland (e.g. entire east coast) are off limits to aquaculture development. Minimum distances are also applied between fish and shellfish production in Shetland, and may be applied elsewhere in Scotland, though this is not regulated.

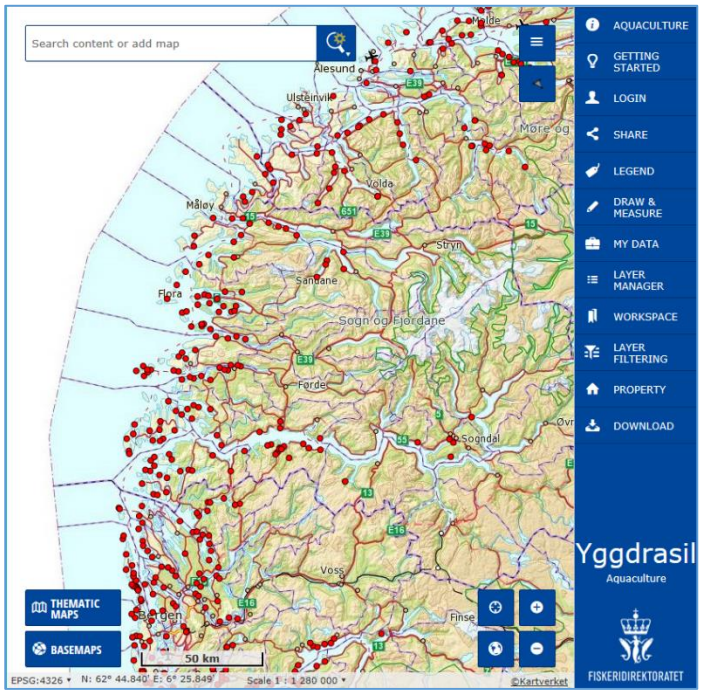


Figure 12: Aquaculture thematic mapping tool in Norway (https://kart.fiskeridir.no/)

More recently the Scottish Government has developed an internet based database and mapping system, which allows the public to search for operational aquaculture sites and view licences and other information about the site[43]. More importantly the mapping of sites and locations using GIS software can be further developed with spatial layers containing other information (water quality, location of other activity etc.) to support longer term maritime spatial planning, optimisation of space for aquaculture and to find additional locations in which to culture animals. A similar system has also been developed in Norway[44] (Figure 12).

Turkey, although not in the EU, shares a common resource (The Mediterranean Sea) with EU Member States, which is managed through the GFCM, with United Nations (FAO) support. In 2008 the SHoCMed project, funded in part through DG MARE, defined a process for the development of AZAs, and associated guidelines on aquaculture planning. In Turkey, recent conflicts with tourism in the Gulluk Bay region, and concerns about environmental impacts of fish farms very close to the shore has resulted cage aquaculture sites moving slightly further offshore, to a minimum distance of 600m. So, there are many examples of spatial management activity, driven by environmental and other concerns, that have led to major changes in the industry over the course of its development. Often these have been wholly aquaculture oriented, and in others resulting from multiple use in the same (marine) space. What most of developments have in common, however, is they relate to a single sector, aquaculture; developing plans for itself and there is no specific integration of wider spatial management requirements.

[43] http://aquaculture.scotland.gov.uk/
[44] https://kart.fiskeridir.no/

Management of aquaculture activity in Member States is now further impacted through enactment of EU policy and regulatory instruments (e.g. Shellfish Directive - now subsumed into WFD, MSFD, and others), which puts aquaculture alongside other activities in maintaining good (ecological or environmental) status for EU water bodies, which requires consideration of multi-impacts and multi-use at varying spatial scales. Inclusion of aquaculture in the Blue Growth agenda and its spatial management through the MSP Directive points to the need to consider further the links between spatial and environmental management of aquaculture, particularly in the marine environment, where most aquaculture takes place. As has been identified in previous sections there is no fundamental dysfunction between EU policies in relation to improving spatial use for aquaculture in an environmentally sustainable way. It remains a question of implementation, and each part not being seen as separate functions competing against each other.

9.2 Environmental conditions suitable for aquaculture

This section focuses on potential feasibility for locating aquaculture in space, and not the environmental impacts of aquaculture. Impacts are determined by final siting decisions which then encompass multi-sectoral components, including assessment of ecological carrying capacity, which is outside the scope of the *AquaSpace* project.

What is more important to evaluate, is where aquaculture can thrive, which at its simplest level requires an understanding of species limitations in relation to environmental conditions, data on environmental conditions and then some means to analyse this as part of a spatial assessment. Having established that an area is suitable for the species intended to be cultured, there may other factors that will affect whether the area is actually available or viable, including conflicts of use, social, other environmental or governance issues; pillars of carrying capacity assessment (McKindsey et al., 2006), the ecosystem approach for aquaculture (FAO, 2010) and for aquaculture spatial planning (FAO and World Bank, in press).

It is no coincidence that, in general, aquaculture species are grown in environments (or at least under environmental conditions) in which they would naturally occur. So, Atlantic salmon are cultured in colder northern European waters and sea bream in warmer Mediterranean waters, for example; with a similar division in shellfish such as mussels and other cultured species. There are exceptions, where conditions can be manipulated to some extent, to achieve the required environmental conditions for species in locations outside their natural range but environmental manipulation (e.g. heating water) is expensive so not generally undertaken. There are, however, many locations where cultivation of multiple species is possible, and areas where cold-water and warm-water species co-exist.

Species operate within environmental and physiological limits (Figure 13) that determine optimal, sub-optimal and lethal ranges for a given parameter, such as water temperature, salinity and dissolved oxygen requirements, among others. Species grown in open freshwater or marine environments are also affected by several intrinsic and extrinsic (Figure 14) factors that determine whether a farm should be located within a specific location or region, and once located, the extent to which the farm is impacted. Extrinsic factors are influenced by the nature of the supply (e.g. of water of a specific quality) and the nature of the system in which the farm sits, which cannot be altered. Marine farms are impacted (and supported) by hydrodynamic currents driven by winds and tides, over which there is no control. In a similar way species operate within defined limits, and although acclimatisation can be used to push species beyond those limits (such as growing freshwater species in brackish water) the locations used must reflect natural ranges. In some species, such as the diadromous Atlantic salmon, acclimation to seawater (termed smoltification) is a natural process that occurs as it prepares for life at sea. Aquaculture simply replicates that process under controlled conditions, and is not

meaningfully attempting to be able grow salmon outside its natural range. Intrinsic factors are generally related to management, and how stock is maintained and fed.

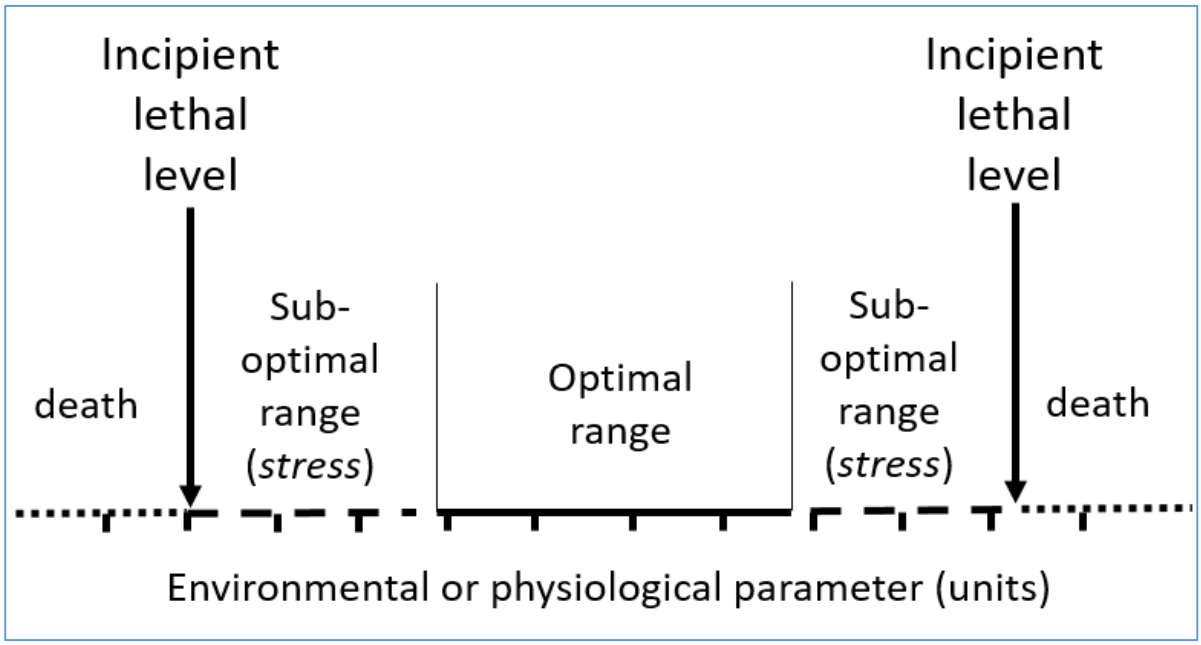


Figure 13: General scheme of optimal, stressful and lethal environmental or physiological factors affecting aquatic species

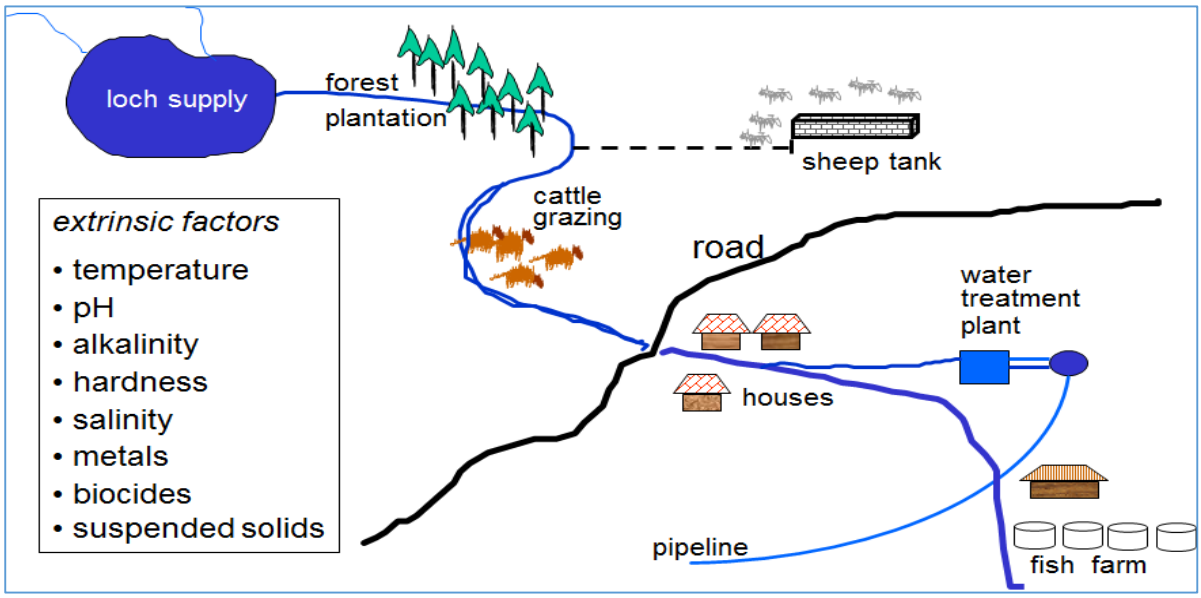


Figure 14: Extrinsic factors affecting freshwater aquaculture in ponds and tank systems, defined by the environment in which the site sits

In general, there are a mix of physical and environmental factors that affect whether a species can be grown in any location. Table 18 summarises key physical and environmental factors where data is available at a large spatial scale (Global, and all Europe) from remote sensing, geographic information systems, and other databases, being used in development of the WATER (Where can Aquaculture Thrive in EuRope) tool, which will support the aquaculture industry by defining spatial locations throughout Europe where environment conditions are appropriate for each species. The same parameters were used by Kapetsky et al. (2013) to provide evaluation of aquaculture potential at a

global scale using GIS, and in *AquaSpace* advancements are being applied at significantly lower spatial resolution across the EU marine waters.

Physical characteristics include the speed of surface currents, wind that affects wave height, wave height and bathymetry. These physical characteristics impact species to some extent but will mainly affect cage and other infrastructure that is required to maintain and feed stock. Strong winds, large waves and fast currents move cages, distort nets and place a great strain on mooring systems, so farmers need information for selection of aquaculture zones and sites which have the correct physical characteristics. Once located, refinement in understanding more local current speeds and other characteristics becomes important, to ensure there is sufficient flushing to remove wastes and water replacement in cages to replace dissolved oxygen removed through bioenergetic processes.

Table 18 also lists several environmental parameters of interest to fish and shellfish farmers. Not all parameters affect all species. Water temperature is important for all species, because it affects growth potential and production cycle times. It is important, not only that species can survive, but they are grown in areas where growth is achieved at a reasonable rate, so the farm can be both productive and economically viable. Many species can survive in a wide range of temperatures, but do not necessarily grow well. High concentrations of dissolved oxygen in the water column is also a critical requirement for all species, as low DO can cause increased stress and increase susceptibility to disease.

In cage aquaculture, all fish species are fed, so there is no reliance on natural consumption of algae, detritus and other organisms to maintain and grow stock. This is the same in freshwater lakes used to grow fish species in net-pens. When considering locations for open-water fish aquaculture, there is no specific need for ecosystems that have a high primary productivity. Conversely, shellfish aquaculture relies on both natural settlement from the wild,[45] which occurs during spring, and to a lesser extent autumn bloom periods; and relies on settled stock taking food (phytoplankton and detritus) from the water column to grow, so primary production is a key consideration for shellfish growth.

Table 18: Physical and environmental parameters affecting the potential to grow aquatic in marine and freshwater environments (adapted from Kapetsky et al., 2013).

Physical parameters	
Currents	In this context, the reference is to ocean surface currents that are wind or tidal driven. Suitability assessment and site selection for offshore mariculture needs long-term historical information on the strength and variability of currents because currents disperse aquaculture wastes and possibly lessen the prevalence of certain ectoparasite infections; however, currents that are too strong can impact the safety of the installation and the cost of marine transport and access and servicing of the facilities, as well as the cultured organisms themselves (e.g. energy expended on swimming rather than growth)
Wind	In this context, average wind speed. Suitability assessment and site selection for offshore mariculture may benefit from long-term information on the exposure of an area to strong winds and storms given the impact on wave heights and currents. There is also a direct wind effect on service boat operations apart from wave height. Monitoring for warnings and forecasts regarding the expected track and severity of storms may also be useful.

[45] Except oysters which are generally cultivated in hatcheries.

Wave height	Is technically defined as the difference in elevation between the crest of an ocean wave and the neighbouring trough; significant wave height (SWH) is a commonly used measure and is the average height of the one-third largest waves. Suitability assessment and site selection for marine aquaculture needs long-term information on SWH because of its importance for cost-effective and robust engineering of the marine aquaculture structures.
Bathymetry	Water depth is variable across oceans and lakes, typically though not always, shallower near to the shore and increasing with distance from the shore. Exceptions can include Fjordic systems in which deep gorges with steep side mean water depth quickly increases. Generally, near-shore waters, being relatively shallow mean cages, feed barges and other infrastructure can be moored (tethered to the seabed via anchors) safety. Mooring lines are typically 2.5 to 4.2 times the water depth, in length. The deeper the water the longer the mooring cables are and the larger the area occupied by the farm.
Environmental parameters	
Sea surface temperature (SST)	Sea surface temperature (SST) is physically determined by the incidence of solar radiation, ocean circulation and the depth of the mixed layer, which is affected by upwelling, surface winds and bathymetry. Offshore mariculture requires data and information on sea temperatures because fish and shellfish growth rates (and survival) are affected by average temperature and temperature variability. SST is the temperature of the water close to the surface, or the ocean "skin", and SST data are most likely applicable for suitability assessment and monitoring, the latter because models of ocean productivity need temperature data.
Primary production	Is the production of organic compounds from carbon dioxide through the process of photosynthesis, primarily by microscopic alga. Net primary production accounts for losses to processes such as cellular respiration. Primary production is mostly determined by the availability of light and mineral nutrients, the latter being affected by stratification and mixing of the water column. Offshore mariculture requires data and information on the primary production of an area because shellfish are filter feeders that rely on sufficient concentration of food particles such as phytoplankton for their growth. Chlorophyll-a concentration products that remote sensing can support are suitability assessment, zoning and site selection, and monitoring. Fish farmers may be interested in historical data and monitoring extremes of primary production, which may be harmful to fish health through oxygen depletion or which produce toxic compounds.
Turbidity	Is a measure of the transparency of sea water. Turbidity can be affected by local and regional currents and waves, coastal erosion, bottom type, phytoplankton concentration and river plumes. Aquaculture requires data and information on turbidity of an area because high concentrations of inorganic suspended matter can negatively affect fish and shellfish growth and health. The primary interest would be historical data.
Salinity	Is a measure of dissolved salt content, and variations can result from rainfall, evaporation, river discharge and ice formation. Offshore mariculture needs to understand the variable levels of salinity because feeding, growth and survival of shellfish can be affected by low salinity. Freshwater river plume distribution is an important site section issue and the interest is in historical data.

Dissolved oxygen (DO)	A relative measure of the amount of oxygen that is dissolved or carried in a given medium. The typical levels of DO and the presence of "dead zones" (i.e. hypoxic [low oxygen] areas in the world's oceans and lakes) because hypoxia may have detrimental effects on fish oxygen consumption, physiology, feed intake, growth and well-being.

Physical and environmental parameters have plasticity and are variable in both time and space. Water temperature is variable through the year, but not necessarily equally variable in different locations. Northern waters tend to vary between 4-6°C in winter and 12 – 15°C in summer. In the Mediterranean temperatures changes less with season, but varies more east to west, so the same species grown in different locations in the Mediterranean will grow differently. Aquaculture spatial planning decisions need to account for this variation over time, as well as the variability in species requirements.

Table 19: Subset of parameter and species showing low incipient (lethal) (LI), low optimal (LO), high optimal (HO) and high incipient (HI) levels, useful in determining at a European scale where aquaculture can thrive.

Genus	Species	Water Temperature (°C)				Salinity (‰)				Dissolved Oxygen (mg L^{-1})			
		LI	LO	HO	HI	LI	LO	HO	HI	LI	LO	HO	HI
Salmo	*salar*	2	10	16	24	0	22	28	35	6	9	11	13
Sparus	*aurata*	6	17	25	32.5	5	15	38	44	2.7	7	9	10
Dicentrarchus	*labrax*	2	19	25	32	4	13	30	40	4	6	8	20
Oncorhynchus	*mykiss*	1	12	18	25	0	0	20	35	2.6	4	6	26.8
Cyprinus	*carpio*	4	20	25	36	0	0	2.5	12	0.5	6	11.3	21.4
Mytilus	*galloprovincialis*	5	14	20	30	8	25	30	39	1	5	7	10
Mytilus	*edulis*	2	8	18	27	4	22	30	40	1	3.6	9.5	12.5
Ruditapes	*philippinarum*	0	20	22	40	14	20	30	38	1	7	9.5	-

For all these parameters, each species has distinct upper, lower and optimum requirements. Table 19 provides a sub-set of a much larger database of species and parameters, which the project has developed, and gives examples of upper and lower incipient lethal limits, and upper and lower optimal levels for water temperature salinity and dissolved oxygen.

What is interesting to note is that sea bass (*Dicentrarchus labrax*) is a species we would traditionally consider Mediterranean, and yet could happily survive in more northern water, given its large natural temperature range. The reason it is not grown further north is that it grows optimally between 19°C and 25°C, significantly higher than achieved in Northern Europe, even in summer. Thus, aquaculture of sea bass could technically be undertaken as high north as the southern North Sea, but is not because the fish would not grow well, and culture would be uneconomic. Any spatial assessment made, or tool developed, needs to account for the fact that species grow better under optimal conditions, when defining which areas are suitable for specific species.

Spatial Planning for Aquaculture and the Environment - Key observations

- Environmental considerations in aquaculture spatial planning is a complex mix of appropriate zoning, site selection and area management, evaluation of carrying capacity at varying scales, use of EIA, and consideration and measurement of impacts assessed against defined standards through monitoring. It is not possible to consider use of marine and freshwater space on its own.
- Improved understanding of environmental impacts is why sites that had historically been located in less than ideal conditions are no longer present, and countries have progressively acted to ensure better zonation and site selection, with a shift to more suitable hydrodynamic and water quality conditions; that has also allowed farm size and production to increase.
- Evaluation of environmental and spatial management in aquaculture is not new and Member States, and countries internationally, have recognised the need to ensure ecological systems are not overloaded, and environments impacted unnecessarily. Such activity has often been done in an uncoordinated way.
- Environmental management of aquaculture activity in Member States now must be considered more in the context of EU policy and regulatory instruments, such as the WFD, MSFD, and others, including consideration of cumulative impacts and other uses.
- Aquaculture species are grown in environments and under environmental conditions they would experience in nature, based on a mix of physical and environmental factors.
- Decisions on zonation and area management, in particular, requires a tool which defines which areas are suitable for which species, based on existing databases of information.
- Any spatial assessment made, or tool developed, needs to account for the fact that species grow better under optimal conditions, when defining which areas are suitable for specific species, but there less optimal conditions where production may be possible.

10. Spatial planning for aquaculture and market issues

10.1 Overview

Food production must be channelled towards more aquaculture production from marine and freshwater, remembering that the planet is challenged by a shortage of land and freshwater. Aquaculture production in the European Union must be analysed in the context of aquaculture and fisheries, as both farmed and wild products are often in direct competition, and therefore cannot be viewed on a standalone basis when assessing market related issues. One of the primary challenges for stakeholders is the lack of access for new market entrants to grow and diversify aquatic products, including but not limited to small and medium size enterprises. Market related aquaculture issues must be addressed to improve the efficiency of farmed products and to maximise the value of existing production.

The strategic guidelines for the sustainable development of EU Aquaculture (EC, 2013a) highlights policy recommendations promoting aquaculture improvement. While existing regulatory and administrative bottlenecks will maintain the EU as a net importer of aquaculture products, the market dimension must continue to evolve, carving competitive advantages for EU producers, that equips the aquaculture industry to compete on a global stage. A strong competitive advantage that is currently experienced related to the quality and sustainability of Europe's aquaculture products, and the degree of future success, depends in part on maintaining healthy marine and freshwater environments. The provisions set out in WFD and to a certain extent the MSFD, further reinforce this requirement, in addition to the legislation relating to product safety, health requirements, consumer requirements, and environmental stewardship. Implementation of these protocols has cost implications that need to be factored in by the aquaculture sector, however economies of scale provided by desired growth of the aquaculture industry in the EU will likely amortise this cost over time. The quality dimension of European Union aquaculture can lend a competitive advantage both for internal and export markets, for consumers that demand quality, and will improve the acceptance of aquaculture as a sector producing high quality products.

Policy recommendations (EC, 2013a) focus on four improvement areas for aquaculture growth, including administrative procedures; spatial planning; competitiveness; and level playing fields. The resistance provided by legislation and administrative procedures in obtaining licences, chokes investment in aquaculture, both from existing players, and new market entrants. Small and Medium Enterprises (SMEs) are disproportionately affected, as the regulatory and administrative burden is often disproportionate to the turnover and the number of employees, providing a significant barrier to entry for SME producers. The suggested steps for Member States to review includes:

- Analysis of the number of new licences granted throughout time-periods;
- The success rate of applications;
- The number of applications being processed;
- The average time to complete licensing procedures;
- The number of institutions involved in the licensing procedures;
- The average cost of licensing procedures for new businesses;
- The average duration of an aquaculture licence.

AquaSpace assists the process of improving spatial planning potential and reducing uncertainty through the delivery of products that simplify initial spatial planning assessment and evaluation of competitiveness in each country. Comprehensive spatial planning, in conjunction with meaningful political support, can result in the identification of zones allocated to increase European production in an acceptable manner, with minimum environmental trade-offs, and providing EU aquaculture with

a platform to address local, domestic, and international export markets. WATER (Where Aquaculture Can Thrive in Europe) and the Aquaculture Investor Index (multi-metric index) assist in framing key considerations in the due diligence process. These tools are consistent with the policy recommendations made by the European Union Strategic guidelines for sustainable aquaculture development (EC, 2013a).

Improvement of the competitiveness of the European aquaculture industry includes marketing and logistical improvements on behalf of aquaculture producers and producer associations, for small and medium scale producers to compete on a global platform. Improved competitiveness must be accompanied by a mandate to allow more production, within the identified carrying capacity ranges to produce sustainable growth rates, enabling Europe to satisfy necessary internal and export volumes, without compromising the fundamental principles of high quality aquaculture. The Common Market Organisation (CMO) recognise the requirement for improved production and marketing plans, and consumers are demanding quality and diverse food products. Continued research, innovation and knowledge transfers are key pillars that will allow Europe to complete successfully on a global stage.

Consumer demand for sustainable, high quality food is growing, with certification playing a significant role for consumer confidence in farmed aquatic products. Traceability across the supply chain in the digital age, will mean consumers demand for knowledge on product origin and environmental conditions under which it is grown will increase, and appropriate spatial management and planning will be one aspect likely to receive attention. Early adoption of strategies that improve spatial planning will support EU aquaculture in providing consumers with good quality products and transparent product information.

Consumer behaviour is key for the acceptance of aquaculture farms and their products for domestic and export markets. Increased demand resulting from consumer shifts from terrestrial livestock protein to aquatic protein, will encourage a greater cultural affinity towards European aquaculture. In countries that have a cultural affinity with wild fisheries, there is a requirement to educate consumers, to encourage the substitution of fisheries for a competitively priced high quality farmed alternative. In countries where aquatic products do not have a cultural foothold, educating consumers to prepare, cook, and enjoy European aquaculture products is crucial to shape habits.

Educating consumers is a major driver for change in the European aquaculture industry. Figure 15 illustrates that except for the southern European countries (referred to as SEU), most fisheries and aquaculture purchases are made in supermarkets and hypermarkets. Furthermore, areas with extensive coastline have fish mongers' outlets, where a significant percentage of fisheries and aquaculture products are sold, namely in southern Europe.

Consumers appear to rely primarily on store employees when receiving advice about purchases related to fisheries and aquaculture products (Figure 16). There are regional differences, whereby consumers in central and eastern Europe also rely heavily on friends and family, whereas those in northern and western Europe also rely heavily on media outlets for information.

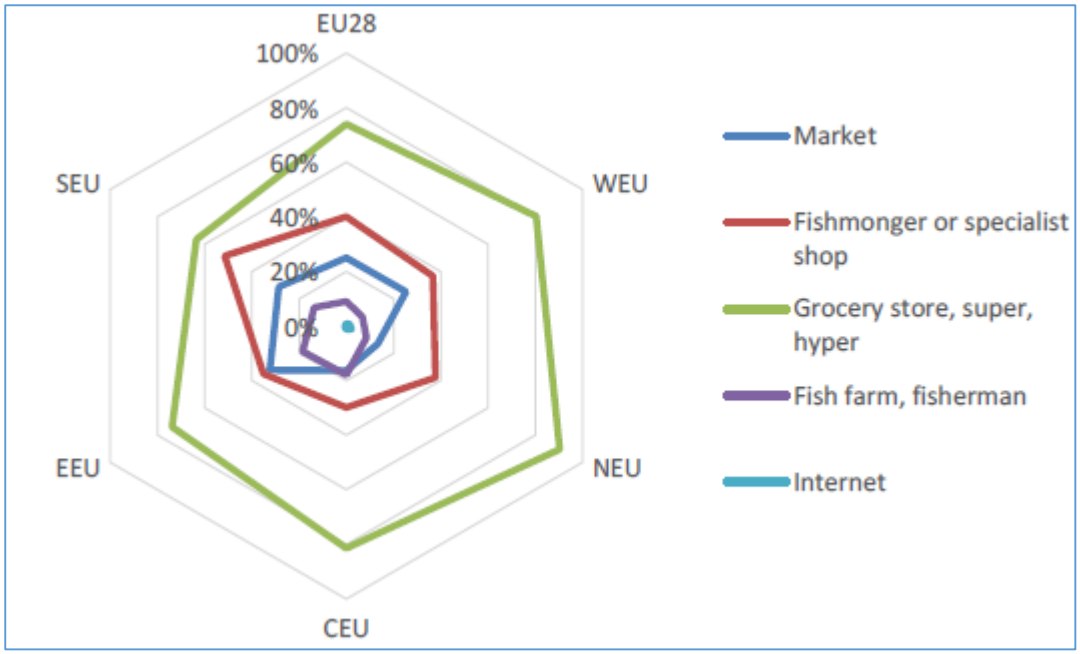


Figure 15: Frequency of purchases by fisheries and aquaculture product's place of sale in the EU28, and Southern (SEU), Western (WEU), Eastern (EEU), Northern (NEW) and Central (CEU) Europe (From EUMOFA, 2016).

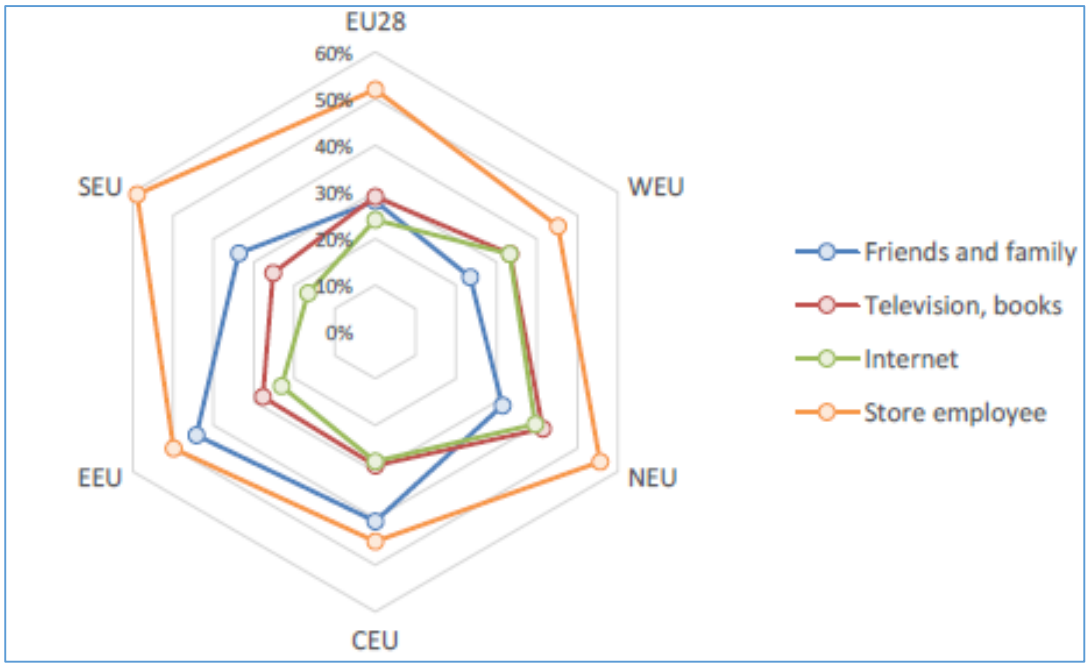


Figure 16: Frequency of sources of information used to make aquaculture and fishery product purchases in the EU28, and Southern (SEU), Western (WEU), Eastern (EEU), Northern (NEW) and Central (CEU) Europe (From EUMOFA, 2016).

10.2 Trade and consumption

Aquaculture production in the EU totalled 1.28 million tonnes in 2014, reaching a peak of just under 4 billion EUR. EU consumers spent 54 billion EUR on fisheries and aquaculture products in 2015, representing the largest amount ever recorded (EUMOFA, 2016). Aquaculture is a significant activity in many European regions, covering 20% of the total EU fish production (EUFOMA 2016; EU, 2016).

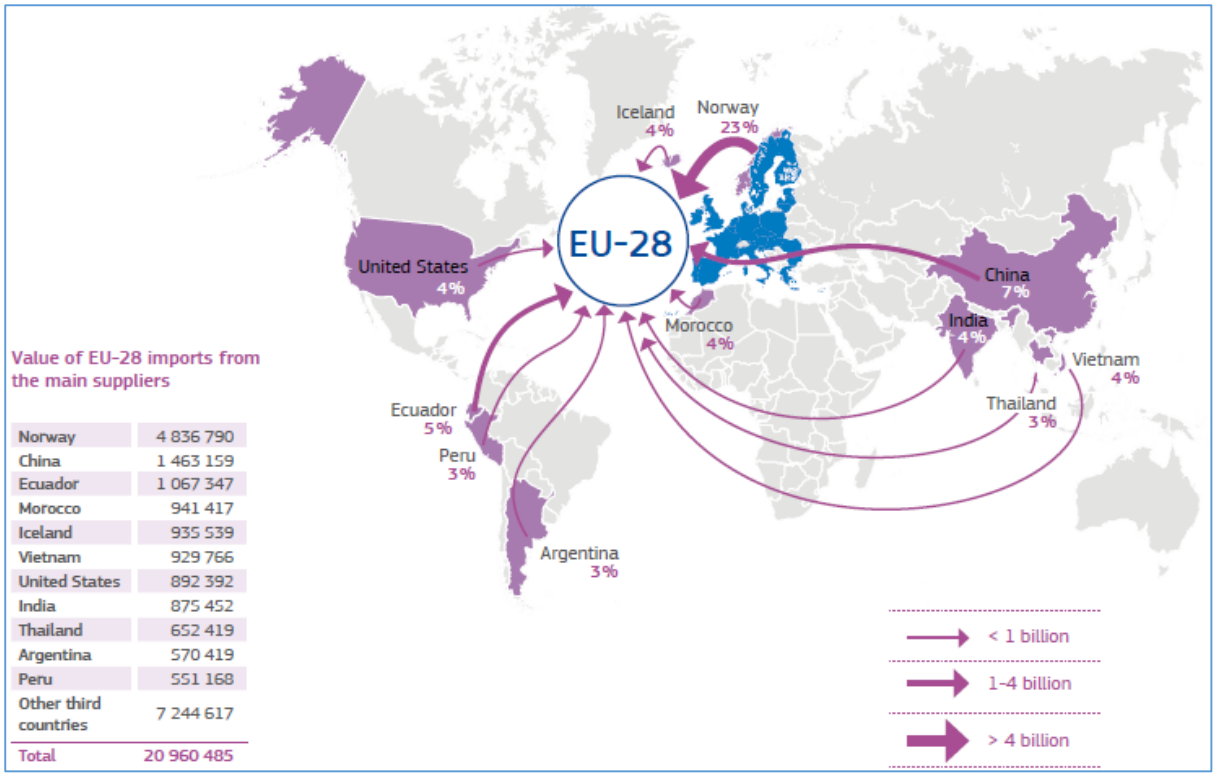
The EU is the leading trader of fisheries and aquaculture in terms of value. Seafood supply expanded by around 650,000 tonnes between 2013 and 2014, representing an increase of 4.5%. Most the expansion was sourced within the European Union through fishing activities, accounting for 570,000 tonnes of the activity, whereas aquaculture activity contributed to the remaining 80,000 tonnes.

The EU is the largest trader of fishery and aquaculture products worldwide in terms of value, and is the largest importer of fishery products in the world, however sustains a trade deficit of 17.8 billion Euros (EUMOFA, 2016). Comparatively, the trade deficit is EUR 6 billion greater than the United States and EUR 7 billion more than Japan. Frozen and fresh products comprise the bulk of the deficit, which has been growing since 2009.

The EU is the top trader of fishery and aquaculture related products in the world in value. The total extra-EU trade (imports plus exports) in 2014 was 25.28 billion Euros (EU, 2016), and increased to 26.81 billion Euros in 2016 (EUMOFA, 2016). Intra-trade encompasses all transactions declared by Member States of the European Union with each other. Intra-trade as reported by EUROSTAT covers both imports and exports, however due to valuation discrepancies (Container, Insurance Freight -CIF > Freight on Board – FOB), imports can be a little higher than exports, explaining asymmetries between import and export figures.

EU domestic consumption is mainly supplied by imports, namely from Norway (4.83 billion Euros), whereas other imports mainly relate to frozen products or prepared meals, comprised of shrimps, tuna, and fish meal. Figure 17 and Figure 18 illustrate the primary import and export market in 2014 for aquaculture and fishery products in the European Union and their respective values. The trade deficit in 2014 was 16.64 billion Euros, derived from Figure 17 and Figure 18, reaching 17.8 billion Euros in 2015. The deficit is due to the importing of frozen and fresh products between 2014 and 2015 (EUMOFA, 2017). The overall extra-EU imports growth came from significant increases from the main six markets: Spain (+EUR 341 million), Sweden (+EUR 371 million), the United Kingdom (+EUR 167 million), Denmark (+EUR 117 million), the Netherlands (+EUR 147 million) and Italy (+EUR 80 million). Intra-EU trade consisted mainly of fresh fish, accounting for 39% of the value in 2014 and 2015 (EUMOFA, 2017).

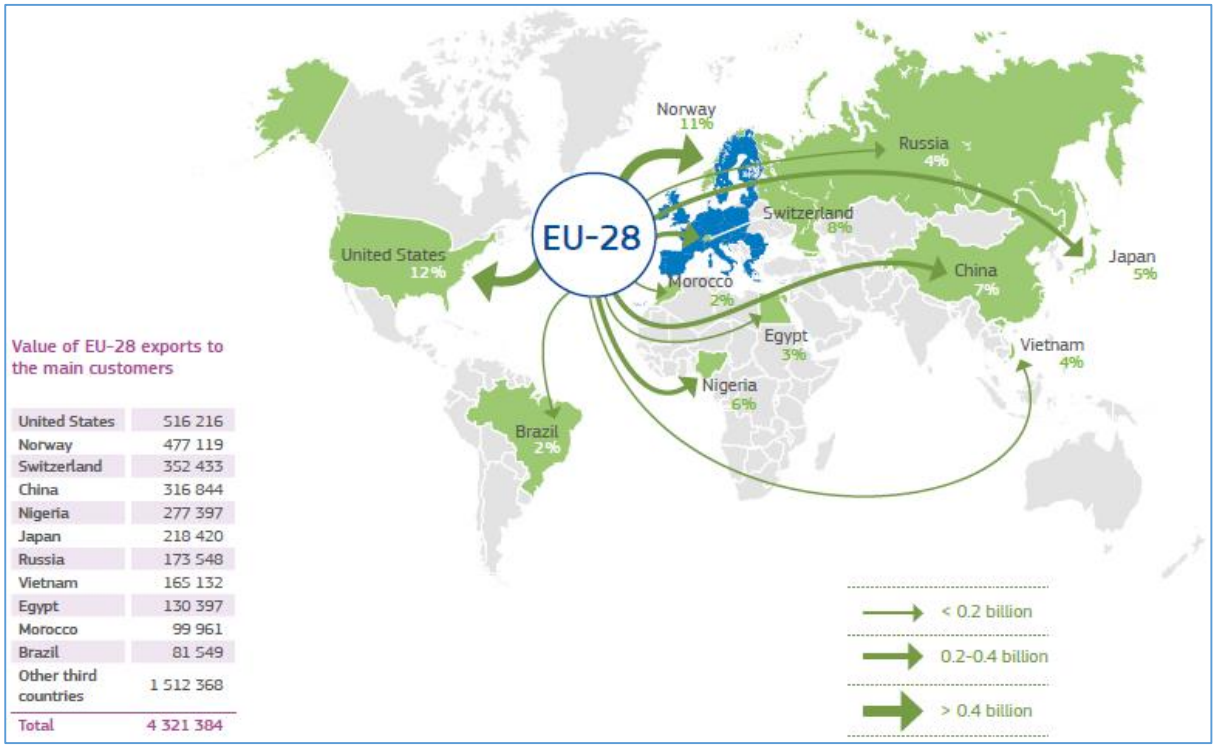
The self-sufficiency rate is defined as the ratio of European Union production (aquaculture and fisheries) to total apparent consumption of the European Market. EUMOFA (2016) report that the total apparent consumption increase from 44.5% to 47.5% during 2013-2014, despite the increase in consumption, suggesting the European Union self-sufficiency kept up with increased consumption. Competition for wild resources is increasing through consumption for fishing rights from emerging consumer markets.



Value of EU-28 imports from the main suppliers

Norway	4 836 790
China	1 463 159
Ecuador	1 067 347
Morocco	941 417
Iceland	935 539
Vietnam	929 766
United States	892 392
India	875 452
Thailand	652 419
Argentina	570 419
Peru	551 168
Other third countries	7 244 617
Total	20 960 485

Figure 17: Trade of aquaculture and fisheries products between the European Union and third countries – Main import suppliers 2014 (EUMOFA, 2016).



Value of EU-28 exports to the main customers

United States	516 216
Norway	477 119
Switzerland	352 433
China	316 844
Nigeria	277 397
Japan	218 420
Russia	173 548
Vietnam	165 132
Egypt	130 397
Morocco	99 961
Brazil	81 549
Other third countries	1 512 368
Total	4 321 384

Figure 18: Trade of aquaculture and fisheries products between the European Union and third countries – Main export customers 2014 (EUMOFA, 2016).

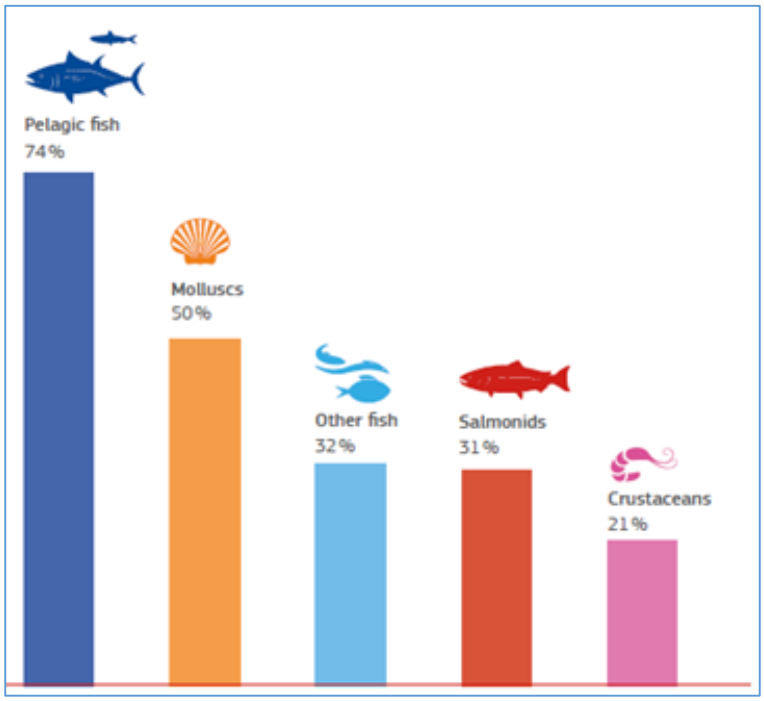


Figure 19: European Union's self-sufficiency rate – percentage by commodity group – 2012 (EUMOFA, 2017).

As reported (EUMOFA, 2017; EU, 2016), self-sufficiency rates in fisheries related catches are healthy, whereas aquaculture products such as molluscs, salmonids, and crustaceans illustrate the extent on which the EU relies on imports (Figure 19).

10.3 Price Analysis

The price structure for aquatic products in Europe is market and species dependent. It is possible to infer macro trends with respect to seafood price structuring, however for aquaculture production to thrive in the European Union, market signals must provide an incentive for producers to allocate resources for development. Fisheries products have a range of denominations, sizes, presentations in different markets, based on consumer preference. The availability of close substitutes, both real and perceived, can influence the substitution effect and price elasticity of the product. The EMFF is providing incentives for European Union aquaculture development, however investigation regarding the species selection driving this growth, requires micro and macro analysis of price structure. The price paid for aquatic products by the end consumer, requires understanding of the price structure in the supply chain, and how value is apportioned along the different stages, starting with raw material outputs from aquaculture and fisheries introduced in to the supply chain for processing. All aquaculture producers engage in processing of some description, ranging from basic primary processing, to secondary value added products. Aquaculture is playing an increasing role as a supplier of raw material outputs for processing. Consistency of sizes and year-round availability of high grade farming products from aquaculture lends a major advantage over fisheries products, which can be seasonal and vary according to climate phenomena such as El Nino. The assessment of market related issues identifies the macro considerations required to assist aquaculture to thrive in the aquatic supply chain.

Aquatic products range from live to secondary processed products, that can be sold to a variety of outlets. EUMOFA (2013) identify four primary types of aquatic product commercialisation:

- Live products (shellfish and fish);

- Fresh fish (whole, gutted, head-on, head-off);
- Primary processing with varying characteristics, such as heading, filleting (skin-on, skin-off, whole fillets, loin), and cutting (slices, consumer portions, sushi, or alternative presentations);
- Secondary processing with broader range of process and products, including preserves (in brine, salted, smoked) to sophisticated value added prepared meals.

Processing characteristics influence the price structure. Live products incur almost no weight loss or processing costs, however require increased logistical and marketing costs, whereas the processing industry accounts for numerous raw material losses during the cutting, drying, and cooking stages. Processing yields and coefficients considerations must be included when analysing price structure. EUMOFA (2013) suggest two tasks with respect to price structure analysis:

- A qualitative description of the processing steps from the raw material to the final product;
- The collection of processing yields and coefficient for the steps in the transformation chain.

The intended market outlets for European Union aquaculture products requires consideration, in addition to the production and supply patterns at different levels (intra-EU and extra-EU). For *AquaSpace* stakeholders to identify areas of expansion for European aquaculture, a market related assessment on a case-by-case basis is warranted to understand production trends (import and export), product specification, and additional supply chain metrics. The length of the supply chain bears relevance, as does the supply chain structure. The Common Fisheries Policy Facts and Figures (EU, 2016) reports that in 2013, 43.6% of the EU's production was comprised of molluscs and crustaceans. A significant proportion of the mollusc producers are small-to-medium stakeholders, who seldom engage in processing of their products, and involve numerous intermediaries before reaching their destination, whereas marine fin fish producers, such as salmon aquaculture, engage in varying levels of processing, marketing and sales, that enable the industry to capture a larger amount of supply chain value. While numerous "space" related factors constrain EU aquaculture expansion, price structure analysis, particularly export focused, coupled with the inability for small-scale producers to develop the sales and logistical platforms required, presents a significant market related bottleneck.

In the context of price structure analysis, the comparison between aquaculture and fisheries products starts at the ex-farm (aquaculture) and first-sale (fisheries). Prices for ex-farm/first sale are monitored across Europe by production associations and fishing ports. Data in the intermediate stage is difficult to obtain, and while numerous wholesale markets publish price information, numerous fish merchants and wholesalers operate outside of the wholesale markets. A proxy methodology to understand value transformation is to apply standard margin coefficients (calculated from average gross margins of a representative sample of wholesalers) to ex-farm or first sale prices (EUMOFA, 2016). A simple analysis involves looking at the price structure differential across the main supply chain steps, such as comparing ex-farm, wholesaler, and retailer prices to understand the distribution in value.

The reported share of the value is neither margin or profit, however does show where the costs and margin breakdown should be analysed. The processing business is not a high margin business, and the distribution of value amongst the stages, does not provide break-even positions of the supply chain actors. A comprehensive analysis of the price structure requires a wide ranging and large dataset on costs and margins of the actors to identify the production, operating, processing, transportation, energy and other inputs costs.

10.4 Consumer behaviour

Consumers are the end users relating to aquaculture market related issues. A significant push for sustainable aquatic products in the EU, has led to improved product traceability and certification of

origin. The EMFF is placing emphasis on the quality of fisheries and aquaculture products (FAP) from the European Union. The expanding global middle class, namely in export markets, where local fisheries and aquaculture products do not benefit from stringent levels of quality and control, are demanding safe protein, which is a pillar of the sustainable aquaculture. Within the EU consumer market, understanding of the mechanisms and motivations that drive the consumption of aquaculture products, is crucial to bring producers and consumers closer together. EUMOFA (2017) conducted an extensive literature review on consumer behaviour, surmising the following:

- **Health risk versus the perceived benefit of seafood consumption** – various studies concluded that traditions and habits weighed more than the perceived health benefits from seafood consumption.
- **Consumer label information** – studies reported attention is paid to food labels, ranging from price, expiry date, species, place of origin, to derive a quality assessment of aquatic products. Additional food safety labels are also reported to be of significant interest to consumers.
- **Perception of farmed versus wild aquatic products on consumption** – consumers are reported to have a positive image of fish products, the health benefits conferred. Furthermore, the fish origin does not appear to be a major importance, and wild fish are generally preferred to farmed fish.
- **Incentives and barriers to consumption aquatic products** – studies report the primary incentive for eating fish are health and taste, whereas the main barriers are a price perception that fish are expensive. The satiety of fish lacks when compared to meat per the referenced studies, however preparation differences in different European Union countries are acknowledged.

Figure 20 shows that southern European and northern European countries rank above the European Union average in quantity consumed and household expenditure. The western and eastern European Union sub-regions (WEU, EEU) are below the bisector, meaning that the expenditure index is lower than the quantity index, suggesting a consumption of products with lower average unit value (reduced price and quality). The central European sub-region is line with the bisector, showing alignment with the European average. Most countries placed below the bisector consumer freshwater and farmed fish, whereas countries above the bisector consume marine fin fish, and farmed and wild such as sea bass, sea bream, shrimp, squid, cod, hake, and salmon.

Figure 21 shows how interviewees in each Member State and sub-regions expressed preference between aquaculture and fisheries products. Note that in Figure 22 that in only five Member States that expressed a preference for wild fish did the preference threshold pass 50%, and all from southern Europe, however the apparent indifference bodes well for aquaculture products going forward. EUMOFA (2017) do not reference to how this preference changes when factoring price different for farmed or wild equivalents of the same species. The study further identifies a significant competitive advantage enjoyed by aquaculture, and mandatory for large surface retailers, that relates to the ability for aquaculture to deliver regular quantities and supply side stability of aquaculture products at competitive prices.

Figure 20: Per capita consumption (kg live weight) and per capita household expenditure (PPP) index: Member States and sub-regions (EUMOFA, 2017).

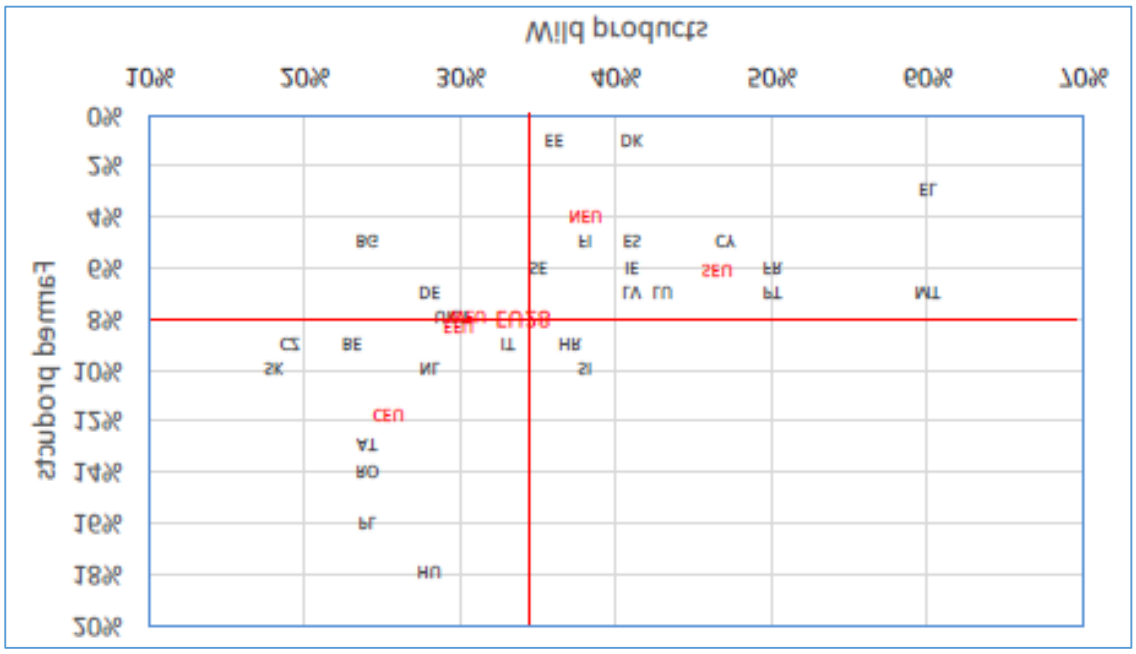


Figure 21: Preference of farmed versus wild products per Member State and sub-region (EUMOFA, 2017).

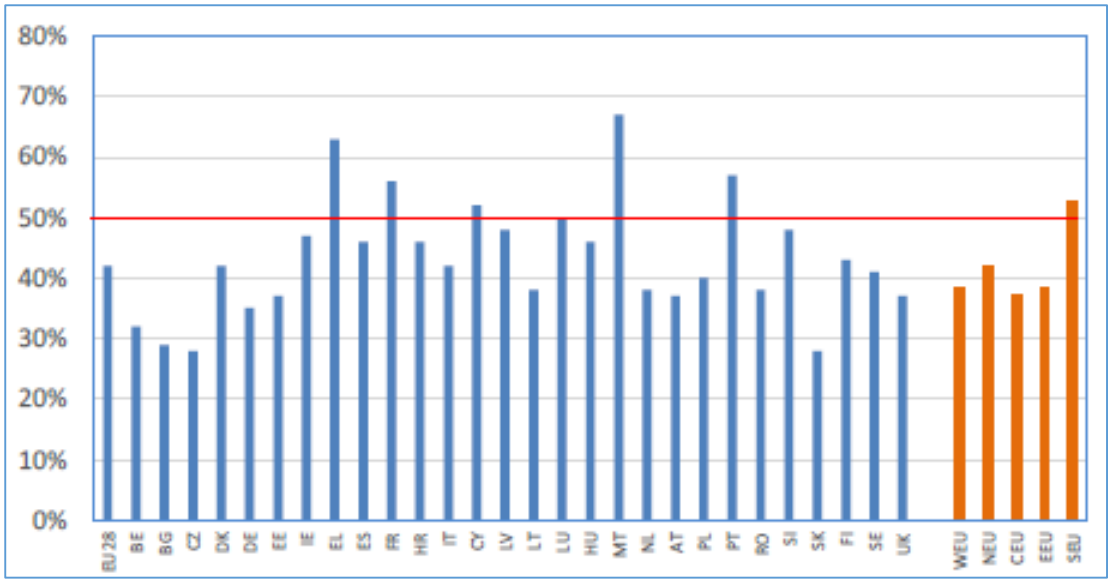


Figure 22: Percentage of people surveyed expressing preference for farmed versus wild products (EUMOFA, 2017)

EUMOFA (2017) conducted a EUROBAROMETER asking interviewees to express an opinion about the relevance of a list of items suggested by the interviewer. The main impacts influencing purchasing behaviour are price, appearance, and geographical origin. Figure 23 shows interviewee answers, and the size of the circles represents the consumer's perceived relevant for country of origin. EUMOFA (2017) note that appearance is the highest factor influencing purchasing decisions (58%), with price and place of original following at 55% and 42% respectively.

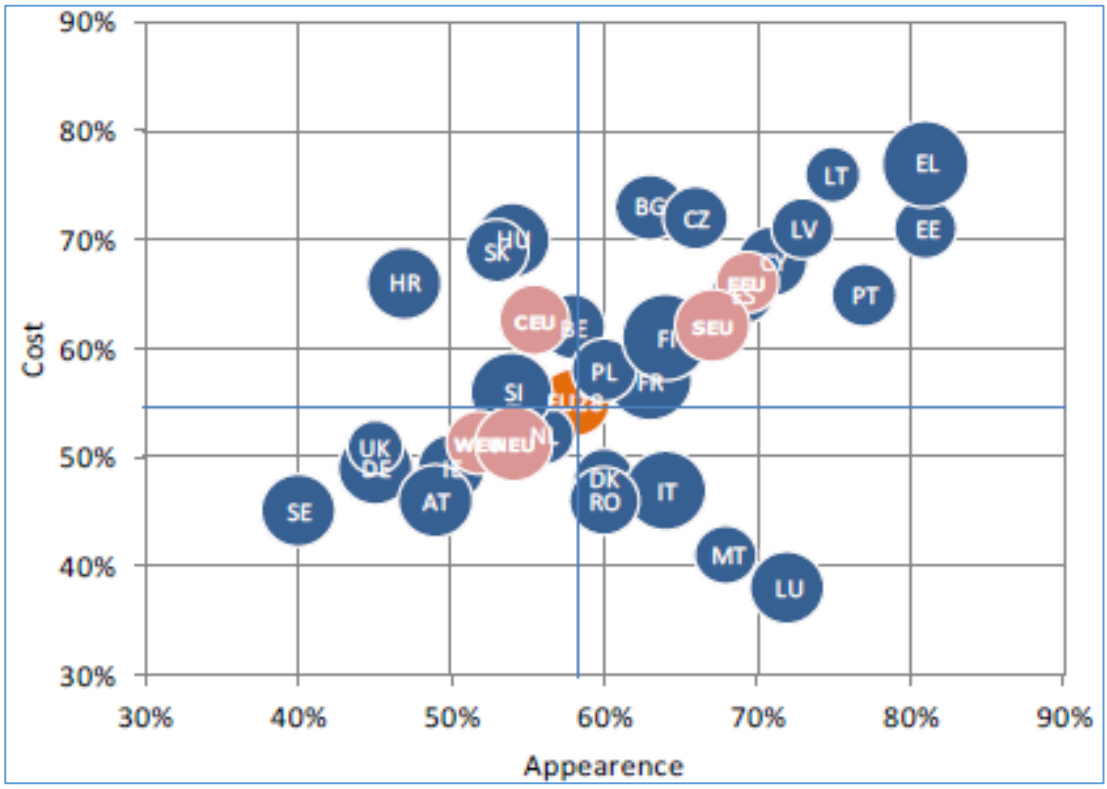


Figure 23: Main factors influencing consumer demand and purchasing behaviour (EUMOFA, 2017).

Consumer behaviour is of relevance and influenced by geographical denomination. Expanding aquaculture products requires careful assessment of the areas that influence purchasing decisions and satisfy consumer perception and product safety.

Aquaculture Spatial Planning and Market Issues - Key Observations

- Aquaculture production in the EU must be analysed in the context of aquaculture and fisheries, as both farmed and wild products are often in direct competition.
- The strong competitive advantage experienced in the EU is related to the quality and sustainability of its aquaculture products, and the degree of future success, depends in part on maintaining healthy marine and freshwater environments.
- Resistance provided by legislation and administrative procedures in obtaining licences, chokes investment in aquaculture. Member States need to review rates of applications and successes, time taken to complete the process and duration of licences, among others to be sure that industry can respond to market and consumer demands for competitive, safe and environmentally sustainable fish and shellfish products.
- Educating consumers should be a major driver for change in the European aquaculture industry, to ensure purchasing decisions are made with relevant high quality information and a shift towards aquaculture products.
- The EU is the largest trader of fishery and aquaculture products worldwide in terms of value, and is the largest importer of fishery products in the world, and sustains a trade deficit of 17.8 billion Euros.
- EU domestic consumption is mainly supplied by imports, often associated with frozen products or prepared meals, comprised of shrimps, tuna, and fish meal, that cannot be offset through expanded EU production directly, whereas Intra-EU trade consisted mainly of fresh fish, accounting for 39% of the value in 2014 and 2015.
- self-sufficiency rates in fisheries related catches are healthy, whereas aquaculture products such as molluscs, salmonids, and crustaceans illustrate the extent on which the EU relies on imports.
- The EMFF is providing incentives for European Union aquaculture development, however investigation regarding species selection driving growth, requires micro and macro analysis of price structure. The price paid for aquatic products by the end consumer, requires understanding of the price structure in the supply chain, and how value is apportioned along the different stages.
- While numerous “space” related factors constrain the EU aquaculture expansion, price structure analysis, particularly export focused, coupled with the inability for small-scale producers to develop the sales and logistical platforms required, presents a significant market related bottleneck.
- Expanding global middle class in export markets, where local fisheries and aquaculture products do not benefit from stringent levels of quality and control like they do in the EU, are demanding safe protein, which is a pillar of the sustainable aquaculture. Within the EU consumer market, understanding of the mechanisms and motivations that drive the consumption of aquaculture products, is crucial to bring producers and consumers closer together.

11. Case studies

In previous chapters, this review identifies the range of policies and other factors that affect the spatial management of aquaculture, and in this chapter we provide a complementary perspective from industry and aquaculture managers, based largely on their own first-hand experience in the aquaculture business. We have selected examples from the EU, Norway, the USA, and Canada, emphasizing the issues facing aquaculture and its expansion. In the four examples where case studies were written directly by the industry, the emphasis is not only on the challenges within a country, but those felt specifically by the authors in their own business.

The first set of case studies focuses on finfish species grown in freshwater and marine environments, and the second group relates to marine shellfish production. These documents highlight specific spatial management challenges and other relevant issues that, in the eyes of industry, limit the capacity to improve production and increase output. These case studies therefore help articulate core issues and barriers, and contribute towards putting the more general scope of this review into perspective.

11.1 Pond aquaculture in Central Europe

Éva Kerepeczki and Gergő Gyalog

Introduction

Farming of carp in ponds is one of the oldest production methods of European aquaculture having been practiced since the late Middle Ages. Although farming technology has intensified significantly since then, current pond aquaculture relies on principles developed centuries ago. The overwhelming majority of the pond farms apply extensive (<500 kg/ha) or semi-intensive (<2000 kg/ha) technologies that have the following common characteristics across pond farming countries:

- The rearing cycle is 3 years in most carp farming regions (some farms operate with 2 year and 4 year cycles). The market size is usually 1.5-3 kg.
- Seasonality is an important factor. Biomass gain takes place in the period of April/May to September/October. Pond farmers commence harvested during autumn, and most retail sales occur in December. The seasonality of supply falls in line with the demand which traditionally peaks during the Christmas period. However, fluctuations in prices indicate that the market is undersupplied during summer.
- Biomass management is based on the separation of 3 major life stages which is consistent with the length of the rearing cycle. Different age classes are usually not farmed together in the same pond. Ponds are divided into: 1) spawning and nursery ponds used during the first year of carp life, 2) on-growing ponds for two-year-old fish, 3) market ponds for last season 4) deeper overwintering ponds provided for fish keeping over the winter periods (< 1 hectare). Typical size of on-growing and market ponds is between 10 and 100 hectares.
- Biomass growth relies on natural food (zooplankton and zoobenthos), feed is added as a supplementary source of nutrients. Unprocessed cereal grains are the most commonly used feed, application of compound feeds is limited.
- Further major material inputs are organic manure used for enhancing plankton production and lime used for control of water quality. Use of machinery and automation in the production process is limited.
- Although common carp is the main target species in pond farming, accounting for 75-90% of production quantity, polyculture stocking is a widely-applied way of fishpond management. Herbivorous fish (Chinese carp) are cultured in pond polycultures (0-20% of biomass) due to their ability to utilize and control the plant organisms (silver and bighead carp are plankton

filtrators, grass carp feed on macrophytes). Supplementary predatory species such as European catfish, pike-perch, and pike are also stocked (up to 1-3% of biomass) to control the biomass of unwanted, naturally occurring fish.

- The extensively cultivated ponds form valuable wetland habitats, and gradually take over the ecological function of the natural wetlands that have vanished due to change in water course management. The agro-ecological potential of fish ponds is extremely high, because they sustain natural values (aquatic flora and fauna) of European significance.

Although the major principles of farming technology have been unchanged for decades, there are some dynamics in the sector: use of formulated feed, novel system engineering solutions and innovative water treatment methods are spreading in some regions, and thus more intensive farming (5-10 t/hectare) is practised by some farms. Diversification of produced species and different strategies regarding market size and harvest time of carp is also a significant issue.

Major pond producers in the EU are Poland (18-22 kT/year), the Czech Republic (18-20 kT/year), Hungary (12-14 kT/year), Romania (8-10 kT/year), France (7-8 kT/year), Germany (6-10 kT/year), Croatia (3-4 kT/year), Lithuania (3-4 kT/year), but there is also pond production at smaller scales in Latvia, Slovakia, Slovenia, Austria and Estonia (all below 1 kT/year)[46]. The total EU pond production is estimated to be 85-90 kT/year (Lane et al., 2014), accounting for 6-7% of total EU aquaculture production. Thus, pond farming is one of the major sub-segments of EU aquaculture in terms of production quantity. With respect to the total space occupied by farming installations, it may account for a higher share, as pond farming is characterised as a land intensive production method (ca 1500 ha are needed for 1 kT/year production capacity) (Figure 24).

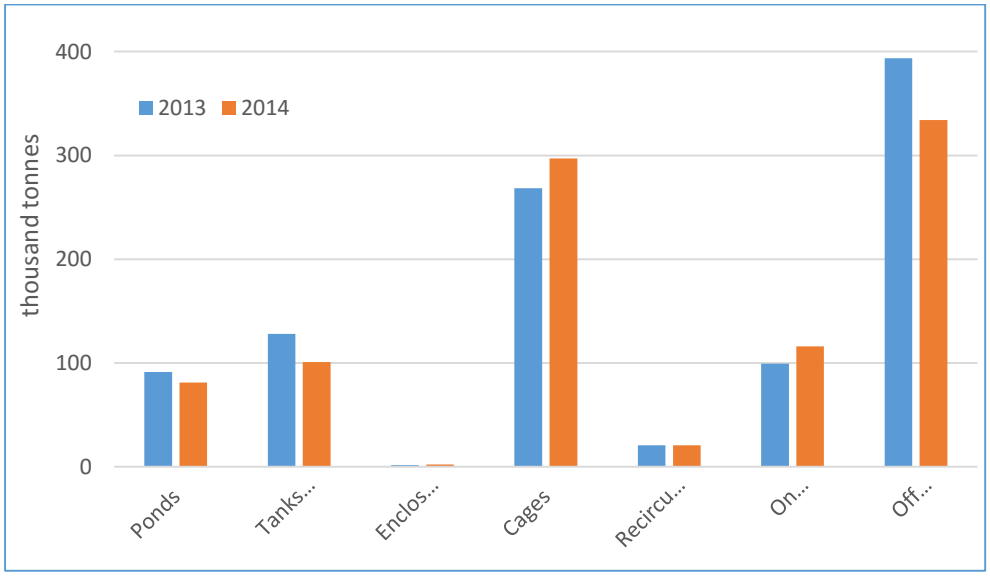


Figure 24: Production quantity by production methods in EU countries (Source: EUROSTAT).

Approach used to assess socio-economic and environmental aspects of freshwater pond aquaculture

In the frame of the *AquaSpace* project, partners working on freshwater aquaculture - the Research Institute for Fisheries and Aquaculture (NARIC HAKI) and the Biharugra Fishponds Ltd. (BHG) -

[46] Production data are calculated from EUROSTAT and from FAO FISHSTAT J carp production statistics.

conducted interviews with Hungarian aquaculture producers (9 interviews covering nearly 30% of total fish pond surface in Hungary, covering small-, medium- and large producers using round dam and barrage pond systems. Issues covered included spatial issues, related constraints and development plans. To have a wider view of major freshwater producers two *country reports* were prepared: 1) Policy, environmental, social and economic issues of freshwater aquaculture in the Czech Republic (by Zdenek Adamek and Jan Regenda); and 2) Polish report (by Andrzej Lirski and Konrad Turkowski). This report is augmented by outcomes from stakeholder workshops held in Biharugra, Hungary in 2016, under Work Package 4.

Sectoral policy of freshwater pond aquaculture

Legal framework of pond aquaculture

Legal frameworks for pond aquaculture in Central and Eastern EU is considered in the main body of the report, under section 5.

Legal thresholds

Pond aquaculture technology is regulated from the aspect of surface water protection in the Czech Republic and Hungary, but with respect to the protection of groundwater resources in Poland. However, technological restrictions are intrinsically connected to nature protection regulations. The aquaculture practice in ponds operating in national parks or Natura 2000 areas cannot contradict the nature protection objectives and/or the Natura 2000 operational plan of the given area. In Poland limitations in fishpond areas are only introduced if significantly negative effects on nature arise. In these cases, the losses caused by the limitation are compensated by the state. In protected areas, the restriction of water management (e.g. limitation of water for filling or drainage during the reproduction period of protected birds), quantitative restriction of fish stocking, restriction of the input of feed and/or manure, restriction of reed cutting, ban or restriction on using bird scarers (e.g. noise scarers) or shooting (mainly great cormorant) are typical measures. The compensation of production loss is not resolved either in Hungary or in the Czech Republic. According to results from the *AquaSpace* interviews, the nature conservation restrictions do not cause significant loss of production directly, while its indirect consequences can be observed in farms larger than 100 ha in Hungary. The nature conservation restrictions making production uneconomical are antagonistic because the wetland habitat itself, and the associated natural values, are produced and maintained by fish farming.

Table 20: Thresholds of fish pond water emitted to natural recipient water bodies in the Czech Republic and Hungary.

Parameter (unit)	Czech Republic[1]	Hungary[2]
Dissolved O_2 (mg l^{-1})	>6	-
pH	6–8	6,5-9,0
Biochemical oxygen demand (mg l^{-1})	6	25
Chemical oxygen demand (mg l^{-1})	35	75
Total organic carbon (mg l^{-1})	13	-
Total phosphorous (mg l^{-1})	0.15	5
Ammonium nitrogen (mg l^{-1})	0.5	5
Nitrate nitrogen (mg l^{-1})	7	-
Total nitrogen (mg l^{-1})	-	25
Total inorganic nitrogen (mg l^{-1})	-	20
Total suspended solids (mg l^{-1})	-	50

[1] Czech Republic: on the basis of GR No. 61/2003 Coll. (other surface waters)
[2] Hungary: on the basis on 28/2004. (XII. 25.) KvVM decree, 2nd appendix (periodical receiver, as typical case)

Governance framework for pond aquaculture

Governance frameworks for pond aquaculture are dealt with in the main body of the report, under section 5.

Development policy for freshwater pond aquaculture

Hungary, the Czech Republic and Poland, as Member States of the European Union, are entitled to draw financial resources from the Structural Funds: in the 2014–2020 period, the European Maritime and Fisheries Fund (EMFF). The Multiannual National Strategic Plan for Aquaculture for the 2014–2020 period serves as a basis for the Operational Programme for Fisheries in each country. Its approval by the Commission grants access to EMFF financial resources.

EU countries' specific strategies had to be developed in line with the national challenges and opportunities which differ between regions and Member States. The three countries studied in this review have recently updated their aquaculture policy strategies, all with a similar focus upon improving environmental sustainability in the aquaculture sector; and there is considerable emphasis on environmental services provided by aquaculture sites. All multiannual national strategies[47] involve a plan for:

- maintaining the current pond area for extensive aquaculture and strengthening its ecological functions (habitat provision, microclimatic effects, landscape formation),
- modernization of existing production units (development and purchase of new technologies),
- diversification of the aquaculture sector in terms of produced species (with high market potential) and activities (multi-functionality, angling, ecotourism),
- knowledge transfer and exchange of best practices at the national level and between Member States,
- development of the post-harvest value chain and boosting the local population's demand for freshwater products.

Thus, spatial expansion of pond aquaculture is not envisaged (or is envisaged to a limited extent) by the national aquaculture strategies, and no financial incentives are available to build new ponds. However, the quality of the space currently devoted to fish farming will be improved with respect to utilisation and environmental services.

Environmental background of pond aquaculture

Main principles of environmental interactions of pond culture

Modern pond aquaculture production started with diversion of water from the Danube catchment (Herman, 1888), and in the European Union about 60% of freshwater pond production is still connected to the same catchment area[48]. The biogeographic features of pond aquaculture production fundamentally define the spectrum of produced species and applied technologies. Pond production technology utilises the natural food chain processes typical for natural aquatic habitats, and production is realized by the joint processes of technological and natural pathways.

[47] http://ec.europa.eu/fisheries/cfp/aquaculture/multiannual-national-plans/index_en.htm
[48] Eurostat 2014 http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=fish_aq2b& lang =en

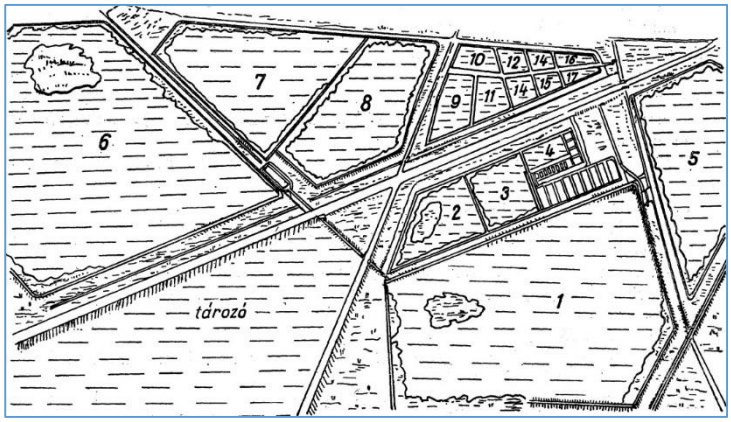


Figure 25: Round dam pond system (by courtesy of Antalfi and Tölg, 1971).

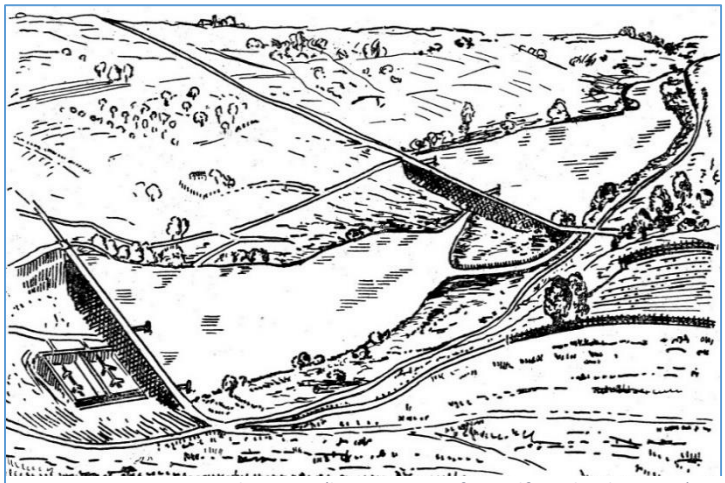


Figure 26: Barrage pond system (by courtesy of Antalfi and Tölg, 1971).

According to WFD terminology, fish ponds are considered 'heavily modified' or 'artificial waterbodies'. There are several types of fish pond. The two most important are the round dam ponds, typical in plain areas; and barrage ponds, which are frequently used in more hilly areas. There are also contour ponds but they are less common. Round dam ponds are artificial, where low land is dammed from every side, hence their water level is higher than the surrounding territory. Water supply mostly arrives from artificial canals. Obtaining water can be gravitational – when the supplying canal is elevated – or managed by pumps (Figure 25).

Barrage ponds are constructed in hilly areas, where the water course is dammed to create ponds. This type belongs to the heavily modified waterbodies. Their water supply arrives directly from the natural water course (Figure 26).

Considering environmental aspects there are numerous differences between marine and freshwater aquaculture. Fish ponds, even when located in the same catchment area, can be as isolated units as they are not connected directly to each other, only by means of the natural river network. Ponds from different catchment areas are not connected hydrologically. Fish ponds thus have a unique structure and function. While in mariculture the farming operation takes place in sites converted from the natural aquatic habitat, fish ponds are fundamentally artificial habitats, where the specific hydro-biological processes are created by the farming technology itself and sustained intentionally during the production period (Halasi-Kovács et al., 2012).

Water management

Pond aquaculture – as an extensive technology – has a huge water demand. In order to produce 1 kg of fish 20-25 m^3 water is required in Hungary (AKI, 2016), and around 30-40 m^3 in the Czech Republic and Poland, where yields are somewhat lower than in Hungary. Consequently, pond production is one of the largest water consuming sectors in pond farming regions. In Hungary, it has a 7% share of the total water withdrawal (Figure 27).

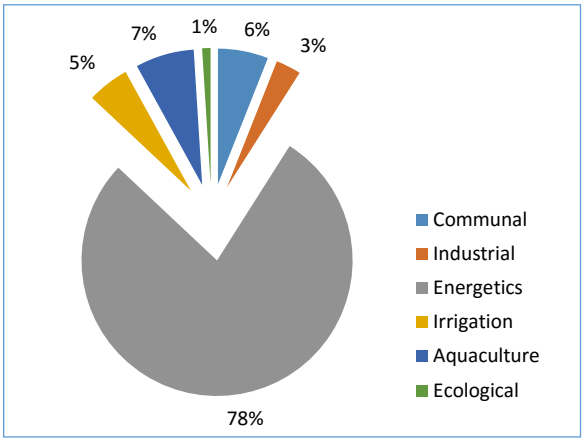


Figure 27: Sectoral distribution of water withdrawal from surface waters in Hungary (Source: OVF General Directorate of Water Management, Hungary).

For the spatial development of pond aquaculture, it is vital to have access to sufficient water resources, both from spatial and temporal aspects. The total water consumption by all sectors (including agricultural, industrial and communal use) accounts for only 5% of the total annual renewable freshwater resources (TARFWR) in Hungary, which is a low ratio[49]. Consequently, the available surface water resources are sufficient for increased consumption. This is further supported by the fact that agricultural (including the aquaculture) water consumption decreased by 40% from 1989 to 2011 (Halasal-Kovács et al., 2012). Poland and the Czech Republic are more water stressed than Hungary with greater pressure on water resources.

The water management of pond production technology is well adapted to the seasonal fluctuation of surface water resources, and the rate of consumption is tailored to these hydrological conditions. On the other hand, the available water resources show uneven spatial distribution. In addition, climate change results in decreasing amounts of renewable water sources, and the occurrence of extreme water levels is increasing (both low and high water levels). Consequently, the barrage ponds constructed on small hilly water courses are at risk of temporal water scarcity and floods that threaten the production infrastructure. Water scarcity is identified as the primary obstacle in the way of spatial development by Czech and Hungarian barrage pond producers. Currently, this problem does not pose a threat to the round dam ponds, which are supported by artificial canals from larger rivers. The available water sources allow the production capacity development in these areas. However, the cost of water in these artificial systems is higher - but this is an economic rather than a water management issue. In addition to the availability and cost of water, the deteriorated state of the inlet canal system may cause local and temporal disturbances in production. The insufficient state of the drainage system can similarly create problems in case of high groundwater levels, as the delay in drainage can adversely affect the technological processes.

Used water from the fish ponds is redirected to surface waters at the end of the production period. The amount of this water is approximately 20-45% of the water abstracted, which implies that fish ponds retain substantial amounts of water, although there are losses from evaporation and leakage. If water management is burdened by extreme water levels invoked by changing climate, fish ponds may play an important role, acting as reservoirs for the excessive water in springtime (e.g. ground waters).

[49] FAO AQUASTAT http://www.fao.org/nr/water/aquastat/data/query/results.html

Spatial variability in the quality of water also affects possibilities for aquaculture development. According to the experiences of fish farmers, the quality of surface waters is not a limiting factor for aquaculture. On the other hand, the intake of ground waters can be considered as a threat for both round dam and barrage ponds, if it is polluted with toxic substances (e.g. runoff from agricultural fields). The limitations of discharged water quality are defined by environmental legislation and are different between countries. These limitations can indirectly affect production.

As a result of the artificially increased nutrient input of pond production (organic manure), the fish ponds have typically higher nutrient levels than natural wetland habitats. Pond production requires natural and artificial supplements, to be transformed into fish biomass and subsequently eliminated from the artificial wetland system as used water, in order to maintain profitability.

The discharged water quality is affected – beside the aquaculture technology – by the received surface water quality, which can be quite diverse, especially when we consider the fact that ground waters can also enter the pond system. The nutrient content of the ground water is directly recycled in the fish ponds; however, the chemical pollutants pose a threat to the organisms and accumulate in the sediment or burden the recipient water body. Gál et al. (2016) noted that as an effect of pond aquaculture technology, the discharged water usually has higher concentrations of organic material (COD) and suspended solids content compared to the influx water in Hungary; and the nitrogen and phosphorus compounds are presented in a similar or lower amount in the discharged water compared to the inflow water. In conclusion, fish ponds often act as biological filters rather than polluters in aquatic and wetland systems.

The role of pond production in maintaining natural values

As a result of pond farming technology, a specific near-natural fish pond ecosystem (Figure 28) is created, that is closely related to natural wetland habitats (Figure 29). Although this is an artificial system, the material flow processes are equivalent to those of natural semi-static wetlands. The fish pond ecosystem is similar to the natural aquatic ecological systems in complexity. The larger homogeneous habitat patches (e.g. open water, dry pond bottom, reeds) allow some specific taxa to be more diverse than in natural habitats. On the whole, however, the biodiversity of fish ponds is lower compared to the natural.

One of the main characteristics of a fish pond producing fish under semi-extensive production method is the trophic status of an ecosystem can, to some extent, be artificially improved; given that phytoplankton transform nutrients that are then consumed by the fish, to improve overall water quality, as well as consuming detritus and other materials directly. The extent depends on whether or not ponds are manured to increase nutrient content, and turnover in waste products, such as faecal matter. existing nutrients helps to transform most of the nutrients into fish biomass that will be removed from the system. There is a relative stability in this kind of ecosystem compared to the natural wetland ecosystems. Another attribute of the fish pond ecosystem is the dominance of planktonic organisms which rely on the easily accessible dissolved nutrients in the water. This state is enhanced by the proper quantity of stocked fish population. The role of the agro-technological interventions (e.g. waterweed control, manure input) is only to create the suitable conditions for that.

Without the proper amount of stocking material, the succession spectacularly converts the fish pond into a shallow aquatic habitat with homogeneous marshy vegetation (reed communities, willow-shrub vegetation) in only three to four years. The increased nutrient input enhances the population sizes of all segments in the food chain, this way the fish ponds maintain notably more organisms compared to the natural ecosystems. When the pond management shifts to a more extensive technology, the nutrient input decreases or ceases completely, the nutrient sources in the pond diminish, which

further decreases the population sizes of all inhabiting organisms (Oláh, 1999). Another unique feature of fish ponds is the seasonality of water coverage. When the harvesting processes are sequential, the different (aquatic, semi-aquatic, terrestrial) stages are simultaneously present in a relatively small area, thus allowing rich habitat complexes to coexist (Kovács, 1984). To conclude, the intensity of fish pond management is vital for the sustenance of natural values related to the fish ponds.

Figure 28: Artificial fishpond, near Biharugra (Hungary) photo by L. Tirják.

Fish ponds provide a unique role in nature protection as they contribute to the existence of largely expanded wetland habitats in dry regions (e.g. hydrophyte communities with *Nymphaea, Nuphar, Utricularia* and *Stratiotes*; eutrophic and mesotrophic reed and *Typha* beds; amphibious communities on river gravel and sand banks). The role of fish ponds in supporting aquatic and wetland habitats is important in Hungary, as their share from the total area of standing waters is 20% (Halasi-Kovács and Váradi, 2012; AKI, 2016).

Figure 29: A natural marsh near Biharugra (Sző-rét, Hungary) photo by L. Tirják.

Besides contributing to the sustainability of aquatic and wetland habitats, fish ponds sustain wildlife of European importance. Their most notable impact is the support of waterfowls that depend on wetland habitats to provide nesting, resting and feeding habitats. Fish ponds also support populations of the Eurasian otter (*Lutra lutra*). The natural value in fish ponds also include habitat for various amphibian and reptile species and protected and endangered fish species, in ponds and associated canals. The Hortobágy Fishponds (Hungary) comprises ca. 5,500 ha area, and surveys there have identified 8 protected fish species, 9 amphibian species, 3 reptilian species and more than 300 bird species. The size of the fish pond shows significant correlation with its role in sustaining natural values (Végvári and Tar, 2002; Stafford et al., 2007). A detailed assessment on the wildlife emerging through the fish pond activities has not yet been conducted at a European level (Kerepeczki et al., 2011).

There have been some attempts to monetise the ecosystem services provided by fish ponds. The value of the habitat service of the Hortobágy Fishponds in Hungary, based solely on the occurrence of bird species, was calculated as 32,000 euro/ha (Halasi-Kovács, 2008). Regarding Polish fish ponds the total non-productive value was estimated at 52,858 euro/ha (Turkowski and Lirksi, 2011).

Supporting actions that protect habitat and animal species – mainly birds and otters – contributes to losses in yields and additional costs for farmers. Species can be grouped according to their economic

impact. Species with direct economic impact consist of fish consumers (e.g. great cormorant, pygmy cormorant, Eurasian otter) and fish feed consumers (e.g. mallard, common pochard, Eurasian coot), which have a direct visible action. There are, however, indirect impacts (Halasi-Kovács, 2008) that stem from regulations that affect filling, draining, fishing, waterweed control, reed cutting processes through the nesting, breeding, migrating or simple presence of protected species. There are no direct losses stemming from such activity, but the inability to manage farms solely for the purposes of aquaculture reduces the overall efficiency in planning and management for productive output, which indirectly affect yields and profitability.

According to responses from interviews, the most important species to cause direct economic impact is the great cormorant. The loss can be as high as 10-20% of the fish production value. The intensity of the damage differs between barrage and round dam ponds, and between smaller and larger ponds. The increase of the great cormorant in Hungary is determined by the accessible resources, such as habitat and food availability (Farago, 2013).

A good indicator of the importance of fish ponds to nature protection is that 49% of active fish ponds in Hungary are within National Parks and 66% are Natura 2000 sites (Halasi-Kovács et al., 2012). Designation of National Parks and Natura 2000 sites happened long after pond farming existed, and thus status was achieved despite the presence of aquaculture ponds. Nonetheless, nature protection legislation in Hungary, as in the Czech Republic, has contributed to limiting technological advancement in pond culture and development of other more intensive production methods within designated sites; with production remaining ostensibly extensive. During project interviews, it became clear that production is mainly limited by nature protection regulations, especially for larger ponds located in national park areas.

There are two further important issues regarding fish pond production and its natural importance that affect the integrity of natural ecosystems. One of these results from barrage ponds, where dams are constructed to cross narrow streams in hilly areas, and the damming fundamentally alters the ecological community of the tailwater. The ecological state of the vulnerable hilly water courses in Hungary is a critical issue, although the vulnerability is only partially associated with fish pond production. The other issue is the ecological impact exerted by fish escapees. Fish farms in Central and Eastern Europe are generally farming long-existing but nonetheless non-native species. Escapees can thus heavily modify fish assemblages in natural water courses, especially where they are connected directly to the fish pond. Escapes are mainly an issue for production in barrage ponds, because the ponds are directly connected to the natural water course networks.

Social aspects of freshwater pond aquaculture in Central Europe

Land use characteristics

Central European aquaculture is historically characterised by use of extensive and semi-intensive fish ponds. Territorial expansion of fish ponds has occurred at various times in the history of Central European countries. The Golden Age of pond farming in the Czech Republic started in the 15-16th century with intensive fish pond buildings. In other countries, river regulations and consequent loss of wetland habitats seriously affected wild fish stocks and inland capture fisheries in the 19th century. This resulted in decreased supply of fish products in the regional markets and stimulated the establishment of further production capacities (fish ponds). Fish ponds were often created on earlier floodplains and partially compensated for the loss of natural aquatic habitats. The most dynamic advancement of fish farming occurred in the first half of the 20th century in most Central European countries.

In Hungary, the current (2015) area of fish ponds is 24,900 ha, accounting for approximately 0.5% of the designated area for agriculture. In Poland, agricultural land area was stable between 2000 and 2010, at approximately 14.4 million ha, and within this total carp ponds designated for production occupied around 52,900 hectares (in 2014)[50]. The utilised agricultural area in the Czech Republic was 3.5 million ha in 2010), and within this the area of carp ponds was 52,000 ha (in 2012).

Water accessibility, irrigation and storage

According to the *World water development report* of the United Nations, a country experiences 'water stress' when its annual water resources drop below 1,700 m^3 per inhabitant. Poland and the Czech Republic were in this category in 2013. Both countries reported shortages of water resources for aquaculture purposes. Other countries are rich in renewable water resources such as Hungary, Serbia and Romania.

The fisheries sector and other industries of the economy in Central European countries, like the Czech Republic and Poland, often compete for available water resources. In Hungary, for example, the competition is usually restricted to dry periods and is mainly attributed to the poor state of canals. Aquaculture water consumption has increased since the 1980s and it usually accounts for more than half of the total agricultural water use. The ratio of the average irrigated area compared to the utilised agricultural area was below the EU average in the three countries in 2013. The Hungarian government aims to increase the irrigated areas by supporting in the introduction of water-saving technologies[51]. When irrigation and aquaculture systems use the same surface water sources, issues may arise in relation to the organic material content or agricultural toxic products in run-off waters. Development of intensive fish farms could decrease cases of conflicts with other sectors because they primarily use groundwater instead of surface waters (e.g. rivers); and water in intensive culture is also fully or partially recirculated. A further opportunity for decreasing conflict in water consumption is the reuse of discharged waters, for example in Poland many fish cage farms operate in canals of electric power plants[52].

The role of fish ponds in flood control is not maximized, and, for example in Hungary, the storage capacity of ponds could potentially stock 150-200 million m^3 excess water (Ministry of Rural Development, 2013) and could also have potential in the promotion of integrated water management.

Employment and education

In 2014 there were 1591 people employed in fisheries-related jobs in Hungary, being 0.04% of total employment (AKI, 2016). Employment rates were similar in the Czech Republic, with 1433 people employed in fisheries (0.03% of total employment); and in Poland, where 7126 people were employed (0.03% of total employment). The fisheries sector generally employs more men than women in European countries. In 2012, the share of female employees was 15% in Hungary, 15% in Poland and 7% in the Czech Republic (OECD, 2015). In Europe, the share of female employment is generally higher in the fish processing sector, but in central and eastern Europe the fish processing industry is not well developed.

Central European aquaculture, especially extensive and semi-intensive fish production, is generally associated with rural, low-income areas. In Hungary in 2012, the average net wage for workers was 6.9% lower than the average wage in the agricultural sector, and 31% lower compared to the national

[50] http://www.fao.org/fishery/countrysector/naso_poland/en

[51] Eurostat Statistics 2013. http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Irrigable_and_irrigated_areas,_EU-28_and_Norway,_2013.png

[52] http://www.fao.org/fishery/countrysector/naso_poland/en

economic sector. Within the sector, net wages in fishing were higher than wages in fish farming (Hungarian Central Statistical Office, 2011a).

Fish pond aquaculture traditionally does not require personnel with higher level education, although secondary education and work experience are well appreciated. In Central Europe, extensive fish farming has a high demand for low-qualified employees for seasonal work, and this creates competition with other industries such as agriculture and construction. On the other hand, in intensive aquaculture there is a demand for highly educated permanent employees. In addition, the Hungarian aquaculture sector is reported to be lacking young and properly qualified personnel. 58% of employed males and 63% of employed females were 40 years old or above in 2011, and many of them close to retirement (Hungarian Central Statistical Office, 2011b). The number of permanent workers is decreasing and the workforce requirement of the sector is shifting to occasional employment.

Nature conservation and environmental protection

Aquaculture activity can support nature protection goals as it provides suitable habitats for species of EU interest. 5% of Natura 2000 sites in the European Union are reported to host aquaculture activities, in over 1200 SPAs (Special Protection Area) and SCIs (Sites of Community Importance). Many of these sites in central and eastern Europe have been designated because of aquaculture activities. The Ramsar Convention recognizes the potential benefits of aquaculture growth in providing additional fish supply and habitats, but also the need for careful planning and management to avoid negative impacts on native species and ecosystems.

Although the production intensity of fish ponds is generally low and cases where aquaculture removes the nutrient surplus from the water, conflict with conservation policies do exist. The effluent water from fish ponds can contain increased levels of suspended solid and organic matter content, and has the potential to harm natural waters. Barrage dam ponds similarly alter the downstream section as a result of damming across rivers. Aquaculture also contributes to the invasion of non-native fish species and can possibly result in conflicts with natural protection agencies.

Furthermore, nature conservation policies and protection of water fowl often result in conflicts with fish pond aquaculture, as predatory animals are commonly responsible for losses in fish yield. This issue is a frequently recurring problem and is of high importance. Compensation from governments in Central Europe is generally low/insufficient, or is predator specific, and ignoring other predators. Until 2013 the Czech Republic government paid compensation for damages caused by cormorants and otters, for example but current legislation only pays for damage caused by otters. In Hungary, no compensation is paid for such losses, although recent communications between farmers and natural protection agencies may resolve this issue. In some cases, there are further methods for compensation. In Poland if the fishery activity requires adjustment because of the requirements of Natura 2000 sites, the regulations provide for compensation. In the Czech Republic selected fish farmers can also receive a subsidy for maintenance of genetic resources.

Angling is a significant sector in Central and Eastern Europe. In Hungary, it yielded 4039 tons of fish in 2012. Designated areas for angling take approximately 1.5% of the country's area covering 130-140 thousand ha (Hungarian Central Statistical Office, 2001a). Angling is also an important commercial and recreational activity in Poland, where it provided 26% of inland fisheries production between 2000 and 2003[53]. Angling also supports environmentally friendly tourism, for example in the Czech Republic where trout species are often used for stocking angling waters[54].

[53] http://www.fao.org/fishery/countrysector/naso_poland/en
[54] http://www.fao.org/fishery/countrysector/naso_czechrepublic/en

Economic aspects of spatial development of Central European pond culture

General growth and economic conditions

It can be concluded from the production statistics that the Central European pond production sector has not expanded its area in the last few decades. Carp production (including all cyprinid species), which is the main output of pond farms, decreased by 47 percent over the period of 1989 – 1998 from 160 kT to 85 kT, and since 1998 it has stagnated at 80-90 kT/year level in the EU-28 countries (FAO 2015). The huge decrease in production which is mainly attributed to the economic shocks in Central European countries in the '90-s, is caused by decreased yields (less intensive production technology) and the contraction of pond areas actively used for fish production. The latter factor is a result of a net effect of degradation/devastation and construction/renovation of pond production infrastructure (barrages, inlet canals, proliferation of vegetation, etc.).

Even though the pond sector has managed to stabilize in the last 10-15 years, the lack of growth in production is in sharp contrast to Asian pond aquaculture and to certain sectors of European mariculture. However, the levelling-off in pond production is similar to other sub-sectors of EU freshwater aquaculture (such as trout farming in tank and raceway systems). This in part can be attributed to limited development in the value chain for carps, in comparison to other fish products. The following factors account for the mismatch between demand and supply:

- The fragmented farm structure of freshwater aquaculture was unable to benefit from economies of scale (Nielsen et al 2015.); and production costs did not decrease, in contrast to mariculture where concentration and vertical integration took place.
- Demand for carps changed drastically along with consumer preferences, consumers' income and availability of competitor imported products of different price segments (such as *Pangasius*, salmon, tilapia, cod, hake and marine pelagic species). Having been pressed by reduced demand there were no economic incentives for the pond production sector to increase production.

Development of Central European pond aquaculture depends on whether the bottlenecks which have impeded growth in the last 10-20 years are removed. Analysis of the future evolution of economic drivers and pressures for general growth in carp production go beyond the context of this study, which is intended to focus only on those economic factors that foster or hinder the spatial development of CE pond aquaculture.

Factors affecting territorial expansion of pond aquaculture

Central European pond aquaculture can be developed in several ways including

(i) allocating more land resources to the sector (spatial development);
(ii) increasing yields by intensification measures (more intensive stocking and feeding, increased use of fossil energy and machinery);
(iii) increasing production value by changing target species / market size or attaching extra value to environmental and societal services provided by the sector.

The choice between different development scenarios is influenced by

i) Internal production economics of pond farming: what are the trade-offs between inputs and how input prices evolve relative to each other. If the marginal return on land and water resources is lower than the marginal return on ex-farm inputs such as feed, it is unlikely that farmers will increase their production by expanding pond area, rather they will increase their production through intensification.

ii) Availability of land and water, restrictions in access to and opportunity cost of these resources. Aquaculture is in competition with other activities for the use of these resources, and investments are likely to be determined based on efficiency. Low return on land and water in the aquaculture sector compared to corresponding values in other sectors would imply that aquaculture is not an efficient user of these resources and investment in land/water is directed toward other sectors.

Internal production economics of pond aquaculture technologies

Pond farmers can choose between particular combinations of inputs to produce a given quantity of fish. Apart from labour and non-tangible inputs (such as technology, know-how, management), there are two main categories of inputs in pond aquaculture:

- On-farm resources such as land and water which are non-transferable from site to site and the quality of which is very site specific; and
- Off-farm inputs, such as feed, fertilizer, seed, machinery, electricity, etc.

Yields in different pond farms in Central Europe vary from 300-500 kg/ha to 5,000 - 10,000 kg/ha reflecting a wide range of technological trade-offs existing between on-farm resources and off-farm inputs.

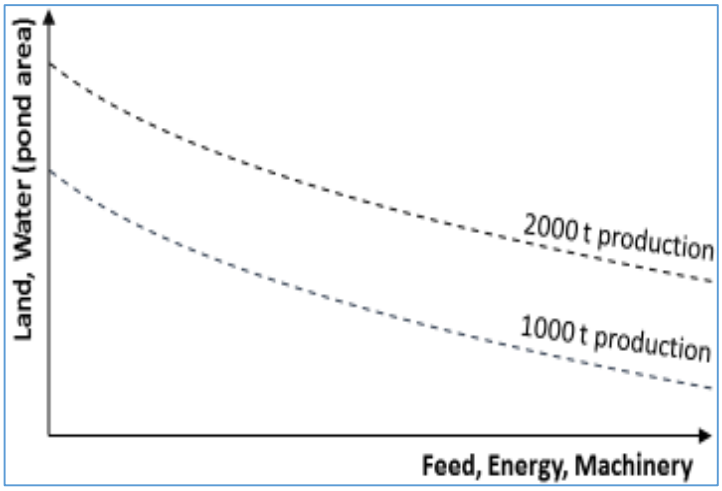


Figure 30: Illustration of trade-offs between off-farm inputs and on-farm inputs with isoqant curves

Under extensive/semi-intensive farming conditions (500-1000 kg/ha) 20-30 m^3 of water and 200-300 g protein (added in feed) are used to produce 1 kg of fish. More intensive technologies (>2-3 t/ha) use less than 10 m^3 of water but more than 500 g of feed protein to produce 1 kg of fish. This way, land and water[55] can be substituted for off-farm inputs to a certain degree keeping a certain production level. Figure 30 illustrates this trade-off situation schematically with the use of isoquant curves, which chart the combinations of inputs that produce a specified level of output. Figure 5 shows that production quantity can be doubled either by increasing the pond area or adding more ex-farm inputs or by combining these two options. Given the substitutability between input categories, farmers are seeking least-cost combinations of inputs to produce the amount that they can sell. Currently it is widely thought that if carp farmers were faced with an increased demand they would meet this by increasing yields instead of constructing new ponds. Intensification is a more viable way of increasing production than spatial expansion nowadays, as land prices and pond construction costs are rising at a higher pace than feed and aquaculture equipment prices. Also, it must take into consideration that recent R&D in aquaculture engineering and nutrition has improved the efficiency of pellet-based technologies and intensive rearing.

[55] Water is proportionately used to land as 15,000 – 20,000 m^3 of water per ha of pond per season is used irrespectively of production intensity.

The construction cost of fish ponds varies from 10,000-15,000 €/hectare in Hungary, 30,000 - 60,000 €/hectare in Poland and the Czech Republic[56]. Calculating with a pond lifespan of 33-50 years (2-3 % annual depreciation rate) and 5-8 % interest rate, the annualized cost of investment capital used for pond construction[57] is around 600-1200 €/hectare in Hungary and 2000-5000 €/hectare in the Czech Republic and Poland. As yields are 1000-1500 kg/ha per year in newly constructed ponds using extensive/semi-intensive technologies, the capital costs of new fish ponds are 0.5-1 € per kg fish in Hungary, and higher in Poland and the Czech Republic. This is not a viable option for carp farmers, as the prevailing producer prices of common carp are 2-2.5 €/kg in the Central European region. It should be noted that EFF and other funds available for the aquaculture sector provide financial incentives to decrease the capital costs, but even with a 50% co-funding rate very few on-growing fishponds have been built since the funds became available.

Although there are no economic incentives for territorial expansion of pond culture with respect to traditional extensive on-growing technologies, taking into consideration market and production economic factors there are some reasons to build new ponds not intended for extensive on-growing:

- Smaller wintering ponds: Available for storage between October harvest and winter sales period, with fish kept alive but not undergoing further fattening; and as juvenile rearing ponds. Investment in these ponds may help to rationalize the biomass management within the existing pond farms and would improve marketing possibilities. These measures improve profitability such that high investment costs are recouped in a relatively short period.

- Ponds for intensive rearing of carp or other fish: Built with good road infrastructure and electricity supply so that machinery (feeders, aerators) can be operated and ponds can be harvested efficiently. Higher yields of carp would share the capital investments over a greater amount of production when calculated on a per hectare basis. Production of more valuable species would further improve net returns on land (or on pond area).

In line with the conclusion drawn above, most fish ponds built in the region over recent decades are not traditional large on-growing ponds used for extensive rearing but are smaller 0.5-2 hectare ponds customised for pellet-based intensive rearing technologies or for storage of biomass and for juvenile rearing.

Land and water: availability and competition for resources

Total pond area actively used for fish production is 53,000 ha in Poland, 43,000 ha in the Czech Republic and 25,000 ha in Hungary, representing 0.4%, 1.0% and 0.5% of total agricultural area (FAOSTAT). Given these low numbers and taking into account that Central European countries do not suffer from a scarcity of land resources in comparison to other countries (Figure 2), competition for land between aquaculture and vegetable crop production is not considered to be a significant issue in Central Europe.

Compared to other agriculture systems, traditional extensive pond aquaculture does not offer higher returns on land. Average gross yields in pond farming are 480 kg/ha in the Czech Republic, 700 kg/ha in Poland and 780-800 kg/ha in Hungary. Production value per ha of water surface is around €1000-1600, varying along with productivity. Considering that pond surface accounts for only 2/3 of farm area, the production value of Central European pond aquaculture is around €700-1000/ha of land.

[56] These construction costs are calculated for 10-50 hectare ponds based on the country reports. Per hectare construction costs are larger for smaller ponds as a result of technical economies of scale.
[57] Calculated Capital Recovery Factor (CRF) is 6 - 8 %

This value is similar to the most common used methods of crop production (cereals and oilseeds) which vary from €600-1200/ha in the region.

As long as there is no pressure on land resources there will be no economic drivers to increase the net returns on unit area of land. However, if land resources decrease in the future either as result of urbanization, industrial and infrastructural expansion or climate change, the efficiency of land use will become important and pond production will have to be intensified.

The average water use of low-intensity pond aquaculture in Central Europe is around 20-30 m^3/kg which is high compared to other aquaculture technologies. This number corresponds to a production value of €0.06-0.1 per m^3 water used, which is relatively low in comparison to values of €0.2-0.4 per m^3 water used calculated for irrigated plant production in Hungary[58]. Moreover, if economic efficiency of alternative water use options were measured as net value added (revenues minus material costs) per m^3 of water, aquaculture would prove even more inefficient compared to irrigation. Taking into consideration that aquaculture accounts for 40-60% of freshwater used for agricultural purposes, competition for water resources between fish farming and the irrigated crop sector can be intensified in the future with altered patterns of precipitation brought about by climate change.

11.2 Trout aquaculture in Italy

Roberto Pastres

Overview

Modern rainbow trout, *Oncorhynchus mykiss,* aquaculture in Italy started in the 1970's and grew consistently for about three decades, reaching a peak of about 51,000 tonnes per year in 1997. In the last two decades, the annual production has decreased, fluctuating around 36,000 tonnes in the years 2010-2014. Despite this, Italy is still the leading rainbow trout producer in the EU, according to MPAF (2013), and in 2012 Italy accounted for about 20% of the EU 28 production, which was about 176,700 tonnes. Within the Italian context, rainbow trout is by far the most important species, as it represents about 90% of the whole freshwater aquaculture production and accounted for about 65% of the national finfish production in 2013, which was about 50,000 tonnes.

Figure 31: Regions in Italy.

Rainbow trout requires relatively cold, well oxygenated, clear and unpolluted waters and as a consequence, farms are not evenly distributed in Italian territory but are mainly established in

[58] The latter numbers were calculated based on estimated extra revenues on irrigated crop lands (using on avg. 800-1200 m^3 of water per hectare per year) compared to non-irrigated croplands (Biró et al. 2011.).

Northern Italy, where the water supply in assured by both alpine rivers and streams, and by groundwater. Due to water quality requirements, 75% of farms are located in Lombardia, Trentino-Alto Adige, Friuli Venezia Giulia, and Veneto: the last two regions account for about 50% of the Italian production.

About 18% of farms are located in central Italy (Figure 31), in particular in Umbria and Abruzzo, along the Apennine mountains, and the remaining 7% in Southern Italy (Figure 32).

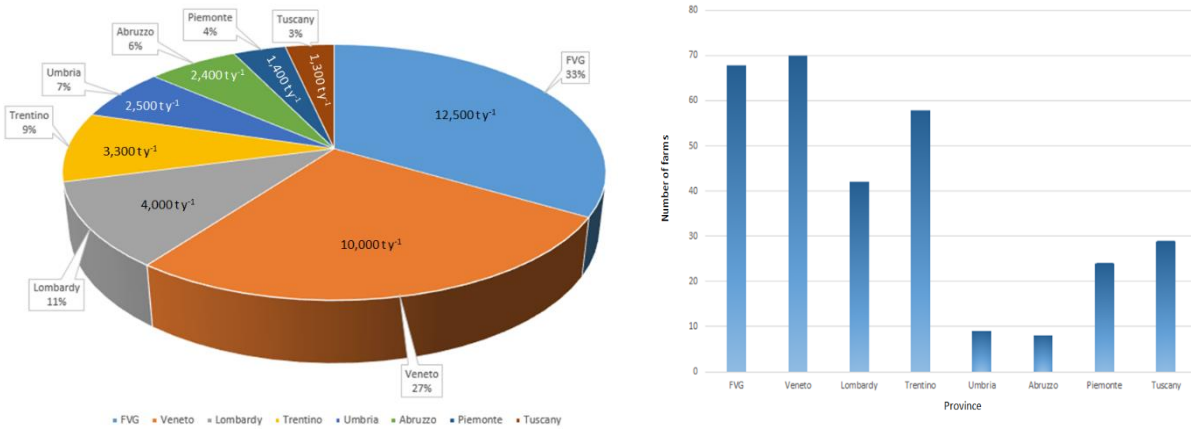


Figure 32: Regional distribution of trout farming in Italy. Left: production by region, right: farms by region (Fabris, 2012).

The trout supply chain in Italy has recently been analysed within the framework of the EU Horizon 2020 project "Primefish" (http://www.primefish.eu/). The results are summarised by Sogari et al. (2016), who found that the size of companies and their production capacity show a large variability, from less than 100 t y^{-1} to more than 1500 t y^{-1}. The stocking density ranges between 8 and 35 kg m^{-3}, with 15-20 kg m^{-3} being the most frequent choice, in particular for high capacity farms. The feed conversion ratio is about 1.2 and production costs about €2.10 kg^{-1}.

Figure 33: Rainbow trout in a raceway farm in Trentino Alto Adige (courtesy S. Maiolo).

One of the keys to the success of trout farming in Italy (Figure 33) has been the capacity to meet consumer demand for safe, healthy and ready-to-cook products. This trend, started in the 1980s, is still driving the sector, with about 84% of the production processed and sold through the GDO (Sogari et al., 2016). Therefore, the largest companies have their own processing unit and the smaller ones often deliver their products to processing units which serve a whole district.

Challenges to expansion

According to Sogari et al. (2016), the further expansion of the sector is limited by: high investment costs and limited profitability; the reduction of consumption due to contractions of the economy in the last few years; the increase in production costs; the competitions with cheaper imported products.

However, data on import-export suggest that there is room for increasing production; in 2015 Italy imported about 4,500 tonnes of trout, i.e. more than 10% of the national production, in volume and about 10 million euros in values. On the other hand, a relevant fraction of Italian production was exported; about 7,800 tonnes in volume and 30 million euros in value (Sogari et al., 2016).

To a large extent, the sector is affected by a set of problems shared by the whole Italian aquaculture industry:

- Excessive bureaucracy;
- Difficulties in coping with sanitary and environmental monitoring;
- Small company size, making it difficult to invest in technological innovation;
- High costs of feed and labour, and low return on investment (ROI);
- Lack of financial instruments and insurance schemes.

To this list, the threat of climate change must be added; most climate scenarios predict an increase in air temperature in the Alpine regions of about 1.5°C, a reduction of frosty days, an increase in days with temperature exceeding 29°C, and a decrease in summer precipitation. Overall, this is likely to lead to a reduction of water quantity and worsening of water quality, through increased water temperature and turbidity, which could be exacerbated by extreme events. Some of these changes are already being felt, with many farms in the Friuli Venezia Giulia region barely surviving in the dry summer of 2015. Climate change may lead to a shift towards partial recirculation systems and/or relocation of farms, due to water scarcity. In this context, an understanding of current and future environmental conditions, along with improved authoritative and regulatory systems means good spatial planning has become essential in determining how and where trout production can increase.

11.3 Salmon aquaculture in Norway

GIFAS Gildeskål Forskningsstasjon a.s

Johan Johansen

Background

Europe needs to have a steady annual increase in aquatic production between 3-5% to meet the goals set by World Bank and FAO for 2023, 2030 and 2050. This would provide self-sufficiency and regional stability in terms of food provisioning, assuming that all agricultural targets for increased production are reached.

Current status

Norwegian aquaculture is centred on salmonids, mainly Atlantic salmon and little trout. All other aquatic production is very limited, and for many species, even more reduced now than in previous years. Thus, the commercial success of the salmon industry, now producing more marine fish than China, has been a curse for other aquaculture crops such as flatfish, cod, wolfish, mussels, sea urchins and seaweed. All business models are compared with salmon, and if they cannot deliver the quarterly revenues, the model is not palatable for investors, and authorities and public funding agencies seemingly agree. It therefore becomes a major challenge to develop new industry within such time-frames.

The two main bottlenecks for further growth identified as national challenges for Norwegian aquaculture are escapees and sea-lice. The concerns about impact of escapees relate to the concept that the carefully selected gene-pool of a native salmon river will be challenged when the wild fish are outnumbered by the outcome of the breeding program (non-GMOs) from a collapsed fish cage close by. The wild breeding stock population of Norwegian salmon may be as low as to be equivalent to 2 standard fish farming licences (500,000+ fish) and has experienced a 50% reduction over the last 30

years. Others place their hope in the escapees, and according to them the rapid environmental (man-made) changes in the salmon rivers make the gene pools refined through evolution less well-suited, and therefore escapees broaden the gene pool and provide better odds for survival. There is uncertainty as to who is right, and the debate has become increasingly emotional. This influences the sea lice-legislation as well. There are thresholds for using chemotherapeutics well below the point where parasite infestation becomes a problem for the salmon, in fact it may be argued that from the farmed fish welfare point of view, the handling stress is much more problematic than the sea lice themselves. Thus, the only reason for such precautionary regulation is to protect the wild salmon population: even if lice/fish numbers are relatively low in the actual farm, the lice population is high.

We have by and large solved the escapee problem, through mandatory certificates on each component as well as the combination of components on the farm in combination with regular inspections. If all is done according to protocol, this provides a satisfactory integrity with respect to breakage and escapees.

Regarding the parasite challenge, we are producing less-sensitive strains of sea lice as a result of frequent treatments, and run out of alternatives too quickly. Recently we have turned to non-chemical (i.e. mechanical) methods of getting rid of these parasites, and fish welfare finds itself again at the short end of the stick. Fish farmers generally have excessive expectations on the delivery rate of new tools from the pharmaceutical industry, and public opinion does not help in this matter. Unlike the escapee problem, the sea lice issue really depends on new approaches for the industry to be able to grow anywhere near the target volume.

Other challenges

The aquaculture industry is very young and in many ways immature. This is true for the regulation and legislation levels as well. Much of the negative public opinion is related to the conspicuous ‘new kid on the block’, and will not be resolved until future generations are as familiar with fish cages as we are with barns and factories. Thus, not all negative opinions require action, some can only be remedied by the passage of time.

Planning

Generally, most areas have good spatial planning for today’s aquaculture industry. Competent foresight will be needed to develop the spatial planning for the future. In contrast to agriculture, polyculture is generally seen as a negative and risky approach by aquaculture regulators. This obviously needs to change, and the concept of ecosystem services (from the North American model) might help us achieve that. Some of the salmon production in the future will evolve in new directions, towards land-based and enclosed systems, as well as towards large complex structures far out in open sea, with a minimum of pathogens to interact with.

Feed

Fishmeal and fish oil replacements are themselves currently being replaced as they are often challenging for fish health, unless refined to get rid of anti-nutrients etc. Thus, more than before, fish welfare has become an economic question. Very exciting work is currently taking place in the blue growth sector, launching micro- and macro-algae as the solution to predicted increased global nutritional demand. On the horizon, the same approach to nutrition that we see in the programmed nutrition and growth in chickens can be envisaged, but presently there are too many confounding factors obscuring nutritional studies.

Eco-intensification

Minimising environmental impact and increasing resource utilisation will give highest yield. Much research effort is currently being channelled in this direction, and concepts like IMTA and aquaponics

holds promise to achieve this. However, as we get more experienced, it becomes more of an engineering problem than anything else; how can we confine the excess nutrients from fed aquaculture long enough for the secondary products to absorb a significant amount?

Breeding

Breeding programs for salmon seem to be at the forefront of development. However, for any other species we do not see anything similar. If there is one obvious task for the national government, that would be to own and control the long term goals for a breeding program – this type of long term investment is nearly impossible to shoulder for an emerging industry.

Biomass control

For such a large industry, surprisingly little development is done in the area of biomass control, partly because the submerged 3D farming environment is very different from other meat production. However, to know the density, size and variation in stock is a prerequisite for all production planning and control.

Mandate

As an industry, we need a clear direction to go in, and a reason why. The future demand for aquaculture products is greater than our current local business models would allow. Yet, when there is a problem or a public opinion, the government does not express 'us and we', but 'they and them' and point fingers at the farmers. Unfortunately, the industry's spokespersons are generally not very convincing in the newsrooms. Their biggest sin is to accept the premises of these debates: European aquaculture products have many challenges and seek better performance, but compared with other meat production, we are not doing badly at all. Much of the perceived difference between aquaculture and agriculture is that aqua farmers are in the public focus, with camera teams regularly reporting from inside production and harvest facilities. When did we last see something similar from other meat production? Although this can be seen as unfair now, but this level of transparency will provide a strong competitive advantage for the aquaculture industry before long.

11.4 Salmon aquaculture in Canada

Jon Grant

Overview

Canada has a vast coastline on three oceans, much of it sparsely populated. Most coastal waters are pristine and ideal for aquaculture. Moreover, there is direct transportation access to the US market to the south, the destination of 60% of Canadian production. The primary culture species is Atlantic salmon (*Salmo salar*) with recent national production figures (2015) in the range of 122,000 tonnes. Salmon production comprises the largest value of the aquaculture industry in Canada, with mussels and oysters forming the second highest value crops (Figure 35). As indicated, British Columbia dominates salmon production, with about three times the tonnage of eastern Canada. Total Canadian salmon production is 4th globally. Mussels are especially significant due to Prince Edward Island's production. Trout farming occurs in freshwater in Ontario and Quebec.

The bulk of Canadian aquaculture occurs in British Columbia, with New Brunswick second, both dominated by Atlantic salmon (Figure 34). Prince Edward Island situated in the Gulf of St. Lawrence, is the largest shellfish producer in North America via blue mussel farming. British Columbia dominates the volume of Canadian oyster culture, but the larger size and slightly reduced price of Pacific oysters (sold by count) allows Prince Edward Island to have comparable production value. New Brunswick has substantial oyster production, also in the Gulf.

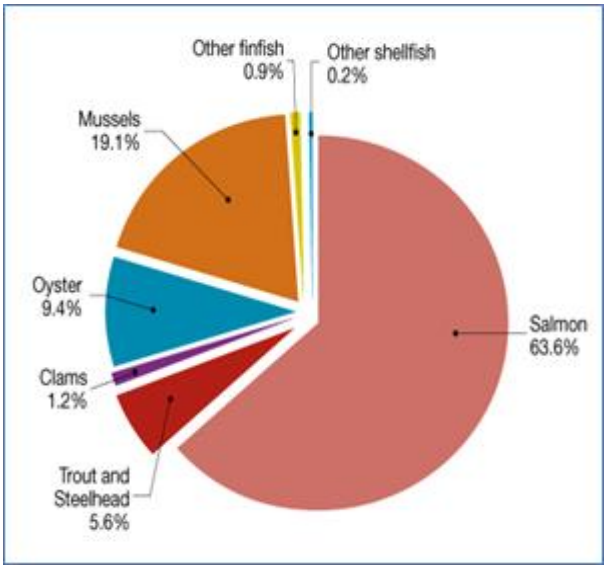


Figure 35: Proportionate tonnage of Canadian aquaculture production by species (2014). More recent production estimates (2015) total 187,000 tonnes nationally. Source: http://www.dfo-mpo.gc.ca/aquaculture/collaboration/ccfam-eng.html

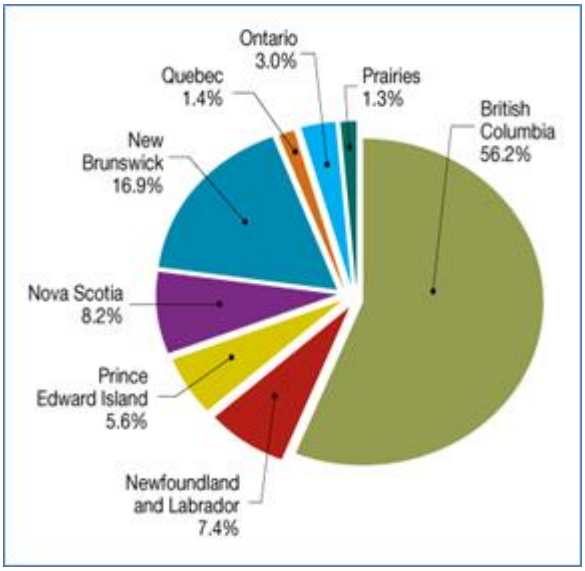


Figure 34: Aquaculture production by Canadian province (2014). Source: http://www.dfo-mpo.gc.ca/aquaculture/collaboration/ccfam-eng.html.

Fish farming in Nova Scotia

In Nova Scotia, fish farming is concentrated in the southwest part of the province, known locally as Sou'West Nova, and curving around into the Bay of Fundy (Figure 36). The easternmost part of the province (Cape Breton) has mostly steelhead farming. The northern waters of the province (Gulf of St. Lawrence) have unsuitable water temperatures for salmonids. Nova Scotia has numerous coastal bays, with rocky or sedimentary shores, and typical water depths of 20m. Salmon farming follows a typical cycle of hatchery smolt production (~1 year) and marine growout (~2 years) in either polar circle pens or rectangular cages. There is risk of superchill in winter, but harvest timing has been adjusted to avoid the coldest temperatures of January. A system of environmental monitoring is mandated by the NS Department of Fisheries and Aquaculture, with an emphasis on benthic variables such as sulphide, and a corresponding rating system. The regulatory system has been overhauled through new provincial legislation, and there is hope that the end of a multi-year moratorium will signal a new chapter in aquaculture development.

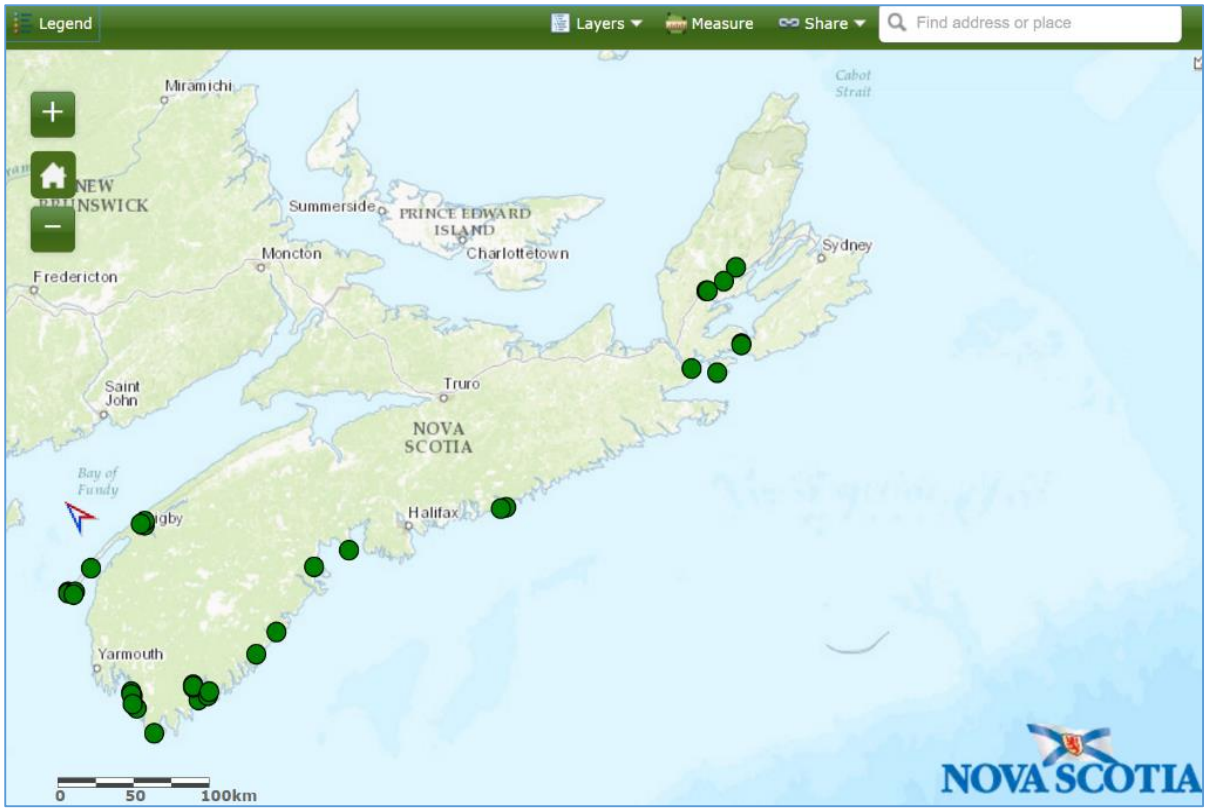


Figure 36: Site map of finfish farms in Nova Scotia. Not all sites are active. Source: http://novascotia.ca/fish/aquaculture/site-mapping-tool/.

Cooke Aquaculture is the primary producer in Nova Scotia, culturing only Atlantic salmon. They are largest salmon farming company in North America with fish farms in New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland, USA (Maine and Washington), Chile, Spain and Scotland. Recent acquisitions by the Cooke family have further expanded the company into wild fisheries including Wanchese Fish Company and Icicle Seafoods, Inc. in the USA, and Fripur in Uruguay. They annually harvest, process and sell over 275,000 metric tonnes of seafood domestically and abroad, with yearly sales exceeding $1.8 billion. Cooke is a vertically integrated business with subsidiaries in salmon farming, shellfish farming, seafood wholesale and retail, wild fisheries, transportation, cage and net manufacture, feed production, and hatcheries. Cooke is fully integrated into the research community, with an emphasis on sustainable production at the ecosystem level. They are partners in *AquaSpace* via the Liverpool NS case study, and sponsor Jon Grant's research as the NSERC-Cooke Industrial Research Chair in Sustainable Aquaculture.

Impediments to development

Industry organisations such as the Canadian Aquaculture Industry Alliance see a favourable prognosis for Canadian aquaculture development, despite rather flat recent trends in national production. This is not an issue of physical capacity or resources; many sections of both Atlantic and Pacific coasts are sparsely populated, with pristine waters, wharves, skilled mariners, and a need for employment in coastal communities. Unfortunately, there are serious impediments to aquaculture development. There is deep public opposition to fish farming, especially on the West Coast. Multiple species of wild salmon are abundant in British Columbia, including valuable commercial fisheries. Disease links (e.g. sea lice) between farmed Atlantic salmon and Pacific salmon species have been made, with wild fish being many more times abundant. There is debate about whether fish farms negatively affect wild salmon populations (Marty et al. 2010). In eastern Canada, wild Atlantic salmon in some watersheds are endangered, and there is concern that fish farms are making the situation worse through disease

and genetic introgression by escapees. However, there is insufficient attention paid to historical overfishing, present day fisheries in Greenland for migratory Canadian fish, mortality from recreational angling, poaching, and stream habitat degradation. With this host of huge threats to wild Atlantic salmon, aquaculture does not seem to be a primary detriment. Another perception among the aquaculture opposition groups regarding faecal/food waste is that coastal ecosystems are 'ruined'. The concept of near-field and far-field benthic impacts is poorly understood by the public.

Alleviation of opposition will occur through research which documents the magnitude of perceived environmental threats, and provides management solutions. For example, aquaculture management areas, also called bay management areas are seen as an important tool in the zonal management of disease (Jones and Beamish, 2011), and research programs at the Atlantic Veterinary College (UPEI) and Dalhousie University seek to further apply this approach on both coasts. A new and large federally funded research initiative based at Dalhousie (Ocean Frontier Institute) seeks to address many of the impediments to aquaculture development ranging from salmon genomics to social licence in coastal communities.

Regulation of Canadian aquaculture occurs via both provincial and federal governments, in often complex arrangements for each province. There is however, extensive research capability and regulatory experience at both levels. Public opposition to aquaculture feeds into caution among regulators to pursue aquaculture development. A national Aquaculture Act is in the initial stages of development and is viewed as an important step in progress of the Canadian industry.

11.5 Mussel aquaculture in Northern Ireland

Heather Moore and Adele Boyd

Overview

At present the blue mussel (*Mytilus edulis*) is the main shellfish species cultivated within Northern Ireland. Approximately 50 – 75% of the total Northern Ireland mussel production occurs on sites licensed for bottom culture within Belfast Lough. Bottom cultivation of mussels began in Belfast Lough in 1989. Seed mussel is dredged from wild seed beds around the coast of Ireland and then relayed on licensed aquaculture sites within the Lough.

Belfast Lough is a shallow semi-enclosed marine bay at the mouth of the River Lagan, on the eastern coast of Northern Ireland with the city of Belfast at its head (Figure 1). Belfast Harbour is Northern Ireland's main port, with around 70% of Northern Ireland's and 20% of the entire island's seaborne trade handled by the Harbour each year (https://www.belfast-harbour.co.uk/port). Belfast Lough is approximately 130 km^2 in size and has a catchment of around 900 km^2. The inner lough is made up of a series of mudflats and lagoons while the outer lough comprises mainly rocky shores with some small sandy bays. Approximately 70% of the population of Northern Ireland lives within the Belfast Lough catchment. In the past nutrient inputs to the Lough have been of concern, with high levels of nutrients leading to eutrophication in the inner Lough.

There are currently twenty-one licensed subtidal aquaculture sites for the bottom culture of blue mussels within Belfast Lough (Figure 37). The total area of Belfast Lough occupied by aquaculture is approximately 1,270 hectares.

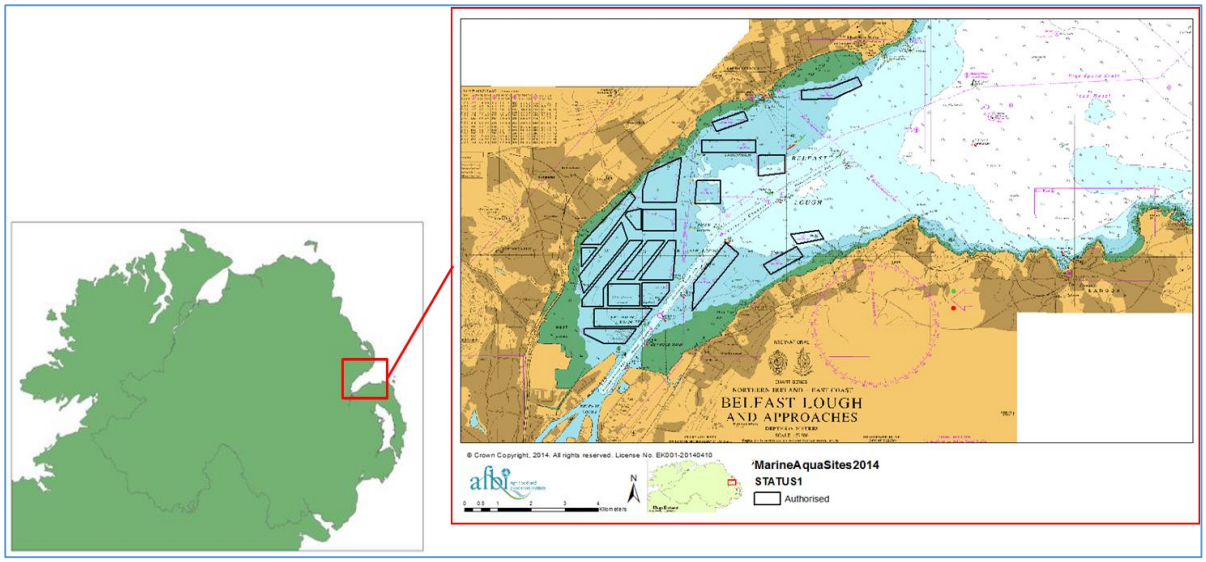


Figure 37: Map showing the location of Belfast Lough within Northern Ireland and the location of licensed aquaculture sites within Belfast Lough.

Challenges to expansion

Further expansion of the mussel industry within Belfast Lough is limited by several factors, some of which are outlined below.

Conflicts with Nature Conservation Designations

Belfast Lough has been designated under the European Council Directive 2009/147/EC on the Conservation of wild birds (often referred to as the Birds Directive) as a SPA for overwintering (non-breeding) Redshank (the Belfast Lough SPA) and for overwintering (non-breeding) Great Crested Grebe (the Belfast Lough Open Water SPA). The boundaries of these designated sites are shown in Figure 38, and all currently licensed aquaculture sites within Belfast Lough are within the boundary of one of the designated SPAs. Any applications for new aquaculture sites within this area will be subject to assessment under the Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995, known as a Habitat Regulations Assessment (HRA). This is then followed by a consultation period. Therefore, before a new aquaculture site within or adjacent to a SPA can be licensed it must first be demonstrated (by means of the HRA report) that this site will not impact upon the conservation objectives of the designated site in question. If this cannot be demonstrated then the licensing department (the Department of Agriculture, Environment and Rural Affairs - DAERA) cannot grant an aquaculture licence. It can therefore take many months/years from the date of application until new aquaculture licences are granted.

The impacts of currently licensed aquaculture sites within Belfast Lough on the designated features of the Belfast Lough SPA (Redshank) and the Belfast Lough Open water SPA (Great Crested grebe) in terms of; human presence within their preferred habitats and damage/disturbance to bird feeding areas were investigated by AFBI in 2014 (AFBI, 2014).

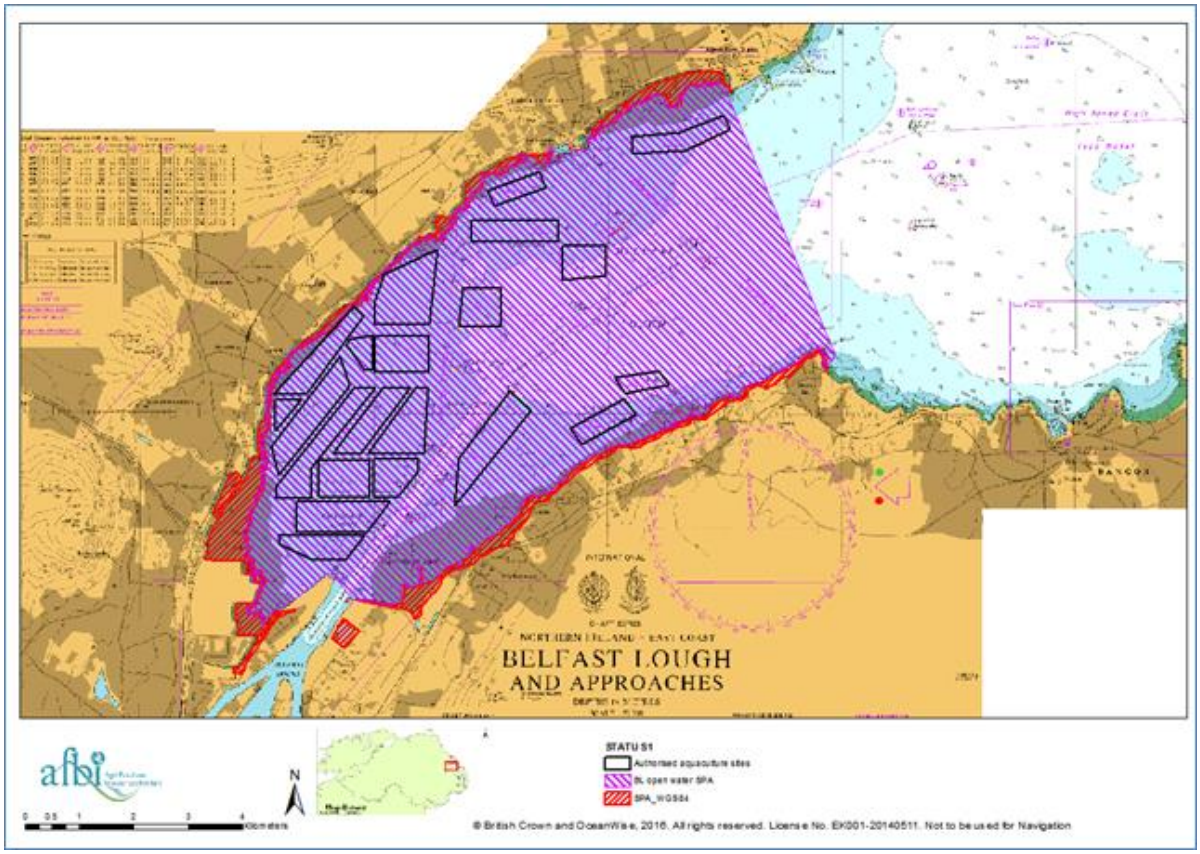


Figure 38: Map showing the location of licensed aquaculture sites within Belfast Lough (Black outlined areas on the map) in relation to the boundary of the Belfast Lough SPA (red hashed area on the map) and the Belfast Lough Open Water SPA (purple hashed area on the map).

Availability and sustainability of seed mussels

Seed mussel for the bottom culture industry is sourced from naturally occurring mussel seed beds, located within the UK and Ireland. Imports of mussel seed from outside Northern Ireland must be accompanied by a health permit to show they have been sourced from areas free from non-native species. Variable recruitment to traditional seed beds has been a limiting factor to the expansion of bottom mussel culture. Climate and predation also affects the amount of seed available for the industry, with winter storms washing away unstable seed beds and starfish feeding fronts decimating this valuable resource (Figure 39). The years of low seed availability are reflected in the Northern Irish mussel production tonnages reported to DAERA which show a decline in recent years (Figure 40).

This has promoted research into alternative sources of seed mussel for the Northern Irish mussel industry. Collaborative work between AFBI and the mussel producers to investigate the use of spat collectors within Belfast Lough to collect mussel spat for on-growing on licensed aquaculture sites was undertaken during 2015 and 2016.

Figure 39: Photos taken from AFBI camera survey in June 2016 of seed mussel beds in the Irish Sea showing a starfish feeding front moving over the bed.

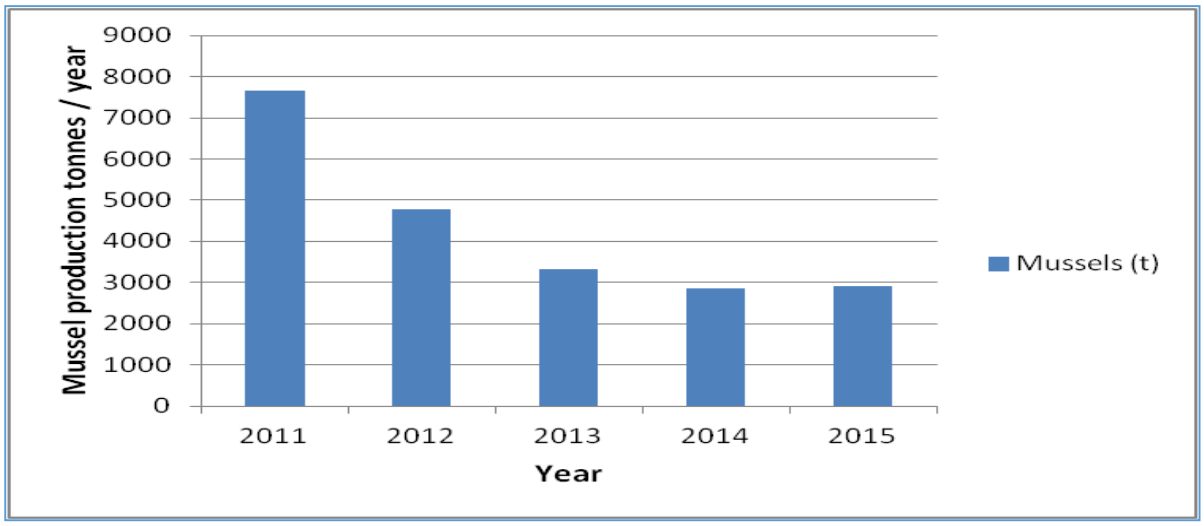


Figure 40: Northern Ireland mussel production (in tonnes per year) for the years 2011 to 2015, as reported to the Department of Agriculture, Environment and Rural Affairs (DAERA).

Sanitary and Environmental Issues

There are nine major sewage treatment works discharging into Belfast Lough (including four over 20,000 PE). This can add nutrients to the Lough and increase the potential for pollution events if the sewage system is overloaded during storm conditions. *E. coli* concentrations are monitored routinely in mussel flesh from a number of representative monitoring points to safeguard human health. Aquaculture sites receive a classification from the Food Standards Agency depending on the level of *E. coli* detected within the shellfish flesh. This classification determines whether the shellfish can be sold directly for human consumption or whether any treatment (depuration, cooking etc.) is required. The classification of shellfish beds may therefore be another limiting factor for expansion of the industry. In 2013 the EU Shellfish Waters Directive was subsumed by the WFD, and as protected areas are now part of the River Basin Management Plan review process under 6 year cycles: 2015 then 2021-2027, mandatory standards for water quality have been superseded by WFD parameters for Good Ecological Health. This results in Regulatory Agencies considering the cost benefit of the necessary sewage treatment options.

Physical constraints on space

Physical space has also become a limiting factor to expansion. Belfast Lough is a busy port, routine dredging of the navigation channel is closely monitored to control potential impacts of sediment movement onto the mussel beds (smothering and potential re suspension of historical contaminants, both chemical and biological). The area near the navigation channel is not suitable for shellfish aquaculture, as heavy shipping activity can have negative effects on mussel growth. Expansion of the port facilities can also affect suitable areas for aquaculture production.

Carrying Capacity

Food availability and Carrying Capacity within Belfast Lough is investigated using the Sustainable Mariculture in northern Irish Lough ecosystems (SMILE) model. Model scenarios are run to look at how any changes to aquaculture activity in Belfast Lough will affect the mussel harvests (for stocking density) and the phytoplankton biomass (for food availability). The SMILE model is currently utilised by AFBI on behalf of local government departments to determine the ecological carrying capacity, the production carrying capacity and the cumulative impact of aquaculture activities within the Sea Loughs for which it was developed (namely, Carlingford Lough, Strangford Lough, Belfast Lough, Larne Lough and Lough Foyle).

The constraints outlined above are not unique to Belfast Lough and reflect the situation within other Northern Irish Sea Loughs.

11.6 Offshore mussel aquaculture in Portugal

John Icely & Bruno Fragoso

Overview

In Portugal, the Mediterranean mussel (*Mytilus galloprovincialis*) has traditionally been harvested from the shoreline by free diving, and is usually associated with Easter celebrations, coincident with summer solstice time when big tides facilitate the harvesting of seafood at low tide. With regard to aquaculture, the relatively low market prices 0.5 – 0.7 euros per Kg, has not encouraged aquaculture production of mussel (INE/DGPA, 2016). Nonetheless, in recent years this situation has begun to change as aquaculture has become art of the National Strategic Plan for the fishing sector, particularly, as Portugal has the highest seafood consumption per capita at European level and the third at global level (56kg/habitant/year). Thus, national production of fish and shellfish is insufficient for current levels of consumption in Portugal and an increase of aquaculture production would make a valuable contribution to reducing this deficit (Ministério da Agricultura, 2012). At present aquaculture production in Portugal is still modest and representing only 5.5% of the total fisheries production. The left pane of Figure 1 shows that molluscs in 2014 represented 45% of total aquaculture production, with clams dominating production at 2251 tons followed by mussels with 1547 tons (INE/DGPA, 2016). The right window in Figure 41 shows that aquaculture production in Portugal has been relatively stable over recent years at around 7.500 tons with, for the first time in 2012, an increase in production to 10.000 tons.

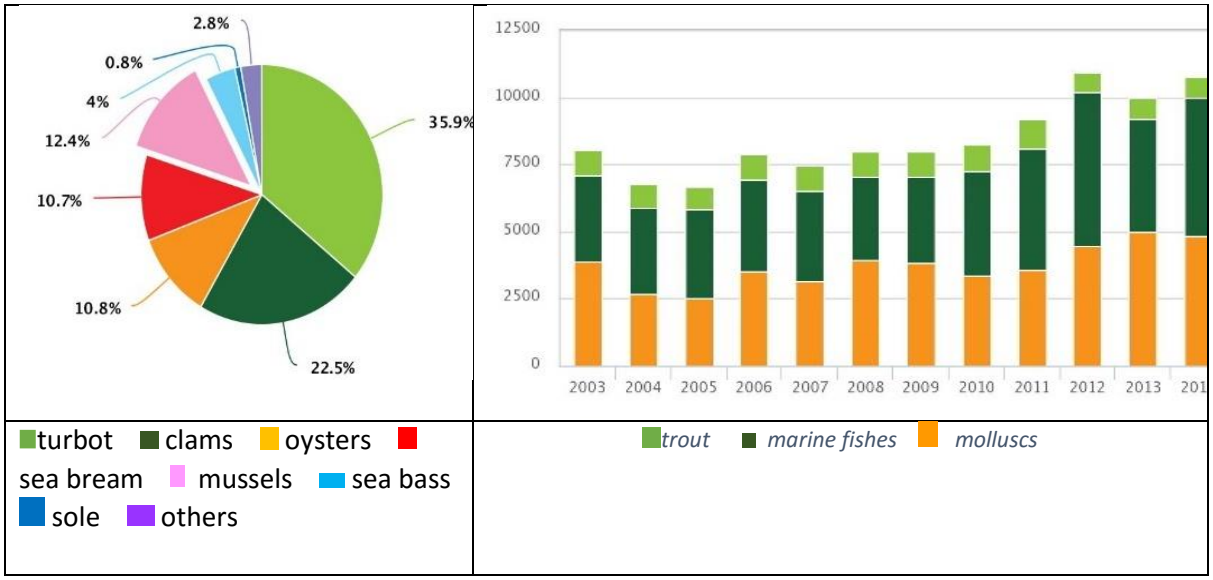


Figure 41: Aquaculture production in 2014 of main species cultured (Left) and production in tonnes, of dominant species of fish and shellfish (right). Adapted from https://rea.apambiente.pt/node/132.

Recently, Mediterranean mussel has become of increasing interest for aquaculture in Portugal, due to the priority to expand aquaculture to offshore. Although the price per kg is not high, mussel has many advantages: it is an endemic species which is well adapted to the local environment; seed can be collected naturally from this environment with suspended ropes as collectors; and it grows relatively fast with limited handling. Indeed, the Algarve region of Portugal (Figure 42) has the ideal environmental conditions for mussel and, thereby, its potential contribution to the development of offshore aquaculture (Ministério da Agricultura e do Mar, 2014). In recent years, offshore farms have been established at Sagres, Lagos and Olhão along the Algarve coast (Figure 42). Additionally, the government has allocated more areas with potential for aquaculture purposes, that are focused on the production of bivalves (hatched blue area in Figure 42). This effort by the Portuguese government to establish areas through Marine Spatial Planning should reduce the licensing time in these areas with prioritized concessions for offshore aquaculture. Figure 42 is an example from the official Portuguese government aquaculture geoportal for identifying to potential investors the location of the sites available for establishing aquaculture along this coast.

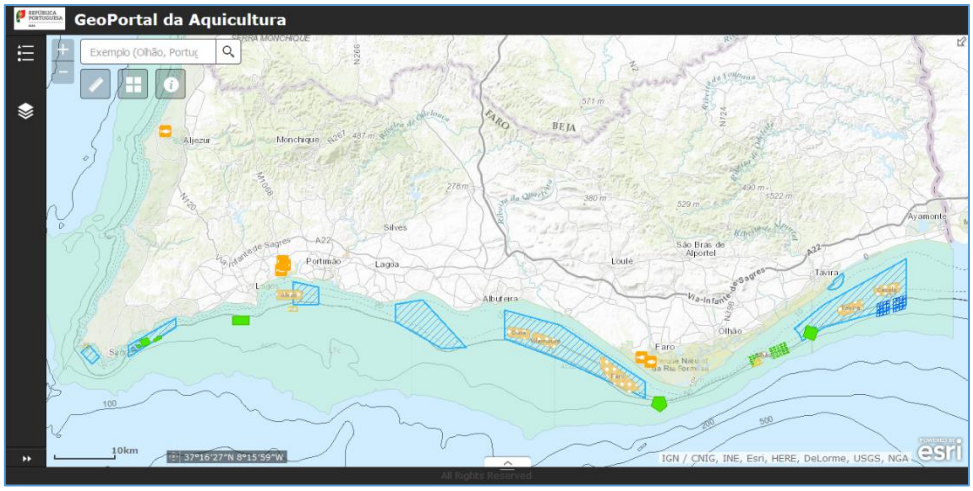


Figure 42: Map of the Algarve region showing the current aquaculture sites (green and orange) and areas with potential for development (blue boxes) (source: http://eaquicultura.pt).

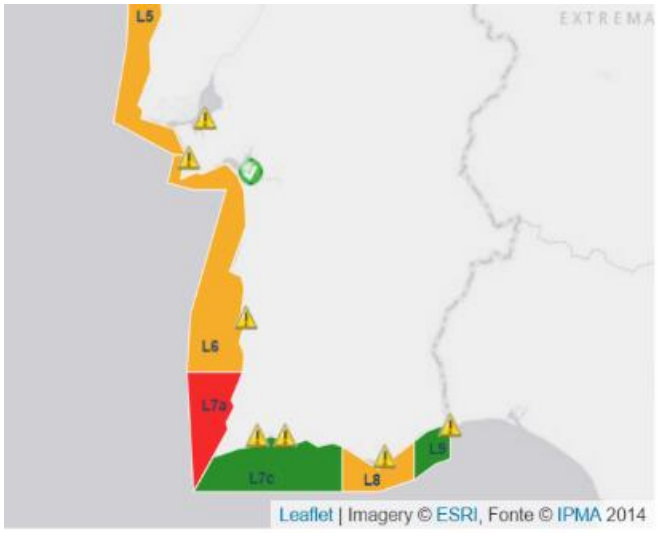
Challenges to expansion

Despite the clear priority that has been granted by the Portuguese government to aquaculture there are still many challenges, with some listed below:

- Excessive bureaucracy as illustrated in Figure 43;
- Temporal and spatial problems related to monitoring of toxic algae. IPMA (Portuguese Institute of the Sea and the Atmosphere), the official agency responsible for monitoring toxic algae, produce regular images for the entire coast of Portugal showing which coastal regions are affected. This is an essential activity for public health and for the credibility of the industry. Nonetheless, there are criticisms: one, the spatial range of the monitoring zones are considered too large (Figure 44) because any toxins identified in any part of a specific zone will ensure closure throughout the zone, even if samples from another section of the same zone are clear of toxins; two, response time of decisions related to specific samples can cause problems for the industry, both from a delay to close a zone when the industry might be selling product with toxins, and from a delay to reopen a zone producing losses for the industry with delays to when they can reinstate their sales.
- Difficulties with coping with sanitary and environmental monitoring as the rules keep changing;
- Low return on investment;
- Lack of financial instruments and insurance.

Figure 43: An image of 12 licences out of 42 currently held by Finisterra Lda at Sagres.

Even without the potential alterations from climate change, the oceanographic conditions along the Algarve coast can change markedly from year which provides a substantial challenge to managing these offshore concessions to produce suitable product for the market. For example, in 2014, the area was dominated by high productivity but extensive closures due to toxins, while, in contrast, 2016 was dominated by higher temperature waters with lower productivity so that the condition index of the mussels was often poor. In both these situations businesses were unable to satisfy their clients requirements.



	Harvesting of all bivalves allowed along coast
	Harvesting of only some species allowed along the coast
	Harvesting of all bivalves banned along coast
	Harvesting of all bivalves allowed in estuaries/lagoons.
	Harvesting of only some species allowed in estuaries/lagoons
	Harvesting of all bivalves banned in estuaries/lagoons

Figure 44: An example of the IPMA maps that are produced weekly[59] show which zones along the coast are subject to official closure orders because of phytoplankton toxins. Note that the specific zones extend for several kilometres.

11.7 Offshore mussel aquaculture in England

John Holmyard

Overview

Offshore Shellfish Limited is the largest offshore mussel farming company in England, with concessions to produce up to 10,000 metric tonnes per annum in Lyme Bay, Dorset (Figure 45). Severe obstacles constrain the development of offshore shellfish cultivation in the United Kingdom. The financing process for commercial-scale aquaculture requires comprehensive due diligence. Aquaculture activities carry risk, resulting from environmental, market, and social factors, that impact the real and perceived financial risk. Distinguishing between the real and perceived risk is challenging for economic actors with no previous aquaculture related experience. Traditional (banking) and alternative (private equity, angel investors) financing sectors, show reluctance in financing the learning curve of operations, making the development opportunities for aquaculture challenging.

Figure 45 - Offshore Shellfish Limited longline and mussels (Courtesy of Offshore Shellfish Ltd)

[59] https://www.ipma.pt/pt/pescas/bivalves/index.jsp on the *22-09-2016*)

Permitting and licensing

The first administrative stage of kick-starting aquaculture ventures requires applying for licences that are required by law. The lack of certainty in applications provides severe disincentives to investment, as length and uncertainty in the duration, and outcome of licensing processes, increases the risk perception of the aquaculture industry. Offshore shellfish limited are familiar with the difficulties involved in starting large-scale commercial areas, identifying numerous risks factors including permitting and licensing, planning and regulations, technology, environmental impact, water quality, financing, and logistics.

The application process must be clear to prospective applicants. Application guidance information must inform stakeholders about the procedural steps, the expected licensing timeframes, and the application costs. The assessment criteria must be transparent, rational, and relevant to the proposed culture methods and species selection. Recognition that aquaculture is executed using an array rearing techniques and species, each with varying benefits and impacts, requires specialised and informed knowledge for application appraisal.

Applicants should be expected to provide to information that is reasonable, relevant, and deliverable. Prospective applications should not be required to deliver evidence that is beyond the reasonable remit of an application, both in scope or cost, and should have a recourse to challenge specific components of the application processes in a reasonable forum. The jurisdiction of applications, and which institutions have jurisdiction over application processes needs harmonization, reducing the time and cost associated with applications. The uncertainty of the application process time is a major disincentive, as this knowledge can be factored into a decision on whether to make an application.

Licences

Aquaculture licences need to span a long-enough period to justify the capital expenditure of developing aquaculture. The tenures of licences need to provide economic and legal security, as well as commercial flexibility, such as the ability to sell, transfer or other provisions available to private sector operators. Generating profit usually requires risking capital to obtain a return on investment. The economic return for aquaculture operations is influenced by numerous variables, relating to husbandry, concessions sizes, financing environments to name a few, however licence tenure must provide enough time to maximise the incentive for economic actors to risk capital. The cost associated with running and maintaining the licences must be affordable to aquaculture stakeholders, and secure transferable tenure with rents that are predictable and related to known factors are vital for the process of raising finance.

Planning

Planners need to have a clear vision for aquaculture and its role is diversifying the rural economy and promoting long-term employment. The selection of viable zones for offshore shellfish cultivation must consider a range of interacting factors including, farming processes and technology, the physical and biological environment, industry economics and their variation with scale, and the possibility of future changes in all the above. Bridging the disconnect between planners, industry, and the scientific community is crucial to create aquaculture zones in suitable areas. Farmers have hands-on experience on the commercial realities of aquaculture, whereas civil servants and scientists often overlook crucial aspects of site selection. It is also a simple fact that a farmer is unlikely to voluntarily assist with site selection processes if it means they are providing competitive advantage to another farmer. Improved spatial planning that encompasses the triple bottom line, people, planet, profit, requires planners to be better trained and better informed.

Marine spatial conflict exists in Europe, and it needs to be recognised that, despite the current mantra, co-location is not always possible or desirable and it will sometimes be necessary for there to be development that is preferential and exclusive to one activity. The basis for strategic sectoral development needs to be transparent and challengeable. Commercial scale aquaculture is a recent activity in Western Europe, when compared to other sectors, and should be granted similar political stimulus as other activities with similar growth characteristics and positive economic and social benefits.

Regulations

Food standards, disease prevention and non-native species are surrounded by a raft of regulation that is often out of date, not fit for purpose and not based on realistic risk assessment. For improved development rates, it needs to be easier, quicker and more practical for regulations to be revisited and amended as and when necessary. The protection of human health via the shellfish water classification process and controls on harvesting requires informed risk assessment and is not proportionate. The lack of a consistent suite of tests that measure actual risks affects public perception and market acceptance of the product, to the extent that investment is choked.

The increasing occurrence of toxicity events affect continuity of supply and market acceptance. Improved monitoring of harmful algal blooms, and the management of these events, both in terms of food security and market information assist in ensuring that these risks are mitigated for production, market, and consumption purposes.

Bio-security protocols are important to minimise species risk factors. Movement restrictions on diseased shellfish and non-native species need to be enforced rigorously and a precautionary principle adopted. Periodic disease outbreaks have threatened all types of animal and crop production, ranging from terrestrial livestock to agricultural products, as well as aquaculture. A clear strategy to manage bio-security risks associated with live shellfish movements is crucial to mitigate risk.

Technology

Lack of innovation of better farming technology does not constrain sector development. Shellfish aquaculture could be accelerated through increased availability to published scientific investigations. The distance between farmers and the scientific community should be reduced, and dialogue promoted, to the extent that such a gap could be reduced through improved information exchange. Few farmers have access to the full range of information that is available to the science community. Improved open access publishing or better access to scientific libraries, such as the Horizon2020 open access portal assist improved knowledge exchange.

Environmental impact

The environmental impact produced by aquaculture, and decisions on what level of change is deemed acceptable needs to be framed on a proportionate, rational and transparent basis. Cutting edge techniques including spatial planning and carrying capacity (farm and system scale) are required to ensure that allowable admissible impacts are observed, and kept in proportion to other industries. The people tasked with making those decisions need to have an improved understanding of the relative dimension and impact of these issues. It should be recognised that what may be deemed acceptable or unacceptable at a certain point may change with time and national economic circumstances.

Quantification of the real impact of aquaculture is required on a standalone basis, but also in comparison to competing sectors such as agriculture, forestry, fishing, energy production or urban development to determine the admissible impact relative to other industries. In the specific situations of extractive shellfish culture, cultivation should be encouraged due to the bio-remediation of nutrient

pollution from land-based activities. Water quality impacts in offshore areas can be affected by activities on land. This includes waste water treatment, agricultural practices, drainage systems and perhaps even upland land management such as deforestation. Bivalve shellfish are closely associated with the water in which they are grown. The quality of the water is affected by a wide range of upstream activities and the "polluter pays" principle must be more rigorously applied. An example of this are nitrogen credit trading schemes that could provide additional revenue streams for nutrient abatement.

Finance

Offshore shellfish aquaculture has no recognised track record so there is no ability for financiers to conduct risk assessment and benchmark performance. Raising finance could be helped by availability of loan guarantee schemes and competitive aquaculture insurance cover to act as a guarantee. Improvement of risk-transfer mechanisms would provide additional comfort for financing entities. Strategic industries such as energy and agriculture have traditionally been supported by capital investment subsidy or guaranteed market support for the product. Aquaculture benefits from some similar support but it is often poorly targeted and limited.

Markets and logistics

Production from individual producers or from small geographic areas can be erratic due to weather, toxins, spawning, unusual growth patterns, etc. This leads to erratic production which in turn affects demand. Coordination of production and marketing across wide areas would improve continuity of supply and the quality of products presented to the consumer. Buyers often consider price, volume, and consistency of supply. The ability to address these three dimensions, would allow for a sustained improvement of market demand.

Production may be in areas poorly supported by storage, handling and transport facilities. Remote areas will be most affected by poor transport links while aquaculture in more heavily populated areas are affected by the cost of shore side infrastructure and the need to compete for space with well-established industries such as fishing and tourism.

11.8 Shellfish aquaculture in Washington State, USA

Bill Dewey

Overview

The state of Washington is the leading producer of farmed oysters, clams and mussels in the United States. The foundation of the success of the shellfish aquaculture industry stems back to laws passed shortly after Washington became a state in 1889. Today Washington shellfish growers use a variety of culture methods to produce approximately 10,000 tonnes of farmed shellfish annually valued at approximately 92 million USD.

Depletion of native oysters in the 1800s led to creation of oyster reserves and the passage of the Bush and Callow Acts by the state legislature in 1895. These laws were, passed in an attempt to stimulate the cultivation of native oysters, and allowed for the sale of barren tidelands from the state into private fee simple ownership, specifically for that purpose. If oystermen did anything else on those tidelands the ownership could revert back to the State. The ability to own the tidelands gave oyster growers an asset they could use to borrow money against to purchase seed from the oyster reserves and to make improvements to the land to increase production. The legislature's goal was achieved and a thriving shellfish aquaculture industry was born and has thrived for over 120 years. While tideland sales stopped in 1971, today approximately 19,000 hectares remain in private ownership deeded specifically for shellfish culture. In addition, waterfront property owners own the tidelands

adjacent to their upland property and this land is also used for shellfish aquaculture. Over 70% of the tidelands in the state of Washington are privately owned. Tideland ownership has motivated shellfish growers to be strong advocates for protecting environmental health and water quality. Long before the term "environmentalist" existed Washington's shellfish growers were suing pulp mills to clean up their effluent and advocating for better sewage, stormwater and agricultural runoff laws and regulations.

Public Health

The National Shellfish Sanitation Program (NSSP) is a highly regarded public health program in the United States for ensuring the food safety of cultured and wild harvest shellfish. Each shellfish producing state is required to adopt laws and regulations that meet NSSP requirements and are audited annually by the U.S. Food & Drug Administration to ensure compliance. All shellfish growing areas are monitored routinely for water quality including periodic sanitary surveys of shorelines to identify and correct potential pollution sources. The U.S. and European shellfish public health programs differ fundamentally in that the EU program relies on testing shellfish meats and the U.S. program relies on routine water quality testing in shellfish growing areas coupled with shoreline surveys. The state of Washington has a particularly robust program that is broadly supported by shellfish growers who share a common interest in protecting public health and selling shellfish that is safe to consume. Representatives of the Pacific Coast Shellfish Growers Association routinely serve on state advisory committees and testify at hearings regarding sewage disposal, storm and agricultural runoff. Shellfish growers in Washington have also forged strong relationships with ENGOs that share common goals.

Washington Farmed Shellfish Production (2013)

	Weight		Value	
Species	Tonnes	Percentage	USD	Percentage
Mussels	1,658	16	7,940,408	9
Geoduck clam	732	7	24,482,209	27
Manila clam	3,293	31	17,451,985	19
Pacific oyster	3,989	38	34,853,940	38
Softshell clam	644	6	454,198	<1
Other	302	3	6,738,647	7
Total	**10,618**	**100**	**91,921,390**	**100**

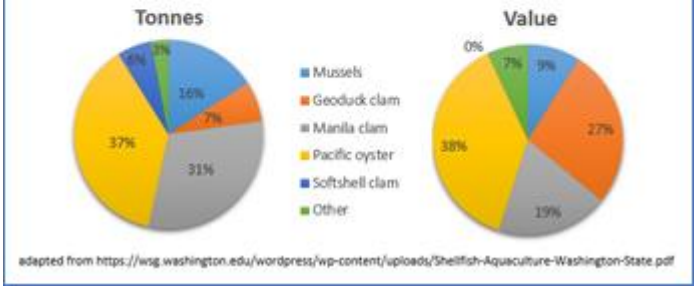


Figure 46: Production (tonnes) and value (USD) of aquaculture in Washington State, USA, in 2013).

Production Trends and Challenges to expansion

In 1921 a law was passed in Washington allowing the culture of species of shellfish other than the native oyster. Struggling with impacts of pollution from pulp mills on the delicate native oyster, *Ostrea lurida*, shellfish growers introduced *Crassostrea virginica*, the East Coast oyster followed by *Crassostrea gigas* and later *Crassostrea sikamea* from Japan. With the advent of shellfish hatcheries

in the 1970s and 80s Washington's shellfish industry began to diversify (

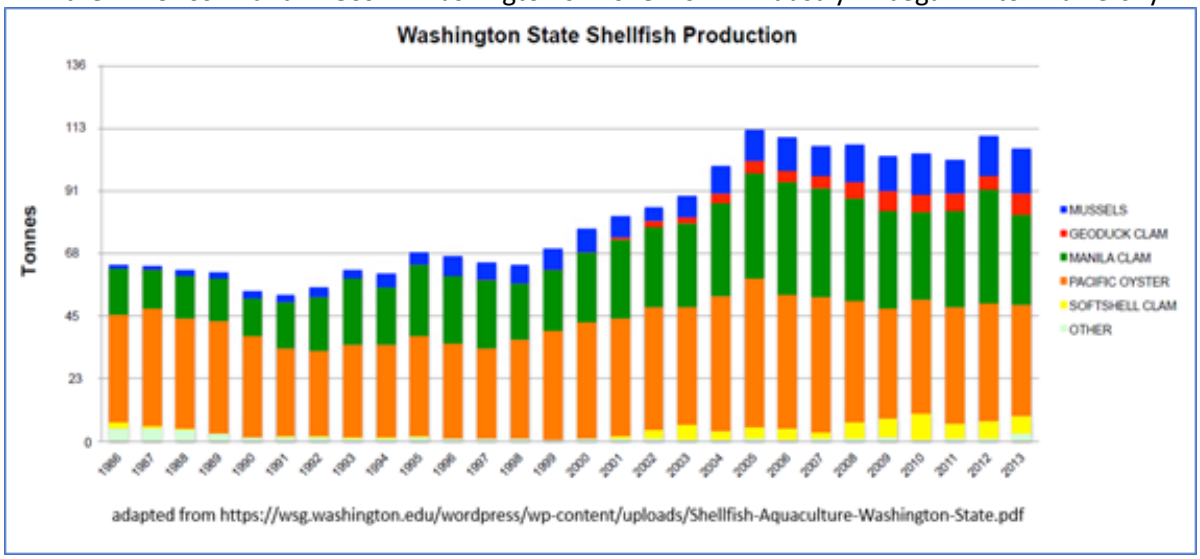


Figure 47).

Even before hatcheries, beginning in the 1960s shellfish growers began marketing Manila clams which naturalized in many areas following their introduction with Pacific oyster seed from Japan. Hatcheries evolved initially to secure a supply of oyster seed when seed became more difficult to acquire from Japan. Once the technology was established companies began producing Manila clam, then mussel and more recently geoduck seed. The relatively secure supply of seed from a few large privately operated hatcheries has fuelled a steady growth in the industry and fostered diversification. Diversification has stabilized growers against market fluctuations, disease, pollution and HAB closures. In addition, the hatcheries have allowed growers to develop breeding programs and the production of triploids which have enhanced yields and improved summer marketability of oysters.

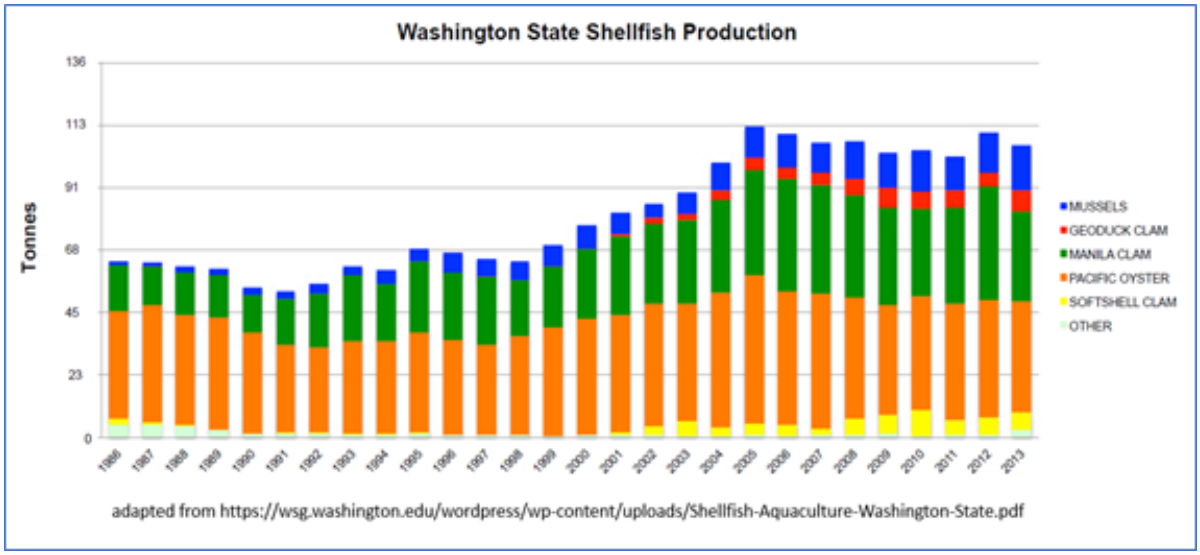


Figure 47: Changes in production of aquaculture species in Washington State, USA from 1996 to 2013.

Shoreline residential development in many of Washington's shellfish growing areas has increased dramatically in recent years. With it have come use conflicts and increased pressure on water quality. A consequence has been more regulatory scrutiny, laws, regulations for shellfish growers on their existing farms and extreme cost and delays in securing permits for new farms. Perhaps the most extreme example to date is a 20-year process and nearly $2 million USD expense that Taylor Shellfish

Farms incurred to get the necessary permits for a new mussel farm. More typically, a new geoduck farm for example of modest size (~ 4 hectares) might take 2-3 years and cost approximately $500,000 USD to secure the necessary permits for. The extreme costs, delays and uncertainty have limited the ability of new start-ups and driven consolidation as multigenerational companies opt to sell under regulatory duress. They have also forced companies to locate in other states or countries in order to grow and meet consumer demand.

In an effort to shift the paradigm and build support for the shellfish aquaculture sector, shellfish growers in the state of Washington worked with the NOAA and the Governor of Washington to launch a National and Washington State Shellfish Initiative. While these initiatives were broad, and include positive measures for water quality, research and shellfish resources, a fundamental purpose of them was to attempt to establish predictable, efficient permit processes for expanding existing and establishing new shellfish farms. Unfortunately for Washington shellfish growers, permitting is complex (Figure 48) with many layers including public health permitting, local shoreline development permitting, disease and animal health permits, federal permits to ensure compliance the Endangered Species Act, Clean Water Act, Marine Mammal Protection Act, Native American Treaty Rights etc. A Shellfish Interagency Permit Team has been established by Washington's Governor to attempt to streamline and bring efficiencies to the process.

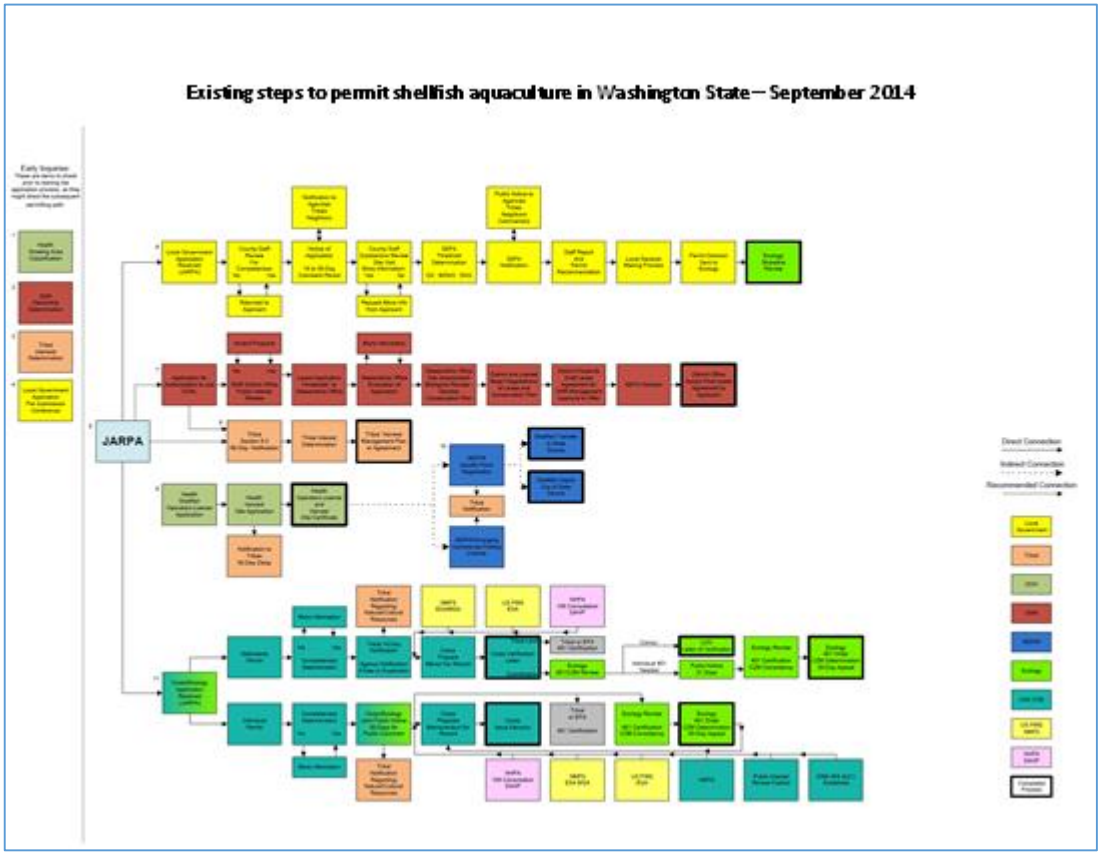


Figure 48: Permitting process for shellfish aquaculture in Washington State, USA.

A more recent and daunting challenge for Washington and other U.S. west coast shellfish growers has been the impact of ocean acidification on their oyster seed production. Upwelling on the U.S. west coast makes it a productive and excellent location for growing shellfish. It also puts them on the front lines for experiencing a significant reduction in carbonate ions, the building blocks of the shells of the animals they are farming. An outcome of the chemical reaction that takes place when carbon dioxide is added to seawater is the reduction of carbonate ions. It is estimated that carbonate ions in the

surface waters of the ocean have already been reduced by 16% since the beginning of the industrial era and the resulting anthropogenic carbon. Scientists predict carbonate ions will be reduced by 50% by the end of this century. Due to the nature of how carbon dioxide is absorbed and circulates in the Pacific Ocean, waters upwelling on Washington's coast are already at levels predicted for the end of the century now. As a consequence, two of the main U.S. west coast hatcheries were experiencing major losses of oyster larvae, resulting in a seed crisis from 2007 through 2009. As part of the Washington Shellfish Initiative an Ocean Acidification Blue Ribbon Panel was established by the Governor. Through implementation of the Panel's recommendations, the establishment of the Washington Ocean Acidification Center at the University of Washington, water quality monitoring and treatment in the hatchery, and considerable collaborative research, the shellfish industry has recovered their seed production and are working on ways to adapt to and mitigate the impacts of an acidifying ocean.

Aquaculture Case studies - Key Observations

- Pond farming plays an integral part in maintaining wetlands in eastern and central EU, but there are no specific plans for expansion of space used for pond aquaculture of carps and other species. Expansion will come from improved infrastructure and increased efficiency in production methods. Management of water, under the WFD is crucial in maintaining and improving carp production.
- Northern Italy is one of the largest producers of RAS and pond produced trout in the EU, but expansion is limited by excessive bureaucracy, small company size that limits investment potential and high costs of production. There is room for expansion and spatially there is need to identify appropriate areas, and sites, that have a ready supply of cold, high-quality water.
- Issues for salmon are linked across countries and include disease and escapes, which impacts public perception along with perceived negative environmental impacts.
- Development that will result in a changed use of space in salmon aquaculture in Norway include an increased use of land-based and enclosed systems, and future development of large complex structures offshore. The Norwegian system of spatial management is good but aquaculture is still seen as risky, and is not considered for its positive attributes like other (agri-) farming systems.
- In Canada, there is sufficient space for development, provided technical improvements, better understanding from both a research perspective and public understanding is improved. Spatial planning needs to account for scientific evidence and not public misconception.
- Shellfish production in Northern Ireland, in certain loughs is hampered by limited space due to the complex other uses (port, dredging) and complexity of operating in designated spaces, including special protected areas. There are also practical limitations including seed supply with which to seed mussel beds, although practical solutions are being sort. Classification of shellfish waters due to sanitary issues (*E. coli*) has been a problem and the transfer of monitoring under the WFD, from the Shellfish Directive has caused authorities to reconsider sewage treatment options and achievement of higher water quality standards in relation to the WFD.
- Similar issues apply in Portugal. Production occurs in more open waters and the move offshore adds to problems, in particular predicting and responding to toxic algal blooms, with failure to have an effective prediction period being a major impediment to growth. Inter-annual variation in weather, and therefore growth makes it difficult to meet customer demand. Portugal has a particularly tortuous licensing procedure, with 42 separate licences identified.
- Lack of consistency in permitting procedures and licence validity once approved are major constraints in England, along with a number of impediments that limit investment potential. The English shellfish farmer points to the need for an overall spatial planning policy, developed by policy makers, with appropriate recognition of the specific needs of shellfish producers, including better water and product testing procedures and more flexibility to respond when needed.
- Canadian shellfish producers have similar problems but point to improvement following collaborative work between research, industry and policy development. This has not so far reduced the licence application procedures, or reduced conflicts, particularly with coastal residents who object to farms, and impacts site availability.

12. Barriers, Gaps, Opportunities and Implications for the spatial development of aquaculture

This section briefly draws together the keys findings of this review report. For this purpose, it takes account of barriers, gaps, opportunities and ultimately the implications for the future spatial development of aquaculture in the EU. In this section a 'barrier' is taken to mean a factor that can impede the sustainable growth of the aquaculture sector and in most cases, has a direct regulatory implication. A 'gap', may have the same effect as a barrier, but it usually refers to situations where there is a lack of information or evidence. An opportunity is self-explanatory in the sense that it is where there is a prospect for sectoral growth. Barriers, gaps and opportunities all have pronounced implications for future growth of aquaculture in the EU.

It is clear from the review that a significant amount of effort has already been invested by the EC and Member State governments in developing a more strategic approach to aquaculture planning in their respective areas. Farmers and respective trade associations have also played a significant part, through cooperation and developing appropriate measures themselves to ensure best practices are implemented. A multitude of strategic aquaculture planning policies, strategies and targeted actions have been put forward to change the sector. Some of these have not always been defined in the context of aquaculture development, however, and Scotland provides an example of spatial planning, in which appropriate areas were established, but defined in the context of a disease outbreak, rather than an expansion of the sector. This was once again supported by industry and as companies consolidated this has often led to management within areas of sea space being controlled by one company. Growth in the salmon industry is also littered with examples where a reduced number of sites has resulted from a better understanding of the impacts of aquaculture on the environment, but production has grown because more appropriate sites have been found that have enabled an increase in the physical size of farms. The same cannot be said of other species, though improvements are being made, especially in northern and southern Europe.

What is clear from the analysis is a continued general weakness in implementation of the strategies and policies that have been developed. As attendees at the workshop on aquaculture spatial planning and the case studies (section 11) testify, gaining additional new sites, or increased production capacity is as difficult as it has always been; with complicated and inflexible licensing procedures and continued misconceptions in consumers about the efficacy of aquaculture production techniques, that contribute additional layers of difficulty in the broad-spectrum potential of spatial planning and development.

Application of an ecosystem approach and MSP are advocated as approaches which will deliver sustainable development. Their respective objectives are compatible, which bodes well in the application of both approaches to improving spatial planning for aquaculture, along with other users of aquatic space. Both the ecosystem approach and MSP have a strong legal basis in EU policy, which should facilitate growth though there are currently few, if any, examples where application of both has shown positive enhancement. Not least most of countries examined are only in the initial stages of designing their Maritime Spatial Plans and how these concepts are interpreted and translated into practice at site level are either difficult to establish or have yet to occur.

In the context of the EU, the ecosystem approach has a legal basis in both the MSFD and the CFP but nowhere in EU Directives is the concept explicitly defined, which could have implications for how it is, and if it is, implemented. At policy level the EU would do well to seek examples where the ecosystem approach has been applied successfully to see what lessons can be learned, and to further implementation cross the aquaculture sector within all Member States. FAO have been developing an

EAA for several years. EAA stems from the CCRF and is "as "*a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems*". More recently, FAO have been working to establish appropriate guidelines on spatial planning for aquaculture, that complement the EAA, incorporating steps that could achieve aquaculture zoning, site selection and area management, if implemented appropriately. In conjunction with FAO, and through the GFCM, some examples of such spatial management exist within the Mediterranean area, but implementation has been rather fragmented and done piecemeal, making the levels of implementation difficult to determine with certainty. Although well established, only the multi-annual strategic plan produced by Italy refers explicitly to the FAO's EAA and spatial planning approach.

What is clear, more broadly, is that zoning areas for aquaculture is the most applied spatial planning approach and hence experiences with this should be useful to other countries where implementation has yet to take place or remains a challenge.

In principle, MSP provides a step-by-step process that allows for the cooperative integration of the major marine uses and users within a defined marine area. These ordered procedures allow all stakeholders to work towards ensuring the long-term sustainability of identified marine activities. The principles of the ecosystem approach to both fisheries and aquaculture can readily be incorporated into the process. There are, nonetheless, many potential barriers surrounding the implementation of MSP in support of aquaculture development and growth. In the Directive, such potential barriers relate to how the concept is defined, its scale of application, and continued uncertainty about its interaction with other legislation and management approaches.

MSP, as defined in the Directive, applies from the baseline to the limits of national jurisdiction. It does not *per se* apply to coastal waters if they are managed through a Member State's land-based planning system, for example, which affects certain Member States. In others, coastal waters are not managed through land-planning and therefore MSP does apply from the coast. Differences of jurisdiction could lead to variable implementation of MSP. Given that more than three-quarters of aquaculture production in the EU occurs along the coast, there is the potential for MSP not to apply to aquaculture development at all. This will inevitably change as aquaculture moves further offshore, but even here there is a misconception about the definition of what constitutes inshore and offshore, when for aquaculture farmers' terms like exposed or not exposed are much more pertinent characteristics of an aquaculture area or site.

There are also potential issues with the scale of application of MSP, where the EU determine that it should be implemented on a regional level. From an aquaculture perspective, this may be too broad to be effective, and at present there is no clear appreciation of the relationship between regional implementation of MSP and zoning and area management under the EAA, for example. It means that MSP may be too far removed and distant from aquaculture, and more so at individual site level. There is hope, however, as evidenced by the recent publication of an FAO report (Meaden et al., 2016) which defines an approach to MSP within the middle-east Gulf region that offers the potential for MSP to be more flexible on varying scales of implementation.

What also remains important with the application of MSP, is the extent to which aquaculture can gain an equal voice among the many users of marine space. Given the review established that the spatial extent of aquaculture is less than 1000 ha covering 95% of all marine aquaculture production, it remains a relatively small, although growing, stakeholder in the marine environment, compared to shipping, energy, tourism and other uses. The case studies point to some of the difficulties aquaculture has in ensuring it has a voice, with one farmer concerned over aquaculture being seen as negative and

risky and "*when there is a problem or a public opinion, the government does not express 'us and we', but 'they and them' and point fingers at the farmers*". This points to potential issues around the extent to which aquaculture can initiate, develop, and implement spatial planning activity, rather than having it imposed upon them by more powerful and influential aquatic users, including regulator. There is, however, an opportunity to develop coordinated structures for MSP implementation. Given the status of implementation of MSP, it is too early to say if this will occur fluidly or through faltering starts. What is clear is that in the opportunity to implement a coordinated approach to MSP, and within that spatial management for aquaculture, it remains critical that the cumulative impacts of multiple use and having appropriate conflict resolution is done at an early stage during the plan development process and not at the implementation stage. This is the approach taken in England, for example, through their marine planning process. Debatably, the need for such measures is questionable given that MSP, as a participatory and integrated process, should address possible potential for conflict, and consider multiple use scenarios

The way in which MSP will be implemented at local level is critical. This applies not only to the plans *per se* but to the governance structures in place, how different sectors are involved in plan development and how stakeholders input to the process as well as to longer-term plan evaluation and amendment. The EC and Directive are quite clear in specifying that MSP will not set any new sectoral objectives. The fact that it is a framework Directive also means that member States have a large degree of discretion when it comes to implementing its provisions. Maritime Spatial Plans must "take account of" land-sea interactions and recognises other management approaches such as ICZM but without a mandatory obligation for Member States to implement ICZM, actual ICZM plans are rare. From the *AquaSpace* countries examined only Spain and Greece have specific ICZM plans, being Party to the Barcelona Convention and associated ICZM Protocol. The management of (aquaculture) activities in nearshore coastal waters will therefore tend to come under land-based planning systems only. Here the interrelationship between MSP and other EU legal instruments as well as national legislation will be a key determining factor in how successful MSP is at delivering growth of maritime economies, including aquaculture.

At present, given aquaculture mainly occurs on land in freshwater environments (lakes) or using river and borehole water; or within 1 nautical mile of the coast; aquaculture is more likely to be covered under the WFD, and application of river basin management plans, which may operate at a more appropriate scale suitable for site selection and area management of aquaculture activity. The shellfish case studies point to some of the difficulties at present, in supporting activities that improve water quality, in supporting shellfish aquaculture which supports ecosystem services (e.g. by removing nutrients), but having to comply with more stringent water quality requirements, since the Shellfish Directive was subsumed into the WFD, and where aquaculture is not seen as a priority activity, when trying to achieve good status. From a spatial planning perspective, the EU has no specific jurisdiction, which remains with Member States, but a framework like MSP might be developed for "inland" aquaculture. Spatial planning for integrated watershed and river and lake basin management needs to gain more importance.

Planning policies need to reflect the different types of aquaculture that are taking place. Whilst the national multi-annual strategic plans provide an important policy basis for sectoral development, they tend to focus on marine aquaculture primarily with little or none of the strategies having dedicated freshwater sections. Lessons could be learned from the Canadian situation, where there is a national/federal strategy but this is then advanced with strategic objectives and targets for different elements of aquaculture including the freshwater sector specifically. Arguably there is a need for this type of a nested approach in the EU also, with targeted actions for each form of aquaculture which can be applied at the appropriate level of governance i.e. national, regional and local depending on

national structures and responsibilities. This in turn would provide the sector with an opportunity to address the perception that the sector is stagnating. Freshwater aquaculture arguably suffers because of this. This review shows that freshwater aquaculture appears to be governed by national legislation more comprehensively than by the EU albeit certain EU legal instruments (e.g. EIA, WFD and the Birds and Habitats Directives), have specific implications for the sector in terms of achieving of GES. In Hungary for example, no aquaculture can take place within designated Natura 2000 sites, despite the fact that there is no fundamental reason why aquaculture cannot take place within designated sites. The Northern Irish case study shows that aquaculture is developing well within a SPA, for example.

This highlights one of the frustrations, in aquaculture not being seen for the positive benefits it can bring. In Hungary, as in other central EU countries, pond culture is adding to local diversity and in parts of Hungary ponds provide wetland habitat that would have otherwise been lost, rather than detracting from the reasons why areas were designated in the first place. Clearly there is a balance to be drawn between conservation legislation, environmental improvement and still improving aquaculture growth potential. The review highlights that none of the major freshwater producers in central and eastern EU Member States intend any form of increased spatial use for aquaculture, as it implements respective strategic plans to grow production. Although improvements in infrastructure and efficiencies in pond production, and perhaps a shift away from large pond systems towards RAS, are positive for increased aquaculture output, in themselves this may not lead to the level of increased aquaculture output that is needed, if the EU's high imports and low self-sufficiency rate, identified in the market assessment, is to be measurably improved.

Across Member States, and evidenced by the case studies and investigation of international examples, there is a need for a more strategic approach to freshwater aquaculture planning at central government level. Implementation challenges do persist in central Europe especially, due to the dominance of decentralised structures and functions that deal with aquaculture development. Differences in governance regimes, again, have pronounced impacts on the operation of the aquaculture sector with an obvious need to clarify rights and responsibilities of farmers in private and public waters, as one example. This can be advanced through the publication of guidance documents on the consenting process, a better understanding of spatial requirements and potential for spatial planning in a freshwater context, and framing it in the wider land-based planning and ecosystem-based context.

The EC Strategic Guidelines for the sustainable development of aquaculture (EC, 2013a) provide the basis for the multi-annual national strategic aquaculture plans. The guidelines state that the multi-annual plans shall guarantee "reasonable certainty for aquaculture operators in relation to access to waters and space". At present this is not translated into easier licensing procedures, or improved certainty over implementing industry growth or sectoral plans. Almost universally across the case studies, farmers and other practitioners point to continued difficulties in licensing procedures, which are complex and inflexible, and contribute significantly as an impediment for expansion; with Portugal's 43 licences required for a shellfish site being perhaps the most prosaic example. Perhaps unsurprisingly all the strategic plans examined identify the need to amend legislation governing aquaculture to make licensing processes more effective. Time will tell whether this is achieved.

Licensing is intimately interlinked to spatial planning, where farmers require more space, new sites and certainty in licensing periods, to achieve growth potential and improve potential for investment. It is noticeable that few of the Member States commit to increasing the amount of space allocated to aquaculture in any definitive way within the strategic plans. There are commitments to improved spatial planning, and development of a means to achieve this, but scant solid evidence of a commitment to more space. As has been identified, Member States where freshwater pond

aquaculture predominates, there are no plans. For marine fish and shellfish aquaculture, quite a number of the national plans focus on constraints but also identify opportunities for improvement, in mapping for example, which could be said to represent an initial step towards improved aquaculture zoning in the longer term. In this study, Section 8 defines how viewshed analysis might be used to overcome some of the issues, particularly those related to an improved public perception. This is vital, as in most northern EU Member States, and increasingly those in the Mediterranean, much of the lack of aquaculture development comes from public objection, often arising from misconceptions, particularly about far-field and near-field effects, and the impacts from aquaculture on the environment and on product quality.

Overall there is a need for improvement in the tools available to assess marine and freshwater environmental characteristics, and suitably for particular species in order to identify areas where aquaculture can thrive. Tools being developed with the *AquaSpace* project will go some way to filling this gap. These tools will complement other available tools such as GIS and the application of remote sensing, and other models that evaluate carrying capacity, towards an overall stock of tools that can also be applied in the sphere of spatial planning for aquaculture. It is self-evident that spatial planning fits within an overall consideration of the ecosystem approach to aquaculture, which in recent years has been a driving force in the development of better and more appropriate tools and models, to aid decision making. Gaps in knowledge remain, however, which can nonetheless be filled through cooperation between government, research and industry partnerships, including through EU research and EMFF funding.

One area that should be improved is additional guidance on the inter-relatedness of the MSP, WFD, MSP and other Directives. The EU has made a start with a 2016 publication on general guidance. What needs to develop are best practices and a clearer understanding of how each Directive inter-relates and what effect this has in relation to spatial planning for aquaculture and implementation of the Member State strategic plans. There is opportunity to assess progress in the 2017 mid-term review, which must also include progress and best practices on implementation of the commitment to improve spatial planning, outlined above. There is also opportunity to at EU level to work further with FAO, to source good examples of where spatial planning under the EAA has been undertaken, which might translate into this further guidance for the aquaculture industry. The case studies highlight the importance of working collectively and farmer's willingness to engage in developments that help them and the EU achieve its target growth of 2.7% per annum, to reduce the reliance in imported fish and aquatic products, to support increased production, provide employment and promote economic growth of the aquaculture sector; all key challenges.

Throughout the review process, coupled with work to date in Workpackage 6 on Effective Knowledge Exchange, the issue of public perception of aquaculture and its implications for spatial planning and future growth of the aquaculture sector has been highlighted. There is a definite need for positive sources of information on aquaculture and whilst the Commission has begun to address this through initiatives such as #FarmedInTheEU, at national level positive information sources are severely lacking. Growth of aquaculture not only delivers on food security but can also contribute to Good Environmental Status under the MSFD, for example, by reducing pressure on fish stocks. The impacts of aquaculture are not always negative but can also be synergistic. There needs to be means by which negative public perceptions of the sector do not persist.

In conclusion, it is clear from this review that all countries recognise the need for spatial planning as a key requirement for the future development of the sector. Almost all countries realise that this requires integration of aquaculture into maritime and land-based spatial plans, which should in turn facilitate forward planning. The critical factor is how spatial planning will be implemented, given there

are few examples of best practice globally. The Commission has already recognised that the ecosystem approach "*cannot and should not be implemented in a specific sector alone, but must be cross-sectoral*" hence there is still a definite need for more work on this at sectoral and sub-national levels. There have been significant strides taken in advancing the EAA in terms of policy through the EC's Strategic Guidelines and, to an extent, through the national multi-annual plans but the reality is that the implications for growth are, as yet, unknown. The conceptual basis of the ecosystem approach and its application through improved spatial planning; and for aquaculture development of zoning, site selection and area management strategies; must be capable of being translated into practical actions.

References

- AFBI. 2014. Cumulative Impact Assessment: Aquaculture activities within and adjacent to Natura 2000 designated sites in Belfast Lough. Report to the Department of Agriculture and Rural Development. pp 80
- Aguilar-Manjarrez, J., Soto, D. and Brummett, R. In press. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. A handbook. Report ACS18071. Rome, FAO, and World Bank Group, Washington, DC, USA. 62 pp. Includes a USB card containing the full document (393 pp.).
- Ahmed, M. 2006. Market Access and Trade Liberalisation in Fisheries, ICTSD Natural Resources, International Trade and Sustainable Development Series Issue Paper No. 4, International Centre for Trade and Sustainable Development, Geneva, Switzerland. 67pp. (available at http://www.ictsd.org/downloads/2010/02/market-access-and-tradre-liberalisation-in-fisheries.pdf).
- AKI. 2016. Report of fisheries and aquaculture production, 1995-2015. *Statistical reports, XXI: 1-91.* Budapest. (in Hungarian)
- Alexander, K.A., Janssen, R., Arciniegas, G., O'Higgins, T.G., Eikelboom, T. and Wilding, T.A. 2012. Interactive Marine Spatial Planning: Siting Tidal Energy Arrays around the Mull of Kintyre. PLoS ONE 7(1): e30031. doi:10.1371/journal.pone.0030031
- Anagnopoulos, N. 2016. Aquaculture Spatial Planning: The case of Greece. First Forum of the EU Strategy for the Adriatic and Ionian Region conference (parallel session on reconciling conflicting interests in a shared maritime space), 13 May 2016, Dubrovnik, Croatia. http://ec.europa.eu/regional_policy/sources/conferences/adriat_ionian/2016/doc/ps_4_anagnopoulos_ulos_greece.pdf
- Barbanti A., Campostrini P., Musco F., Sarretta A., Gissi E. (eds.). 2015a. Developing a Maritime Spatial Plan for the Adriatic-Ionian Region. CNR-ISMAR, Venice, Italy. http://adriplan.eu/index.php/news/334-adriplan-conclusions-and-recommendations
- Barbanti A., Campostrini P., Musco F., Sarretta A., Gissi E. (eds.). 2015b. ADRIPLAN Conclusions and Recommendations: A short manual for MSP implementation in the Adriatic-Ionian Region. CNR-ISMAR, Venice, Italy.
- Bardach, J.E., Ryther, J.H. and Mclarney, W.O. 1971. Aquaculture: the farming and husbandry of freshwater and marine organisms. John Wiley and Sons, London. 868pp.
- Becker-Weinberg, V. 2015. Portugal's legal regime on marine spatial planning and management of the national maritime space. Marine Policy, 61, 46-53. http://dx.doi.org/10.1016/j.marpol.2015.06.014
- Biró, S., Apáti, F., Szőllősi, L. and Szűcs, I. 2011. Economic context of irrigation development. In: Biró, S., Kapronczai, I., Szűcs, I. and Váradi, L. (eds.) 2011. Water use and irrigation development in Hungarian agriculture. Agrárgazdasági Kutató Intézet, Budapest, Hungary. pp. 45-74.
- BMVBS. 2009a. Spatial Plan for the German EEZ in the Baltic Sea - Text and Map sections. http://www.bsh.de/en/Marine_uses/Spatial_Planning_in_the_German_EEZ/documents2/Spatial_Plan_Baltic_Sea.pdf
- BMVBS. 2009b. Spatial Plan for the German EEZ in the North Sea - Text and Map sections. http://www.bsh.de/en/Marine_uses/Spatial_Planning_in_the_German_EEZ/documents2/Spatial_Plan_North_Sea.pdf
- Bundesministerium für Ernährung und Landwirtschaft (BMEL). 2014. Nationaler Strategieplan Aquakulturfür Deutschland. https://www.portal-

fischerei.de/fileadmin/redaktion/dokumente/fischerei/Bund/Nationaler_Strategieplan_Aquakultur_Deutschland.pdf

- Commonwealth of Massachusetts. 2015. 2015 Massachusetts Ocean Management Plan. Volume 1: Management and Administration. http://www.mass.gov/eea/waste-mgnt-recycling/coasts-and-oceans/mass-ocean-plan/2015-final-ocean-plan.html
- Corner, R.A. and Aguilar-Manjarrez, J. In press. Tools and Models for Aquaculture Zoning, Site Selection and Area Management. In J. Aguilar-Manjarrez, D. Soto & R. Brummett. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. A handbook, pp. 95–143. Report ACS18071. FAO, Rome and World Bank Group, Washington DC. 393pp.
- Da Silva, S.S. 2012. Aquaculture: a newly emergent food production sector, perspectives of its impacts on biodiversity and conservation. Biodiversity and Conservation, 21(12): 3187-3220.
- Defra. 2011. A description of the marine planning system for England. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/183195/110318-marine-planning-descript.pdf
- Defra. 2014. East Inshore and East Offshore Marine Plans. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/312496/east-plan.pdf
- Defra. 2015. United Kingdom multiannual national plan for the development of sustainable aquaculture. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/480928/sustainable-aquaculture-manp-uk-2015.pdf
- Department for Communities and Local Government. 2012. National Planning Policy Framework (UK). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf
- Department of Agriculture, Environment and Rural Affairs (DAERA). 2015. A Report by the Department of the Environment on the Marine Plan Process in Northern Ireland. https://www.daera-ni.gov.uk/sites/default/files/publications/doe/marine-report-plan-process-in-ni-oct-2015.pdf
- Department of Agriculture, Fisheries and Forestry. 2005. Best practice framework of regulatory arrangements for aquaculture in Australia. http://www.agriculture.gov.au/SiteCollectionDocuments/fisheries/aquaculture/best_practice_paper.pdf
- Department of Agriculture, Food and the Marine. 2015. National Strategic Plan for Sustainable Aquaculture Development. http://www.agriculture.gov.ie/seafood/marineagenciesprogrammesdivision/aquaculturepolicy/nationalstrategicplanforsustainableaquaculturedevelopment/
- Department of Economic Development, Jobs, Transport and Resources. 2016. Victorian Aquaculture Strategy 2016-2021 Final Draft 1 for Comment: Working Paper Only 11 July 2016. http://agriculture.vic.gov.au/__data/assets/pdf_file/0010/321787/Victorian-Aquaculture-Strategy-for-consultation.pdf
- Department of Fisheries and Oceans (DFO). 2010a. National Aquaculture Strategic Action Plan Initiative (NASAPI) 2011-2015: an initiative of the Canadian Council of Fisheries & Aquaculture Ministers (CCFAM): overarching document. Canadian Council of Fisheries and Aquaculture Ministers; Canada and Dept. of Fisheries and Oceans, Ottawa, Canada. http://waves-vagues.dfo-mpo.gc.ca/Library/343981.pdf
- Department of Fisheries and Oceans (DFO). 2010b. National Aquaculture Strategic Action Plan Initiative (NASAPI) 2011-2015: an initiative of the Canadian Council of Fisheries & Aquaculture

Ministers (CCFAM): Freshwater Sector Strategic Action Plan. Canadian Council of Fisheries and Aquaculture Ministers; Canada and Dept. of Fisheries and Oceans, Ottawa, Canada. http://www.dfo-mpo.gc.ca/aquaculture/lib-bib/nasapi-inpasa/freshwater-eauxdouces-eng.pdf

- Department of Housing, Planning, Community and Local Government (DHPCLG). 2016. Overview of Consultation on Transposing Regulations. http://www.housing.gov.ie/sites/default/files/public-consultation/files/2016_06_17_consultation_overview_final_0.pdf
- Department of Primary Industries. 2005. Planning Guidelines for Land Based Aquaculture in Victoria. Fisheries Victoria Management Report Series No.21. http://agriculture.vic.gov.au/fisheries/aquaculture/aquaculture-planning-guidelines/report-aquaculture-planning-guidelines
- Department of the Environment and Heritage. 2006. Marine Bioregional Planning – A new focus for Australia's marine planning [brochure]. https://www.environment.gov.au/system/files/resources/5aa4ff80-e0d7-4ec8-8e39-d58e9352eeeb/files/mbp-brochure.pdf
- Direcção Geral de Recursos Naturais, Segurança e Serviços Marítimos (DGRM). 2014. Plano Estratégico para a Aquicultura Portuguesa. https://www.dgrm.mm.gov.pt/xportal/xmain?xpid=dgrm&xpgid=genericPageV2&conteudoDetalhe_v2=4829995
- Enablers Task Force on MSP. 2015. Report to the Inter-departmental Marine Coordination Group. http://www.ouroceanwealth.ie/sites/default/files/sites/default/files/Publications/2015/OurOceanWealthEnablersTaskForceReport.pdf
- EUR-Lex. 2017. National transposition measures communicated by the Member States concerning: Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning. http://eur-lex.europa.eu/legal-content/EN/NIM/?uri=celex:32014L0089
- European Commission. 2007. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An Integrated Maritime Policy for the European Union (COM(2007) 575 final). http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52007DC0575
- European Commission. 2008a. Communication from the Commission - Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU (COM(2008) 791 final). European Commission, Brussels. http://eur-lex.europa.eu/procedure/EN/197673
- European Commission. 2008b. Communication from the Commission to the Council and the European Parliament. The role of the CFP in implementing an ecosystem approach to marine management (COM(2008) 187). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0187:FIN:EN:PDF
- European Commission. 2010. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Maritime Spatial Planning in the EU - achievements and future development (COM(2010)771 final). http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52010DC0771
- European Commission. 2011. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Developing a Maritime Strategy for the Atlantic Ocean Area (COM(2011) 782). http://eur-lex.europa.eu/procedure/EN/201071

- European Commission. 2012a. Guidance on Aquaculture and Natura 2000: Sustainable aquaculture activities in the context of the Natura 2000 Network. http://ec.europa.eu/environment/nature/natura2000/management/docs/Aqua-N2000%20guide.pdf
- European Commission. 2012b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Blue Growth opportunities for marine and maritime sustainable growth (COM(2012) 494). http://eur-lex.europa.eu/procedure/EN/201926
- European Commission. 2012c. Report from the Commission to the to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Progress of the EU's Integrated Maritime Policy (COM(2012) 491). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0491:FIN:EN:PDF
- European Commission. 2013a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Strategic Guidelines for the sustainable development of EU aquaculture (COM/2013/0229). http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1477555805378&uri=CELEX:52013DC0229
- European Commission. 2013b. Commission Staff Working Paper. Executive Summary of the Impact Assessment accompanying the document Proposal for a Directive of the European Parliament and of the Council establishing a framework for maritime spatial planning and integrated coastal management (SWD(2013) 64 final). http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52013SC0064
- European Commission. 2013c. Proposal for a Directive of the European Parliament and of the Council establishing a framework for maritime spatial planning and integrated coastal management (COM(2013) 133 final). http://ec.europa.eu/environment/iczm/pdf/Proposal_en.pdf
- European Commission. 2013d. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Action Plan for a Maritime Strategy in the Atlantic Area: Delivering smart, sustainable and inclusive growth (COM(2013) 279). http://eur-lex.europa.eu/procedure/EN/202661
- European Commission. 2015. Report from the Commission to the Council and the European Parliament. The State of Nature in the European Union Report on the status of and trends for habitat types and species covered by the Birds and Habitats Directives for the 2007-2012 period as required under Article 17 of the Habitats Directive and Article 12 of the Birds Directive (COM(2015) 219). http://eur-lex.europa.eu/legal-content/EN/HIS/?uri=COM:2015:219:FIN
- European Commission. 2016a. Summary of the 27 Multiannual National Aquaculture Plans. https://ec.europa.eu/fisheries/sites/fisheries/files/docs/body/27-multiannual-national-aquaculture-plans-summary_en.pdf
- European Commission. 2016b. Commission Staff Working Document on the application of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) in relation to aquaculture (SWD(2016) 178 final). http://ec.europa.eu/environment/marine/pdf/SWD_2016_178.pdf
- European Union Market Observatory for Fisheries and Aquaculture Products (EUMOFA). 2016. The EU Fish Market. DG Maritime Affairs and Fisheries, Brussels.
- European Union Market Observatory for Fisheries and Aquaculture Products (EUMOFA). 2017. EU Consumer Habits Regarding Fisheries and Aquaculture Products. DG Maritime Affairs and Fisheries, Brussels.

- European Union. 2016. Facts and Figures on the Common Fisheries Policy. Brussels: Publications Office of the European Union. doi:10.2771/607841
- Eurostat. 2016. Fisheries statistics. Viewed online at http://ec.europa.eu/eurostat/statistics-explained/index.php/Fishery_statistics on 25th January 2017.
- Fabris, A. 2012. La trota iridea, situazione attuale e prospettive a livello nazionale ed internazionale. Workshop Sostenibilità, Sanità, Qualità, e Sicurezza Alimentare nella Filiera Trota Iridea. in: Atti del XVIII Convegno Nazionale SIPI 9-11 maggio 2012 Udine. p.59.
- Falconer, L., Hunter, D.C., Telfer, T.C., and Ross, L.G. 2013. Visual, seascape and landscape analysis to support costal aquaculture site selection. Land Use Policy, 34, 1-10.
- Fang, Q.H., Zhang, R., Zhang, L.P., and Hong, H.S. 2011. Marine Functional Zoning in China: Experience and Prospects. Coastal Management, 39(6), 656-667.
- FAO and World Bank. 2015. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. Policy brief. FAO, Rome. www.fao.org/documents/card/en/c/4c777b3a-6afc-4475-bfc2-a51646471b0d/
- FAO. 1995. Code of conduct for responsible fisheries (CCRF). FAO, Rome, Italy. 41pp.
- FAO. 2010. Aquaculture development. 4. Ecosystem approach to aquaculture. FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. FAO, Rome, Italy. www.fao.org/docrep/013/i1750e/i1750e00.htm
- FAO. 2012. The state of world fisheries and aquaculture 2012. FAO, Rome, Italy. http://www.fao.org/docrep/016/i2727e/i2727e.pdf
- FAO. 2015. Fisheries Global Information System. FAO, Rome, Italy. Available at http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en
- Faragó, S. 2013. Population number of great cormorant (*Phalacrocorax carbo*) migrating and wintering in Hungary. Hungarian Waterfowl Publications, 23, 239-274. (in Hungarian with English summary).
- Ferreira, J.G. and Bricker, S.B. 2016. Goods and services of extensive aquaculture: Shellfish culture and nutrient trading. Aquaculture International, 24(3), 803-825.
- Ferreira, J.G., Hawkins, A.J.S., Monteiro, P., Moore, H., Service, M., Pascoe, P.L., Ramos, L. and Sequeira, A. 2008. Integrated assessment of ecosystem-scale carrying capacity in shellfish growing areas. Aquaculture, 275, 138–151. http://dx.doi.org/10.1016/j.aquaculture.2007.12.018
- Ferreira, J.G., Sequeira, A., Hawkins, A.J.S., Newton, A., Nickell, T.D., Pastres, R., Forte, J., Bodoy, A. and Bricker, S. 2009. Analysis of coastal and offshore aquaculture: Application of the FARM model to multiple systems and shellfish species. Aquaculture, 289, 32-41.
- Findlay, R.H. and Watling, L. 1997. Prediction of benthic impacts from salmon net-pens based on the balance of oxygen supply and demand. Marine Ecology Progress Series, 155, 147-157.
- Fisheries and Oceans Canada. 2002. Canada's Oceans Strategy Our Oceans, Our Future: Policy and Operational Framework for Integrated Management of Estuarine, Coastal and Marine Environments in Canada. Published by Fisheries and Oceans Canada, Oceans Directorate, Ottawa, Ontario, Canada. http://waves-vagues.dfo-mpo.gc.ca/Library/264678.pdf
- Fisheries and Oceans Canada. 2014a. Regional Oceans Plan Scotian Shelf, Atlantic Coast, Bay of Fundy. Part I: Background and Program Description. ISBN 9781100238241. http://waves-vagues.dfo-mpo.gc.ca/Library/365205.pdf

- Fisheries and Oceans Canada. 2014b. Regional Oceans Plan Scotian Shelf, Atlantic Coast, Bay of Fundy. Part II: Implementation Priorities. ISBN 9781100253459. http://waves-vagues.dfo-mpo.gc.ca/Library/365207.pdf
- Fisheries and Oceans Canada. 2016. Aquaculture Development Strategy 2016-2019. Canadian Council of Fisheries and Aquaculture Ministers (CCFAM) and Fisheries and Oceans Canada, Ottawa, Canada. http://publications.gc.ca/collections/collection_2016/mpo-dfo/Fs23-606-2016-eng.pdf
- Flannery, W., O'Hagan, A.M., O'Mahony, C., Ritchie, H., and Twomey, S. 2015. Evaluating conditions for transboundary Marine Spatial Planning: Challenges and opportunities on the island of Ireland. Marine Policy, 51, 86–95 http://dx.doi.org/10.1016/j.marpol.2014.07.021
- FOESA. 2013. Estrategia para el desarrollo sostenible de la acuicultura española. FOESA, Madrid, España. 88 páginas. http://www.mapama.gob.es/es/pesca/temas/acuicultura/estrategia_desarrollo_sostenible_marcadores_tcm7-381581.pdf
- Gál, D., Pekár, F. and Kerepeczki, E. 2016. A survey on the environmental impact of pond aquaculture in Hungary. Aquaculture International, 24(6), 1543-1554. http://dx.doi.org/10.1007/s10499-016-0034-9
- Garza-Gil, M.D., Prada-Blanco, A., Vasquez-Rodriguez, M.X. 2006. Estimating the short-term economic damages from the *Prestige* oil spill in the Galician fisheries and tourism. Ecological Economics, 58, 842-849.
- Gee, K., Kannen, A., and Heinrichs., B. 2011. BaltSeaPlan Vision 2030 for Baltic Sea Space. http://www.baltseaplan.eu/index.php/BaltSeaPlan-Vision-2030;494/1
- GESAMP (IMO/FAO/Unesco-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 2001. Planning and management for sustainable coastal aquaculture development. GESAMP Reports and Studies, 68. 90pp.
- Government of Ireland. Harnessing Our Ocean Wealth – An Integrated Marine Plan for Ireland. 2012. http://www.ouroceanwealth.ie/sites/default/files/sites/default/files/Publications/2012/HarnessingOurOceanWealthReport.pdf
- Gowen, R.J. and Bradbury, N.B. 1987. The ecological impact of salmonid farming in coastal waters: A Review. Oceanography and Marine Biology Annual Review, 25, 563-575.
- Halasi-Kovács, B. 2008. Conservational significance of the Hortobagy fish farm, the natural values of the fishponds. (in Hungarian).
- Halasi-Kovács, B. and Váradi, L. 2012. The role of inland fisheries in the biodiversity of the Hungarian aquatic ecosystems. Természetvédelmi Közlemények, 18, 191-201. (in Hungarian).
- Halasi-Kovács, B., Puskás, N. and Szűcs, I. 2012. The characteristics of the Hungarian pond aquaculture, its complex ecological and socio-economic importance, and evaluation of the threatening factors of the sustainable aquaculture production. Fisheries Development, 34, 78-95 (in Hungarian).
- Her Majesty's Government (HM Government). 2011. UK Marine Policy Statement. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69322/pb3654-marine-policy-statement-110316.pdf
- Herman, O. 1888. A brief summary of pond aquaculture. K.m. Természettudományi Társulat Budapest (in Hungarian).

- Hofherr, J., Natale, F. and Trujillo, P. 2015. Is lack of space a limiting factor for the development of aquaculture in EU coastal areas? Ocean & Coastal Management, 116, 27-36. http://dx.doi.org/10.1016/j.ocecoaman.2015.06.010
- Hofherr, J., Natale, F., Fiore, G. 2012. An Approach towards European Aquaculture Performance Indicators: Indicators for Sustainable Aquaculture in the European Union. European Commission Joint Research Centre: Institute for the Protection and the Security of the Citizen. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC75891/jrc_g04_fishreg_eapi%20final.pdf
- Hungarian Central Statistical Office. 2011a. Fish production and fish consumption in Hungary and worldwide. www.ksh.hu (In Hungarian).
- Hungarian Central Statistical Office. 2011b. Statistics on employment by gender, industry, age and education. www.ksh.hu (In Hungarian).
- Industry and Investment New South Wales. 2009. NSW Land Based Sustainable Aquaculture Strategy. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/638720/NSWLBSAS.pdf
- INE/DGPA. 2016. Estatísticas da Pesca, 2015. Instituto Nacional de Estatística, I.P., Lisboa, Portugal. 144pp. (in Portuguese).
- Jones, S. and R. Beamish. 2011. Salmon lice: An Integrated Approach to Understanding Parasite Abundance and Distribution. Wiley-Blackwell, USA. ISBN 9780813813622.
- Kapetsky, J. M., Aguilar-Manjarrez, J., and Jenness, J., 2013. A global assessment of offshore mariculture potential from a spatial perspective. FAO Fisheries and Aquaculture Technical Paper No. 549. FAO, Rome. 181pp. www.fao.org/docrep/017/i3100e/i3100e00.htm)
- Kearney, J. 2010. Food consumption trends and drivers. Philosophical Transactions of the Royal Society B, 365, 2793-2807.
- Kerepeczki, É, Gyalog, G., Halasi-Kovács, B., Gál, D. and Pekár, F. 2011. Ecological values and functions of extensive fish ponds. Fisheries development, 33, 47-54 (in Hungarian).
- Kovács, G. 1984. Avifauna of the Hortobágy fish ponds, based on a 10-year observation. Aquila. (in Hungarian).
- Lane, A., Hough, C. and Bostock, J. 2014. A Study on The Long-Term Economic and Ecologic Impact of Larger Sustainable Aquaculture, European Union. Report for Directorate-General for Internal Policies, Policy Department B: Structural and Cohesion Policies, Fisheries. 100pp. Available at http://www.europarl.europa.eu/RegData/etudes/STUD/2014/529084/IPOL_STU%282014%29529084_EN.pdf
- Lange, M., Cummins, V., O'Hagan, A.M., Devoy, R. and Le Tissier, M. 2016. Managing a future with energy farms at sea - exploring governance responses to support marine energy developments. Proceedings of Conference of the Estuarine Coastal Sciences Association, ECSA 56, Bremen, Germany.
- Lilley, B. 2011. The Ordnance Survey OpenData Initiative. The Cartographic Journal, 48(3), 179-182. http://dx.doi.org/10.1179/000870411X13044121958821
- Maltby, E. 2000. Ecosystem approach: from principle to practice. Proceedings of the Ecosystem Service and Sustainable Watershed Management conference in, Beijing, P.R. China, August 23 – 25. Available at http://www.biotechnology.uni-koeln.de/inco2-dev/common/contribs/18_maltb.pdf
- Marine Management Organisation (MMO). 2013. Spatial trends in aquaculture potential in the South and East Inshore and Offshore Marine Plan Areas (MMO 1040). http://webarchive.nationalarchives.gov.uk/20140108121958/http:/www.marinemanagement.org.uk/evidence/documents/1040.pdf

- Marine Scotland. 2014. Scottish Fish Farm Production Survey 2014. Scottish Government. Edinburgh, Scotland. pp52.
- Marine Scotland. 2016. Locational guideline for the authorisation of marine fish farms in Scottish Waters. http://www.gov.scot/Resource/0050/00502588.pdf
- Marty, G.D., Saksida, S.M. and Quinn, T.J. 2010. Relationship of farm salmon, sea lice, and wild salmon populations. Proceedings of the National Academy of Science, 107, 22599–22604
- McKindsey, C.W., Thetmeyer, H., Landry, T. and Silvert, W. 2006. Review of recent carrying capacity models for bivalve culture and recommendations for research and management. Aquaculture, 261(2), 451–462.
- Meaden, G.J., Aguilar-Manjarrez, J., Corner, R.A, O'Hagan, A.M. and Cardia, F. 2016. Marine spatial planning for enhanced fisheries and aquaculture sustainability: Its application in the Near East. FAO Fisheries and Aquaculture Technical Paper No. 604. FAO, Rome, Italy. 102 pp. http://www.fao.org/3/a-i6043e.pdf
- Ministério da Agricultura e do Mar. 2014. Plano Estratégico para a Aquicultura Portuguesa 2014-2020. 86pp. (in Portuguese).
- Ministerio de Agricultura, Alimentación y Medio Ambiente (MAGRAMA). 2001. Libro Blanco de la acuicultura en España. http://www.mapama.gob.es/app/jacumar/recursos_informacion/publicaciones_ficha.aspx?Id=es&IdPublicacion=24
- Ministerio de Agricultura, Alimentación y Medio Ambiente (MAGRAMA). 2014. Plan Estratégico Plurianual de la Acuicultura Española 2014–2020. http://www.mapama.gob.es/es/pesca/temas/acuicultura/plan_estrategico_6_julio_tcm7-389036.pdf
- Ministerium für Energie, Infrastruktur und Digitalisierung Mecklenburg-Vorpommern. 2016. Landesraumentwicklungsprogramm Mecklenburg-Vorpommern 2016 (LEP M-V 2016) [In German]. http://www.regierung-mv.de/Landesregierung/em/Raumordnung/Landesraumentwicklungsprogramm/aktuelles-Programm/
- Ministero delle Politiche Agricole Alimentari e Forestali (MiPAAF). 2014. Plano Stretegico per L'acquacoltura in Italia 2014-2020. https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/8752%20 [Allegato 6, in Italian].
- Ministrère de L'écologie, du Développment Durable et de L'énergie. 2014. Plan Stratégique National: Développement des aquacultures durables 2020. French version. http://www.developpement-durable.gouv.fr/Approbation-du-programme,45747.html [Document 3].
- Ministry of Rural Development and Food, Directorate-General for Fisheries Management, Aquaculture and Inland Waters. 2014. Πολυετές Εθνικό Στρατηγικό Σχέδιο για την ανάπτυξη των υδατοκαλλιεργειών στην Ελλάδα, 2014-2020 [National Strategic Aquaculture Plan for Greece, 2014-2020]. [Greek version, translated] http://www.alieia.gr/polietes-ethniko-stratigiko-schedio-gia-tin-anaptixi-ton-idatokalliergion-stin-ellada/
- Ministry of Rural Development: Hungary. 2013. National Water Strategy on water management, irrigation and drought management. (In Hungarian).
- National Ocean Council. 2013. National Ocean Policy Implementation Plan. https://www.whitehouse.gov/sites/default/files/national_ocean_policy_implementation_plan.pdf
- North, B., Turnbull, J., Ellis, T., Porter, M., Migaud, H., Bron, J. and Bromage, N. 2006. The impact of stocking density on the welfare of rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 255(1-4), 466-479. http://dx.doi.org/10.1016/j.aquaculture.2006.01.004

- Northern Economics, Inc. 2009. Valuation of Ecosystem Services from Shellfish Restoration, Enhancement and Management: A Review of the Literature. Prepared for Pacific Shellfish Institute. Available at http://www.pacshell.org/pdf/ShellfishEcoServices.pdf.
- Norwegian Ministry of the Environment. 2009. Integrated Management of the Marine Environment of the Norwegian Sea. Report No.37 (2008-2009) to the Storting. [English version] https://www.regjeringen.no/en/dokumenter/report-no.-37-to-the-storting-2008-2009/id560159/
- Norwegian Ministry of the Environment. 2011. First update of the Integrated Management Plan for the Marine Environment of the Barents Sea–Lofoten Area. Meld. St. 10 (2010–2011) Report to the Storting (White Paper). [English version]. http://www.miljodirektoratet.no/Global/Havforum/Meld.%20St.10%20(2010-2011)%20Report%20to%20the%20Storting%20(white%20paper)%20First%20update%20of%20the%20Integrated%20Management%20Plan%20for%20the%20Marine%20Environment%20of%20the%20Barents%20Sea-Lofoten%20Area.pdf
- Norwegian Ministry of the Environment. 2013. Integrated Management of the Marine Environment of the North Sea and Skagerrak (Management Plan). Meld. St. 37 (2012–2013) Report to the Storting (White Paper). [English version]. http://www.miljodirektoratet.no/Global/Havforum/Meld.%20St.37%20(2012-2013)%20Report%20to%20the%20Stortinng%20(white%20paper)%20Integrated%20Management%20of%20the%20Marine%20Environment%20of%20the%20North%20Sea%20and%20Skagerrak.pdf
- Nunes, J.P., Ferreira, J.G., Bricker, S.B., O'Loan, B., Dabroawski, T., Dallaghan, B., Hawkins, A.J.S, O'Connor, B. and O'Carroll, T. 2011. Towards and ecosystem approach to aquaculture: Assessment of sustainable shellfish cultivation at different scales of space, time and complexity. Aquaculture, 315(3-4), 369-383.
- O'Hagan, A.M. In Press. Planning and Management Frameworks for Renewable Ocean Energy. In: Marine Renewable Energy: Resource Characterization and Physical Effects, Yang, Z and Copping, A. (Eds.). Springer, USA.
- O'Higgins, T., Black, K. and Dunne, D. *Submitted*. Many Points of View: Visual Amenity Mapping for Marine Spatial Planning. PLoS ONE.
- OECD. 2014. Measurement and Reduction of Administrative Burdens in 13 Sectors in Greece (Sector 5 Final Report Fisheries). OECD. 79pp. Available at http://www.oecd.org/greece/measurement-and-reduction-of-administrative-burdens-in-greece.htm
- OECD. 2015. Review of Fisheries: Country Statistics 2015. Available at http://www.oecd.org/tad/oecd-review-of-fisheries-country-statistics-rev-fish-stat.htm
- Oláh, J. 1999. Changing avifauna on a changing fish pond system. University of Debrecen. p. 33. (in Hungarian)
- Osmundsen, T.C., Almklov, P. and Tveterås, R. 2017. Fish farmers and regulators coping with the wickedness of aquaculture. Aquaculture Economics and Management, 21, 1-21. http://dx.doi.org/10.1080/13657305.2017.1262476
- Papageorgiou, M. 2016. Marine spatial planning and the Greek experience. Marine Policy, 74, 18-24. http://dx.doi.org/10.1016/j.marpol.2016.09.003
- Policy Research Corporation. 2011. Exploring the potential of Maritime Spatial Planning in the Mediterranean Sea: final report. Framework contract FISH/2007/04 Specific contract No 6 for the European Commission: Directorate General for Fisheries and Maritime Affairs. http://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/body/msp-med_final_report_en.pdf and http://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/body/italy_01_en.pdf (on Italy).

- Potts, T., Alexander, A., O'Higgins, T.G., MacLucas, N. 2015. Supporting Marine Spatial Planning with Local Socio-Economic Data (MSP-LED). Affiliation: CREW (Scotland's Centre of Expertise for Water). https://www.openchannels.org/sites/default/files/literature/Supporting%20Marine%20Spatial%20Planning%20with%20Local%20Socio-Economic%20Data.pdf
- Savage, J. 2015. Australian fisheries and aquaculture statistics 2015. Fisheries Research and Development Corporation project 2016-246. ABARES, Canberra, December. CC BY 3.0. http://data.daff.gov.au/data/warehouse/9aam/afstad9aamd003/2015/AustFishAquacStats_2015_v1.0.0.pdf
- Sogari, G., Mora, C., Morelli, G. and Menozzi, D. 2016. Trout value chain overview in Italy. Available at http://www.primefish.eu/sites/default/files/Report_17_Italy_Trout.pdf
- Stafford, J.D., Horath, M.M., Yetter, A.P., Hine, C.S. and Havera S P. 2007. Wetland use by mallards during spring and fall in the Illinois and Central Mississippi River Valleys. Waterbirds, 30(3), 394-402.
- Statistics Canada. 2015. Aquaculture Statistics 2015. http://www.statcan.gc.ca/pub/23-222-x/23-222-x2015000-eng.pdf
- STECF (Scientific, Technical and Economic Committee for Fisheries). 2014. The economic performance of the EU aquaculture sector (STECF 14-18). Publications Office of the European Union, Luxembourg. 457pp.
- Suárez de Vivero, J.L. and Atmane, T. 2011. Report on Spatial Planning Systems in Mediterranean countries: Spain. UNEP/PAP/RAC report. http://www.marineplan.es/en/SPAIN_FINAL_10_02_2012.pdf
- Telfer, T.C., Atkin, H. and Corner, R.A. 2009. Review of Environmental Impact Assessment and monitoring of Aquaculture in Europe and North America. 285 –*394p*. In: Fisheries and Aquaculture Technical Paper No. 527: Environmental impacts assessment and monitoring in aquaculture: Requirements, practices, effectiveness and improvements. FAO, Rome. 648pp. Available at http://www.fao.org/docrep/012/i0970e/i0970e00.htm
- The Scottish Government. 2015a. Scotland's National Marine Plan (NMP) – A Single Framework for Managing Our Seas. http://www.gov.scot/Publications/2015/03/6517/downloads#res-1
- The Scottish Government. 2015b. Scotland's National Marine Plan - A Single Framework for Managing Our Seas. A Summary of Objectives and Policies. http://www.gov.scot/Resource/0047/00474848.pdf
- Turkowski, K. and Lirski, A. 2011. Non-productive functions of fish ponds and their possible economic evaluation In: Lirski, A and Pyć, A. (eds). Carp culture in Europe. Current status, problems, perspective. IRŚ Olsztyn.
- Végvári, Z. and Tar, J. 2002. Roost site selection of the Common Crane (*Grus grus*) in the Hortobágy National Park, Hungary between 1995-2000. Ornis Fennica, 79, 101-110.
- Visit Scotland. 2014. Tourism in Scotland's Regions 2013. http://www.visitscotland.org/pdf/Tourism%20in%20Scotland's%20Regions%202013.pdf
- Welsh Government. 2015. The Welsh National Marine Plan – Initial Draft. http://gov.wales/docs/drah/publications/151130-welsh-national-marine-plan-initial-draft-november-2015-en.pdf
- World Bank. 2013. Fish to 2030: prospects for fisheries and aquaculture. Agriculture and environmental services discussion paper No 3. Washington DC; World Bank Group. http://documents.worldbank.org/curated/en/458631468152376668/Fish-to-2030-prospects-for-fisheries-and-aquaculture