



Horizon 2020

AQUASPACE

Ecosystem Approach to making Space for Aquaculture

EU Horizon 2020 project grant no. 633476

Deliverable 5.2

report on

Stakeholder decision-support toolbox

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The research leading to these results has been undertaken as part of the AquaSpace project
(Ecosystem Approach to making Space for Aquaculture, <http://aquaspace-h2020.eu>)
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Change log

This section is used to track changes through the review process.

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2.0	30/08/2018	PT	Revised report for submission

Review log

Version	Date	Reviewer	Comments
1.0	July 2018	External reviewers	Rejected deliverable, with recommendations
2.0	30/08/2018	PT	Report revised, with inclusion of 'guide to toolbox'

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EXECUTIVE SUMMARY

This is the final report on Aquaspace Deliverable 5.2, 'Stakeholder decision-support toolbox'. The report describes the structure and contents of the (virtual) toolbox, which is a part of revisions to the Aquaspace website at www.aquaspace-h2020.eu.

The main contents of the toolbox are factsheets describing tools and factsheets describing good practice in using the tools. Both will be linked to material on other pages of the Aquaspace web-site such as that for the Masters Module (D6.1).

A new 'Guide to the AquaSpace ToolBox' has been prepared, and is appended to this report. It draws on non-confidential parts of D6.4, the AquaSpace Business Plan.

1. INTRODUCTION

This is the final report on Aquaspace Deliverable 5.2, 'Stakeholder decision-support toolbox'. The report describes the structure and contents of the (virtual) toolbox, which is part of the Aquaspace legacy website at www.aquaspace-h2020.eu.

According to the Aquaspace D1.7 Year 3 Activity Plan, the T5.3 "*decision-support toolbox will be constructed, drawing on the example of the ECASA toolbox, to help managers and stakeholders in spatial planning and licensing processes. It will take data from T5.2, which itself will synthesise information on issues, tools and case study applications from WP2, WP3 and WP4. The format of the toolbox will be agreed with the Aquaspace steering committee soon after the T5.1 synthesis workshop (MS19) in M27, drawing on the example of the ECASA toolbox. Work will take place between M28 and M33.*"

For present purposes, a *tool* is any legal instrument (laws, regulations, guidelines), process (such as stakeholder engagement), computer model application (such as GIS, or computer models to assess impacts of aquaculture), or any other hardware, software or set of instructions that can be used to help and support (in this case) the purpose of making more high-quality space available for aquaculture, including the gathering, analysis and presentation of data to aid decision making in this context.

2. BACKGROUND: ECASA TOOLBOX

The ECASA project (2004-2008; DGFish contract 006540) aimed to develop an ecosystem approach to sustainable aquaculture. Its virtual toolbox (<http://www.ecasatoolbox.org.uk>) provided 'tools' to aid owners and operators of fin-fish and shell-fish farms in selecting farm sites, and operating farms, so as to minimize environmental impact and ensure the sustainability of sites and water bodies for aquaculture.

The ECASA toolbox included pages containing:

- introductory information, providing the background knowledge required for toolbox users to understand the remainder of the contents
- information about indicators for environmental management
- information about models tested and developed during ECASA
- examples of Environmental Impact Assessments carried out at ECASA study sites

3. AQUASPACE TOOLBOX

It was agreed by the Aquaspace Steering Committee that the ToolBox would be closely coupled with the Masters Module (D6.1), which would serve the same purpose, in relation to Aquaspace tools, as the introductory information provided by ECASA. Figure 1 presents an overview of the Aquaspace legacy website, and shows the relationship between the ToolBox page, the Masters Module page, the Library pages, and the Case Study pages. The Library contains, amongst other materials, a set of downloadable versions of Aquaspace deliverable reports.

The ToolBox page on the website contains two main sets of materials (developed in WP5 for MS20):

- factsheets describing tools tested during Aquaspace
- factsheets describing good practice in selecting and using tools

Both may be downloaded as pdf. An example of each kind of factsheet is annexed to this report.

A ‘Guide to the ToolBox’ has been developed, drawing on non-confidential material in AquaSpace D6.4, the project’s Business Case (for development of tools). The guide includes a summary of each tool texted during the project; a table outlining the main purpose of, requirements for use, and skills needed to use, each tools ; and links to units in the AquaSpace Masters Module that provide background knowledge needed for the tools.

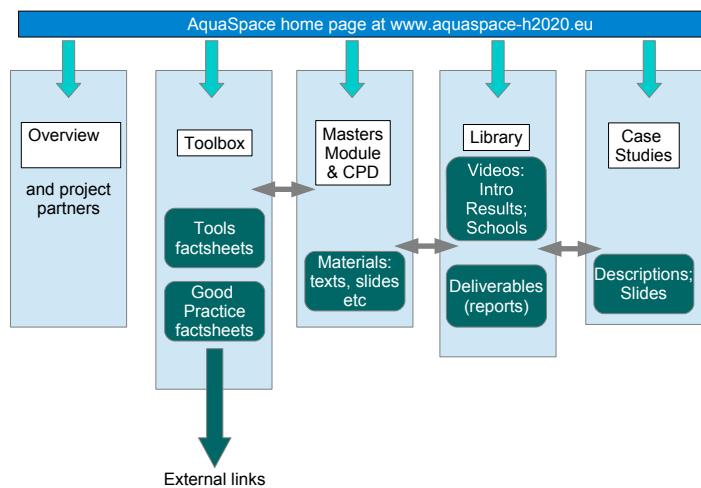


Figure 1. The Aquaspace website in its final form, including the ToolBox (D5.2) and Masters Module (D6.1)

4. ANNEXES: FACTSHEET EXAMPLES, AND TOOLBOX GUIDE

EXAMPLE OF TOOL FACTSHEET

EXAMPLE OF GOOD PRACTICE FACTSHEET

GUIDE TO THE AQUASPACE TOOLBOX



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TOOL FACTSHEET



Tool name

WATER - Where Aquaculture Thrives in EuRope

Tool type

Model / Site-selection tool (Spatial analysis model)

Short description of the tool

Where Aquaculture Thrives in EuRope (WATER) is a web-based site-selection tool for aquaculture based on observed and modelled data of basic parameters, conditioning the biology of the species and the operational aspect of the production. Water temperature, Salinity, Dissolved Oxygen, Chlorophyll, Current Velocity and Significant Wave Height from observed and modelled data are combined using variable-specific algorithms and variable-combining indexes together with species-related and operational-related thresholds from the database to yield georeferenced images. Ranked suitability is presented for each of the requested exclusive economic zones and area per suitability class.

Source (where/ link)

<http://longline.co.uk/water>

Licence cost or other type of costs (e.g. maintenance)

Context-dependent, please use contacts above.

General requirements (technical and input data)

Up-to-date html 5.1 compatible web-browser.

Management dimension for which the tool could be used

- Policy / Management
- Environmental
- Economic / Market
- Other sectors

Main functionality

- | | |
|---|---|
| <input checked="" type="checkbox"/> Site identification | <input type="checkbox"/> Modelling |
| <input checked="" type="checkbox"/> Mapping | <input checked="" type="checkbox"/> Stakeholder engagement |
| <input checked="" type="checkbox"/> Economic analysis | <input checked="" type="checkbox"/> Ecosystem services assessment |
| <input checked="" type="checkbox"/> Scenario analysis | <input type="checkbox"/> Other: (Please specify) |



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TOOL FACTSHEET



Fields of application (i.e. issue to be solved)

WATER is designed to identify best placement for new aquaculture sites in Europe. Due to its current 1 km resolution, this analysis should be made at the EEZ scale and not at the local scale.

Circumstances in which it can be implemented (strength and opportunities)

The tools is already implemented for the current EU EEZ base data, thus it can be ready applied to this region.

Limitations

This tool is limited by the resolution of the source data. Typically, the products used for input range between 10 – 60 km, overlayed and regridded to 1 km resolution. Hence, the tool is only fit for regional analysis.

Technical skills needed to operate the tool

None.

Background knowledge needed to implement the tool

None.

How can the tool contribute to the EAA

Thw EAA steps that the tool can contribute:

1. Scoping
2. The identification of issues and opportunities
3. Prioritisation of issues
4. Objectives
5. Management actions
6. Monitoring

How can the tool contribute to the MSP

The MSP steps that the tool can contribute:

1. Define goals and objectives
2. Gather data and define current conditions
3. Identify issues, constraints, and future conditions
4. Develop alternative management actions



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TOOL FACTSHEET



5. Evaluate alternative management actions
6. Monitor and evaluate management actions
7. Refine goals, objectives and management actions

AquaSpace case studies in which it has been implemented

Case study name:

NA.

Reference and link to case studies report:

<http://www.aquaspace-h2020.eu/>

Other bibliographic references

none

The information in this fact-sheet has been assembled as part of Milestone 20 (WP5) of the AquaSpace project (Ecosystem Approach to making Space for Aquaculture, <http://aquaspace-h2020.eu>), which has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement n° 633476.

Cite as:

Longline Environment Ltd. (2017) WATER - Where Aquaculture Thrives in EuRope.
Tools factsheet from Aquaspace toolbox. <http://aquaspace-h2020.eu>



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TOOLS IMPLEMENTATION EXAMPLE



Issue types(s)

Potential use conflicts of aquaculture with other activities, i.e. fishery and navigation.

Specific Issue(s):

Saturation of the area within 3 nm from the shore. Need for product diversification: oyster farming is being introduced. Transition towards new production technologies in order to lower the environmental impact: this may require the siting of farms in deeper areas.

Case study:

Shellfish culture in Emilia-Romagna, Adriatic Sea, Italy

Objective(s):

- to identify the most suitable sites for off-shore mussel culture in the coastal area comprised between 3 and 12 nm from the shore;
- to assess the potential for co-farming mussels and Pacific oysters.

Tool(s):

Ecophysiological models for Mediterranean mussel and Pacific oyster. FiCIM model for estimation of local environmental impact. Free GIS, i.e. QGIS. BLUEFARM-2.

How tool(s) has/have been implemented

We used individual ecophysiological models for Mediterranean mussel and Pacific oyster, forced by remotely sensed Earth Observation of Chlorophyll a and Sea Surface Temperature downloaded from Copernicus Marine Environment Monitoring Services (<http://marine.copernicus.eu/>), for mapping the potential productivity of both species at 1 Km resolution. The FiCIM model, originally developed for estimating the impact of finfish farms on benthic environment, was used for mapping the impact of mussel biodeposition. These maps were combined with other criteria and constraints using BLUEFARM-2, a tool which implements a Spatial MultiCriteria Evaluation methodology already tested in aquaculture.

Results:

BLUEFARM-2 allowed us to map a suitability index ranging from 0 (impossible to locate a farm) to 1 (highly suitable area). In this case study, we took into account the following criteria: number of days to reach the market size for mussels and oysters, extension of areas moderately impacted by shellfish biodeposition; significant wave height, distances from ports and motorways. The results are presented in Fig.1, which shows the suitability maps obtained giving equal weight to both mussel and oyster productivity indicators.



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TOOLS IMPLEMENTATION EXAMPLE

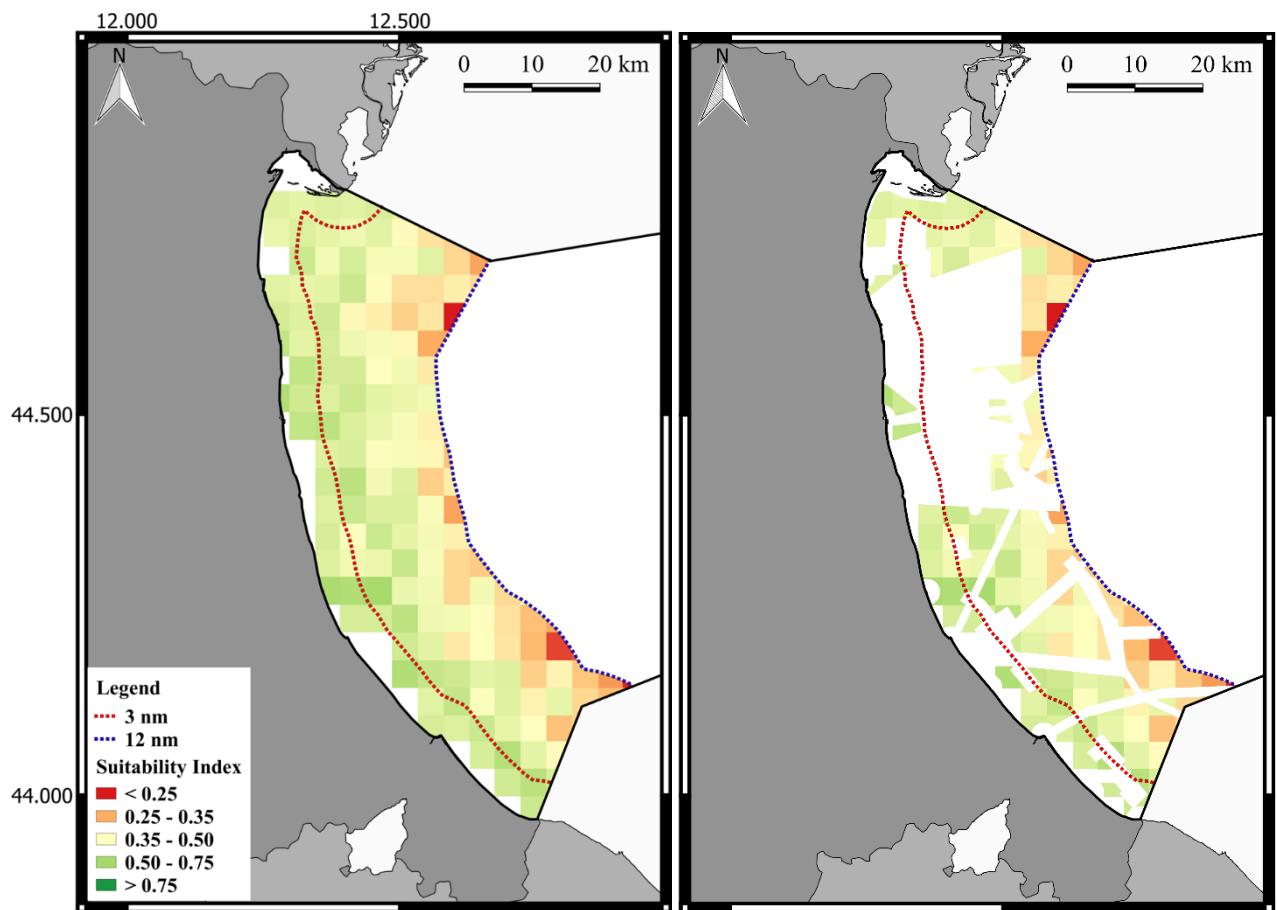


Fig. 1. Map of suitability index for the case study area (left) and final map, obtained by overlapping constraints to the establishment of a shellfish farm (right).

Links:

Reference

Brigolin, D., E. M. D. Porporato, G. Prioli & R. Pastres (2017). Making space for shellfish farming along the Adriatic coast. ICES Journal Of Marine Science 74(6): 1540-1551. doi: 10.1093/icesjms/fsx018

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Cite as:

Bluefarm s.r.l. (2017) Shellfish culture in Emilia-Romagna, Adriatic Sea, Italy.
Implementation factsheet from Aquaspace toolbox. aquaspace-h2020.eu/



Horizon 2020



AQUASPACE

Ecosystem Approach to making Space for Aquaculture

EU Horizon 2020 project grant no. 633476

Guide to the AquaSpace ToolBox

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27 August 2018

The research leading to these results has been undertaken as part of the AquaSpace project
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Summary

This document provides an introduction to the tools that are described in the AquaSpace ToolBox. It includes a summary of each tool texted during the project; a table outlining the main purpose of, requirements for use, and skills needed to use, each tools ; and links to units in the AquaSpace Masters Module that provide background knowledge needed for the tools.

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1. Introduction

Aquaculture is a growing industry worldwide, which already provides over half of the total production of aquatic products for human consumption and is progressively becoming a key component of a sustainable food supply. Currently, the EU aquaculture sector produces approximately 1.2 million tonnes of fish and shellfish with a total value of around EUR 4 billion (EC, 2016a). This is slightly greater than 1% of the global aquaculture production. The sector is composed almost entirely of micro-enterprises and provides employment to approximately 85,000 people (EC, 2016b).

At present, the most important farmed species in the EU are mussel, oyster, salmon, trout, carp, seabass and seabream, using various techniques such as on-bottom as well as off-bottom (rafts and long-lines) cultures for shellfish farming. Relatively small quantities of other species are also produced in freshwater (EC, 2016a).

Between 2000 and 2013, aquaculture registered annual growth rates at a world level of approximately 6%, while it was stagnating, or even decreasing, in the European Union (O'Hagan et al., 2017). Stimulating the growth of aquaculture in the EU is regarded as a key objective of the Blue Growth initiative: its agenda, adopted in 2011, 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. Furthermore, the Strategic Guidelines for Aquaculture produced by the European Commission (EC, 2013) underline the need to increase aquaculture across the EU and considered the development of spatial planning for aquaculture as a key enabler of that activity. Likewise, the reformed Common Fisheries Policy (CFP; Regulation (EU) 2015/812) places an increased emphasis on the sustainable development of aquaculture, recognising that sustainable solutions should be achieved through integrating the social, economic and environmental dimensions. As a result, following the EC Guidelines, all EU Member States developed their own multi-annual aquaculture plans and set targets to increase aquaculture production. Altogether, EU production is projected to increase to approximately 1.76 million tonnes by 2025, with an annual growth rate of 2.7%. To achieve these results, aquaculture requires access to sufficient space to fulfil favourable operational characteristics, minimise conflicts with existing or planned uses, and utilise locations that could support maximum production within acceptable limits of environmental impact. The aim is to increase global production of aquatic products, while maintaining environmental sustainability.

2. The AquaSpace project

Spatial planning for aquaculture is receiving increased attention globally, 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 to maintain environmental integrity but increase global production and trade of fish products.

In this context, the central goal of the AquaSpace project was to optimise the available area for aquaculture, in both marine and freshwater environments, by adopting the Ecosystem Approach to Aquaculture (EAA), and spatial planning for aquaculture, within the wider context of EU

legislation, such as the Maritime Spatial Planning, Water Framework, and Marine Strategy Framework, Directives, and policies, such as the Integrated Marine Policy and Blue Growth. The core objectives of AquaSpace were to: (i) support increased production; (ii) provide employment opportunities; and (iii) promote economic growth of the aquaculture sector.

The project applied a case study approach, where 17 case studies were used to identify key planning issues for aquaculture development, based on stakeholder requirements, and to develop, fine-tune, test and/or evaluate various tools for facilitating the spatial planning process, thus supporting the industry and investors in selecting new sites. These tools were reviewed in AquaSpace Deliverable 5.1, Galparsoro *et al.* (2018) and are described in detail in a set of factsheets that are the main content of the AquaSpace ToolBox. The tools' application to case studies is presented in detail in AquaSpace Deliverable 4.2, Strand *et al.* (2018) and summarised in Annex 3 of the same report. In the next section, we present the main features of the tools for which factsheets are available, focusing on their potential exploitation beyond the project lifetime.

The Aquaspace ToolBox is part of the AquaSpace website (<http://www.aquaspace-h2020.eu/>).

Most of the text of the present document is taken from AquaSpace deliverable 6.4, which also includes parts presenting a business case for the further development of tools. Those parts remain confidential to the members of the AquaSpace consortium.

3. Innovative tools applied in AquaSpace

In the AquaSpace Case Studies, we developed and tested several tools for supporting the achievement of the project main goals, summarised in Section 2. The term '**Tool**' is used here in a broad sense, and includes legal instruments, guidelines, methodologies for participatory processes, simulation models, methodologies for implementing spatially explicit multi-criteria analysis, as well as other approaches that can be used for supporting regulators, farmers and investors in dealing with issues concerning the optimal use of space in the aquaculture sector. Even though some of these tools were already available at the start to the project (AquaSpace Deliverable D3.1, 2016) their testing in AquaSpace case studies led improvements and enhanced the capacity of project partners of selecting and applying of the most suitable ones, in relation to the issue to be dealt with. Tools are briefly presented, in alphabetical order, below while their main features are summarised and compared in Table 3.1.

"All" Aquaculture Investor Index: this mobile application for Android provides investors with a synthetic index for ranking the attractiveness of the aquaculture sector in every European country. The Aquaculture Investor Index combines twenty indicators, grouped into five categories, i.e. market, production, legislation, environment and social. The index is designed to rank aquaculture competitiveness for each country, by producing a quantitative, and scalable assessment, for stakeholders to assess and monitor aquaculture attractiveness. Up to now, the Index does not calculate scores for the potential for onshore aquaculture. Additional criteria will be implemented in future to deal with this option. Worldwide data to include additional countries may, in some cases, present challenges due to poor data availability.

"APDSS" Aquaculture Planning Decision Support System: is a GIS based modelling platform that integrates environmental data concerning a given area and support decisions of aquaculture operators and regulators, regarding aquaculture planning and management, based on suitability assessment and the calculation of aquaculture carrying capacity. At present, it can be used for site selection within marine areas, assessment of habitat suitability, risk analysis and environmental impact assessment of aquafarms, supporting aquaculture manager decisions. The tool, however, has technical limitations for spatial analysis (see AquaSpace Milestones 20).

AquaSpace tool: is one of the first GIS-based planning tools empowering an integrated assessment and mapping of 30 indicators reflecting economic, environmental, inter-sectoral and socio-cultural risks and opportunities for establishing marine aquafarms in a given area. The GIS Add-In builds on open source datasets at a European scale, hence aiming to improve reproducibility and collaboration in aquaculture science and research. It supports the planning and management of sustainable aquaculture development and helps to reduce uncertainty in new investments. The tool currently presents a static geo data base and, therefore, results do not fully satisfy real-world requirements for decision making, because there is not comprehensive coverage of open source data at an EU level and the Geo Data Base cannot be regularly updated. This shortcoming could be removed by linking it to Web Feature Service (WFS) datasets, but, in this case, input-output operations are likely to markedly increase the time required for the analysis (see Gimpel *et al.*, 2017 and Gimpel *et al.*, 2018 for further details).

ArcGIS Visibility Analysis: is a licensed tool that enables the determination of the extent of surface locations (e.g. aquaculture developments) visible to one, or a set of, observers. It can be based upon the analysis of individual fish cages, individual aquaculture sites, or across multiple aquaculture sites. It is used for Environmental Impact Assessment (Landscape and Visual Impact Assessment) of proposed aquaculture development, to assess the potential impacts of aquaculture development on the visual landscape. This is to comply with regulations under the EC Environmental Impact Assessment Directive (85/337/EEC, amended 2014/52/EU; European Union, 2014), as implemented in national or regional legislation.

"ASSETS" Assessment of Estuarine Trophic Status: this model can be used for assessing the overall eutrophic condition of a waterbody and the likely change (worsen, improve) of condition in the future.

"BLUEFARM-2": this plug-in, designed for the open source Q-GIS, implements a flexible Spatial Multi Criteria Evaluation methodology, which combines different information layers, provided by users, to generate maps of a single suitability index. It can support policy makers and investors in selecting sites for developing aquaculture activities. The tool was designed for identifying i.e. Allocated Zones for Aquaculture (AZAs) in coastal areas and in AquaSpace, it was tested for shellfish farming. The methodology can be easily applied to fish farm site selection, but such application still needs to be tested in a real world case study. The current version allows one to deal with information layers characterised by different spatial resolutions: at present, a user can select the highest or lowest resolution for mapping the suitability index.

EcoWin.NET framework: this ecosystem-scale ecological model combines a 3D hydrodynamic model with biogeochemical models, shellfish growth models, and a eutrophication screening

model for the determination of shellfish production and for the assessment of water-quality changes due to shellfish cultivation. EcoWin can be used to determine production, nutrient removal, changes in environmental variables, and economic value of product and nutrient removal. It requires environmental data measured at the site where analysis takes place. A circulation model should be available at the location where the model is being applied, and a hydrological model is a very useful addition.

"FARM" - Farm Aquaculture Resource Management: is a local-scale carrying capacity model (www.farmscale.org) that combines physical and biogeochemical models, shellfish growth models, and screening models at the farm scale for the determination of shellfish production and for the assessment of water-quality changes due to shellfish cultivation. FARM can be used for site identification of where aquaculture will be most successful, estimate nutrient reduction potential of shellfish-based removal and the economic value of both the shellfish production and the removed nitrogen. This is a local-scale model and cannot be used to determine system-wide production or nutrient removal without several caveats and assumptions.

Lakeselus.no (IMR): this model is used for estimating the infestation pressure from salmon lice on wild and farmed salmonid fish along the Norwegian coast. It is also used for locating the "fire brake" areas, i.e. zones of minimal connectivity among farming areas: 11 to 13 such areas are going to be established, based in Lakelus results. Model results are made publically available through a regularly-updated webpage. Although the model parameters are based on the best available knowledge from scientific literature, processes simulated by Lakeselus.no are still far from being fully understood and more research is required to increase the accuracy of the results in the near future. As for weather forecast models, the embedded chaotic nature of ocean hydrodynamics introduces uncertainty to the results, mainly in the level of absolute numbers, timing of events and small-scale details.

"META" – Maritime and Environmental Thresholds for Aquaculture: this web-based platform (www.longline.co.uk/meta) was designed to provide easy access to data on biological and other thresholds that condition growth of cultivated species in different marine and freshwater areas. It combines physiological data obtained from experimental work with accepted ranges for culture practice, e.g. the depths at which structures can be moored. It allows a user to list all known thresholds for a species and to search for all species that can be cultivated within a particular parameter range. The tool is implemented for 45 species and 16 parameters. The core functionality of some META components extends to site selection and other components which are key for aquaculture development.

Aquaculture conflict analysis and uses reallocation opportunities analysis: is a spatially explicit Bayesian Belief Network (BBN) developed in Netica software package. In AquaSpace, the model was developed to analyse the potential reallocation of artisanal fishing effort to alternative sites due to the introduction of a new, non-take area: an offshore aquaculture site along the Basque continental shelf. The constructed model combined discrete, operational fisheries data, continuous environmental data, and expert judgment to produce fishing activity suitability maps for three different métiers (longlines, nets and traps). The BBN was run with various effort reallocation scenarios for each metier, and the best alternative fishing locations were identified based on environmental suitability, past revenue, and past fishing presence (Coccoli *et al.*, 2018). This approach can also be

implemented for other purposes related to spatial planning of aquaculture such as the determination of area suitability, risk analysis, environmental impact assessment.

Public comment analysis: this methodology aims at revealing the drivers of complex social interactions between policy, planning, local communities and aquaculture development and can uncover mitigation options/strategies. It involves searching and qualitatively coding statements of support and of objection to proposed marine aquaculture development whenever they available on a local authority planning web-site. It was used for characterising spatially relevant and location-specific social management issues. The application of this analysis takes a significant amount of time and requires public access to information about application for planning permission. It is only available where there is legislation in place for stakeholder engagement during a licensing process.

Seascape visualisation: virtual reality and visualisation tools enable the exploration, interpretation, design and dialogue about aquaculture developments in seascapes with different types of stakeholder. An interactive 3D model for creating seascapes can be used to enable options for aquaculture, renewable energy and tourism related activities to be selected and located within the area of relevance. The development of options for locating aquaculture developments enables the exploration of choices made by members of the public with respect to uses of coastal waters and reasons for their choices.

"SNAP" - Sentinel Application Platform: combines all the toolboxes used to process images from the ESA Sentinel satellites, offering the most complete processing platform for these missions. The satellite images from the Sentinel programme can be accessed, and the data extracted, with this software. The platform provides data and output maps, but they must be developed and customised. One of its limitations is the confidence of the estimated values based on global algorithms not validated or calibrated with *in situ* observations, which is essential to ensure the optimal quality of the data. Additionally, satellite-derived products can only make estimates for the surface layer of the ocean, and spatial and temporal coverage is only possible during cloud free conditions. It is also important to recognise that uncertainties for satellite products increase close to the coast due to land adjacency, bottom reflection in shallow waters, and high amounts of suspended matter from river outlets, etc.

"SISAQUA": is an interactive web portal based on the free and open source software QGIS, hosted by an Infrastructure of Geographical Data (Sextant), which can be used for site selection of aquafarms. It is originally derived from the Norwegian demonstrator AkavaVis. SISAQUA allows the integration and visualization of different types of spatial data relevant for aquaculture as well as constraints, due to regulatory frameworks, including environmental protections, and other conflicting usages. A module treatment was implemented to allow the generation of indicators based on the combination of different layers of information. The number of indicators is, at present, still limited: however, the flexible structure of the module allows one to expand SISAQUA indicator portfolio. Dynamic modelling tools are not included: SISAQUA output is based on the results of predefined model simulations. The superimposition of constraints is possible but there is no direct cross-spatial analysis. At present, there is no economic module.

"SMILE": the model was developed in 2007, enabling the application of an integrated framework for the determination of sustainable carrying capacity within the shellfish production areas for which it was developed. The SMILE model framework includes a 3D hydrodynamic model,

a shellfish growth simulation model, a biogeochemical model, and an aquaculture-specific ecological model, and can include detailed catchment modelling for analysis of pressure, state, and response. Primarily, it is used primarily to provide data to help inform management decisions regarding at stocking density and potential areas for the expansion of aquaculture based on food availability. SMILE is also used as an ecosystem health tool, providing data from scenarios to indicate potential impacts of changes in the ecosystem, e.g. impacts on water quality due to changes to shellfish cultivation in the system. When the outputs of SMILE are coupled with other environmental data sources in the AkvaVis model, it can be used for site identification for aquaculture sites.

EAF toolbox (SGM): this toolbox was developed to support stakeholder consultation on the implementation of an Ecosystem Approach to Fisheries. It includes various tools to assist and facilitate input from stakeholders: Project meetings, Community and Stakeholder meetings, Stakeholder workshops, EAF presentation materials, Surveys and Questionnaires, Focused Conversation, Team Building Methods, Facilitation-online guides, Facilitation courses, Conflict management, negotiation and consensus building, Consensus workshop method.

WATER Where Can Aquaculture Thrive in EuRope (LLE): is a web-based model for aquaculture based on observed and modelled data of parameters that condition the feasibility of aquaculture at the EEZ level. WATER (www.longline.co.uk/water) is designed to identify best placement for new aquaculture sites in Europe. Ranked suitability is presented for each of the requested exclusive economic zones and area per suitability class. Due to its current 1 km² resolution, this analysis should be made at the EEZ scale and not at the local scale.

Web-based tool for forecasting mussel yield (NIWA): This is a web-based tool for forecasting greenlip mussel yield for the Pelorus Sound Greenshell™ mussel industry. The forecasts were created from the NIWA research, made in conjunction with the mussel industry. Currently, access to the tool is restricted to mussel growers who contributed to the project. The tool can forecast three levels of historical mussel yields (above, mean and below), based on climate forecasting scenarios.

WestLice (SAMS): this model predicts the spread of sea lice between defined locations. This allows the estimation of spread patterns and “connectivity” between salmon aquaculture sites, the identification of distinct self-contained units for management, and the assessment of potential impacts from new sites, coherent area management strategies, and strategic spatial planning for the industry. Lice count data are required to fully validate model. There is the potential to predict lice metapopulation dynamics, but at present this is not well developed or validated.



4. Features of the Aquaspace tools (in a table).

The table will be found on the next page.

Tool	IPR own/shared by at least one beneficiary	Beneficiaries who own IPR	Tool type	Management dimension				Main functionality					Skills needed to operate the tool				
				Policy / management	Environment	Economic / Market	Other sectors	Site identification	Modelling	Mapping	Stakeholder engagement	Economic analysis	Ecosystem services Ass.	Scenario analysis	No customization and training	Requires minimum customization	Requires short training
Aquaculture Investor Index	Y	LLE	Spatial analysis model	X	X	X	X	X			X	X		X	X		
Aquaculture Planning Dec. Support System (APDSS)	Y	YSFRI	GIS based modelling platform	X	X	X	X	X	X	X				X		X	
AquaSpace tool	Y	TI-SF	Arc GIS AddIn	X	X	X	X	X		X		X		X		X	
ArcGIS Visibility Analysis	Y	JHI	Arc GIS AddIn	X	X				X	X	X	X	X	X		X	X
Assessment of Estuarine Trophic Status (ASSETS)	Y	LLE, NOAA	Model	X	X			X	X	X	X			X		X	X
BLUEFARM 2	Y	BF	Plug-in for QGIS free software	X	X	X		X		X	X			X		X	
EcoWin.NET	Y	LLE	Ecological model	X	X	X	X	X	X	X	X	X	X	X			X
FARM	Y	LLE, NOAA	Production Model	X	X	X	X		X			X		X		X	
Lakselus.no	Y	IMR	Model	X	X	X	X	X	X					X			X
META	Y	LLE	Online platform	X	X	X	X	X			X	X		X	X		
Aquaculture conflict analysis and uses reallocation opportunities analysis	Y	AZTI	Model (Bayesian belief network)	X	X	X	X		X	X				X			X
Public comment analysis	N		Procedure	X	X	X	X	X			X						X
Seascape visualisation	N		Simulator	X	X			X	X		X		X	X			X
Sentinel Application Platform (SNAP)	N		Processing of satellite data	X	X	X	X	X	X	X			X	X			X
SISAQUA	Y	IFREMER	Web based dynamic GIS	X	X		X	X	X	X				X			X
SMILE model	Y	LLE, AFBI	Dynamic mod. framework	X	X	X			X		X		X	X			X
Stakeholder consultation (EAF toolbox)	Y		Process	X	X	X	X	X			X		X	X			X
WATER - Where Can Aquaculture Thrive in EuRope	Y	LLE	Spatial analysis model	X	X	X	X	X		X	X	X	X	X	X		
Web-based tool for forecasting mussel yield	Y	NIWA	Production Model	X	X	X	X		X		X				X		
WestLice	Y	SAMS	Model (Biophysical connectivity)	X	X				X	X	X			X			X

5. Links to Masters' Module and other Resources

The AquaSpace Masters' Module, Planning and Managing the Use of Space for Aquaculture, can be found on another page on the [AquaSpace website](#).

Several of the units of the Masters' Module provide introductions to tool theory and practice. They are listed below.

Unit	Title	Relevant for
5	Introduction to Geographic Information Systems	All GIS tools: AquaSpace Tool, ArcGIS Visibility Analysis, BlueFarm2, WATER, plus AkvaVis and the tools derived from it: APDSS and SISAQUA
6	Introduction to AquaSpace integrating tools	Aqua Investor Index, AquaSpace Tool, META and WATER
7	Remote Sensing for Marine Spatial Planning and Aquaculture	SNAP
8	Sea lice and Salmon Aquaculture	Laxselus and WestLice
9	Introduction to Visualisation Issues and Tools	ArcGIS visibility analysis, SeaScape visualisation
10	Social Investigation and Public Engagement Tools	Public comment analysis, Stakeholder consultation (EAF toolbox),

In addition, the older [ECASA ToolBox](#) provides information on physical-biological models.

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