Masters Module
PLANNING AND MANAGING THE USE OF SPACE FOR AQUACULTURE

Topic 6: Introduction to the AquaSpace Tool for use in spatial planning

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Horizon 2020

Indicators for an integrated assessment of aquaculture in a multi-use environment

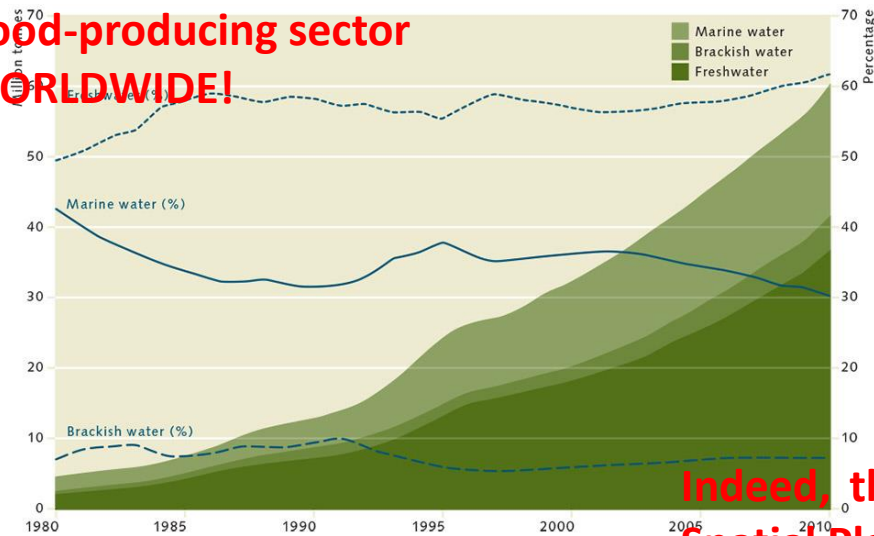Vanessa Stelzenmüller, Antje Gimpel

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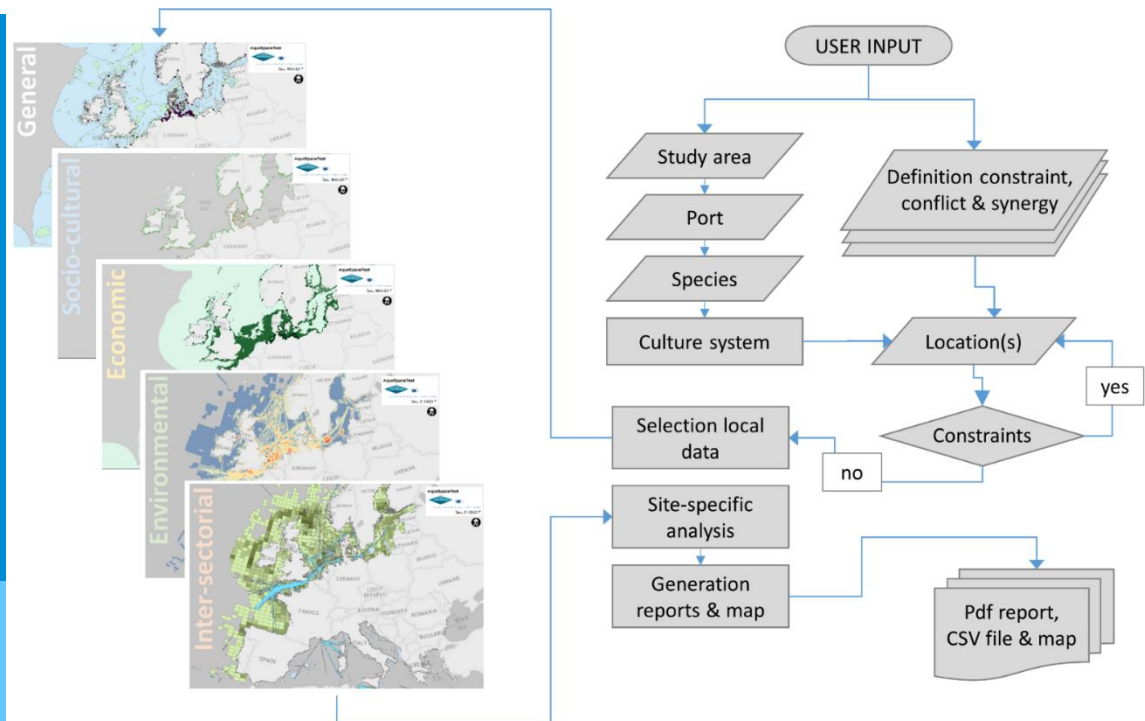
Aquaculture and EU policy requirements?

Aquaculture is the food-producing sector growing the most WORLDWIDE!

Marine water, brackish water and freshwater – aquaculture production has shown strong growth in all areas over the past 30 years (WOR 2013)

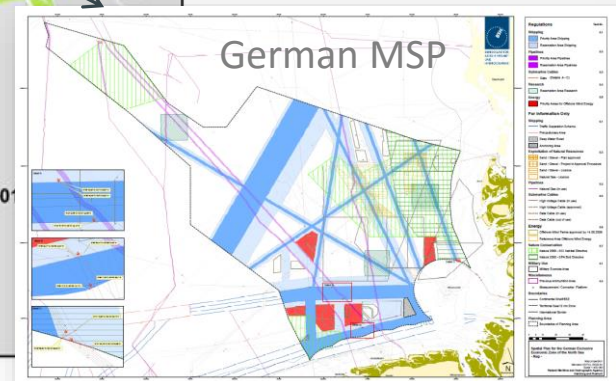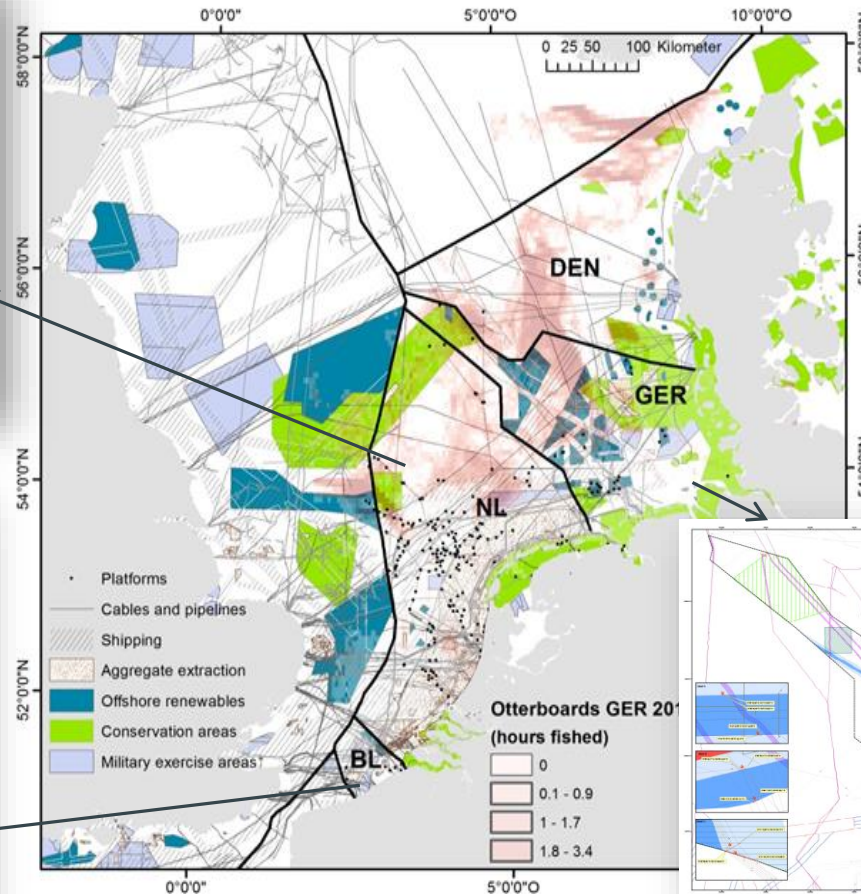**Indeed, there is a need for Marine Spatial Planning (MSP) in the EU**

Marine Spatial Planning (MSP)

➢ contributes to "***sustainable growth*** *of maritime economies […]*" *while* "*applying an* ***ecosystem-based approach*** *with the aim of (...) achievement of* ***good environmental status***" (EC, 2014)

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What is Marine Spatial Planning (MSP)?

MSP in the EU so far…

Dutch MSP

Belgian Masterplan

German MSP
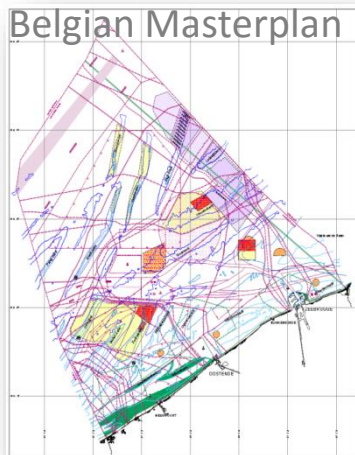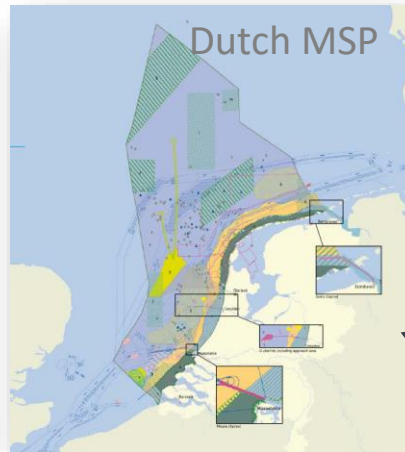
MSP is a process which allocates human activities in space and time to achieve ecological, economic, and social objectives
(Douvere 2008; Foley et al. 2010)

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Spatial planning with aquaculture

Aquaculture intensification has to be sustainable!
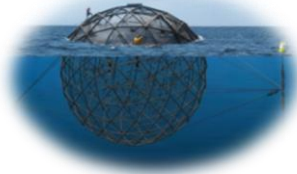
Aquaculture plays a major role in meeting the rising demands for fish products and protein....Larsen & Roney (2013)

Suitable co-location sites in the German EEZ of the North Sea per aquaculture candidate (spring, 10-20m) Gimpel et al. (2015)
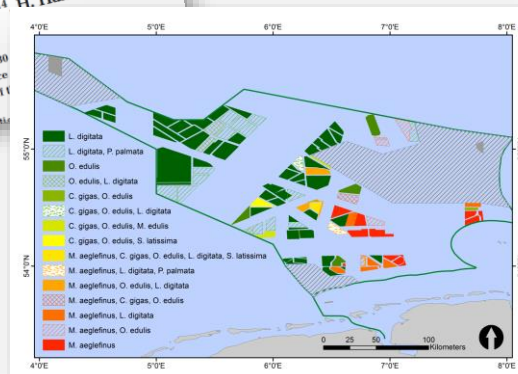
Spatial planning with aquaculture - current issues

- Increasing human uses and the need for marine conservation areas call for practical tools for an ecosystem-based spatial management enabling integrated assessments of ecological, economic and social trade-offs

- As yet, spatial requirements for aquaculture and fisheries are not considered in most MSP initiatives (Stelzenmüller et al. 2016)

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The Ecosystem Approach to Aquaculture to support MSP

How to support (selected) countries in managing aquaculture intensification by using the 6 steps of the EAA to support MSP?

(FAO and World Bank, 2015)
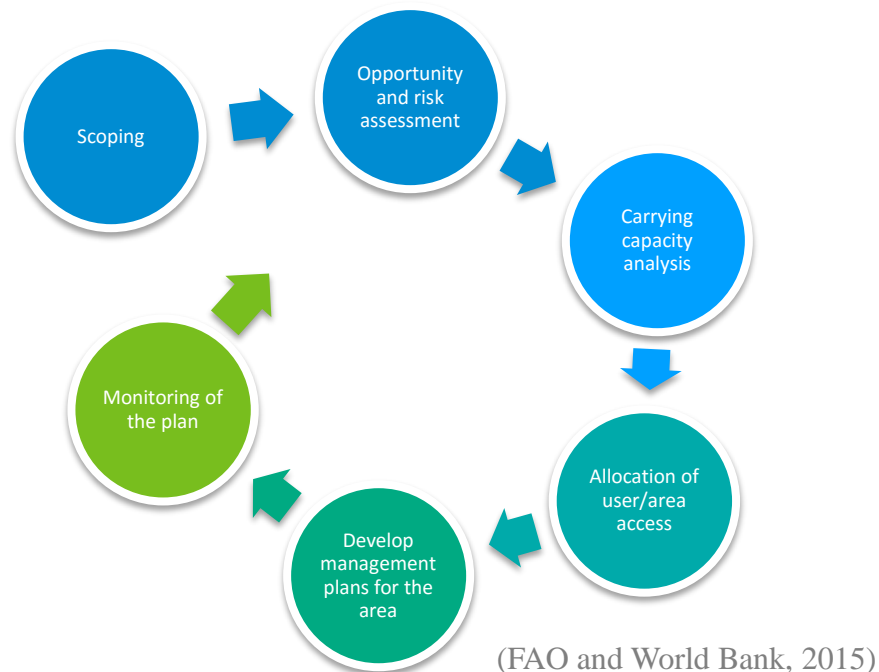
EAA has been defined by FAO (2010) as "*a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems*".

Do methods exist to support an EAA?

A review of tools and methods to support an EAA resulted in the following gaps:

Nature of issue which can be addressed by tools reviewed

GAP

Legend:
- ■ physical
- ■ ecological
- ■ geographic
- ■ authorative legal
- ■ biological
- ■ economic
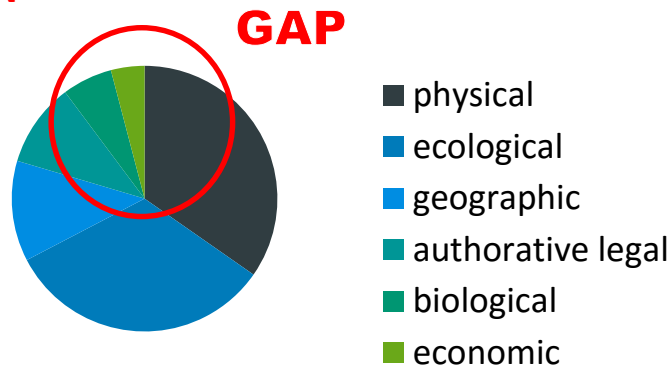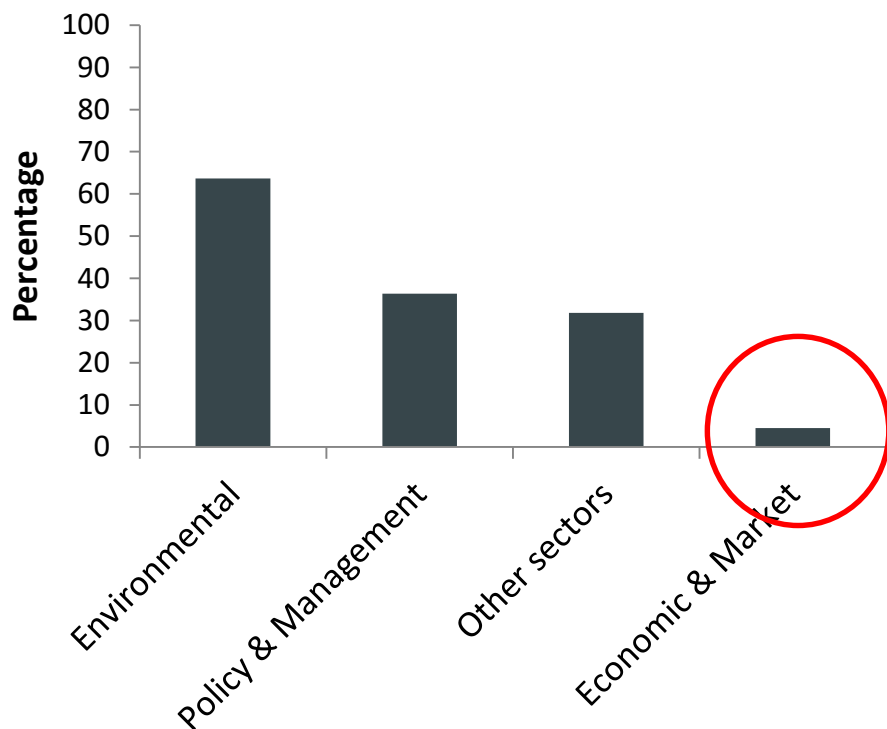
Input data types required by tools reviewed

GAP

D3.1 Tools and Methods to support an Environmental Approach to Aquaculture (EAA) – practical needs (2016)

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Stakeholder opinions on what is needed to support an EAA

Stakeholder consultation on issues constraining the growth of aquaculture resulted in the following gaps (structured around the steps of the EAA):

Sum of isues (related to research) mentioned at AquaSpace stakeholder workshops
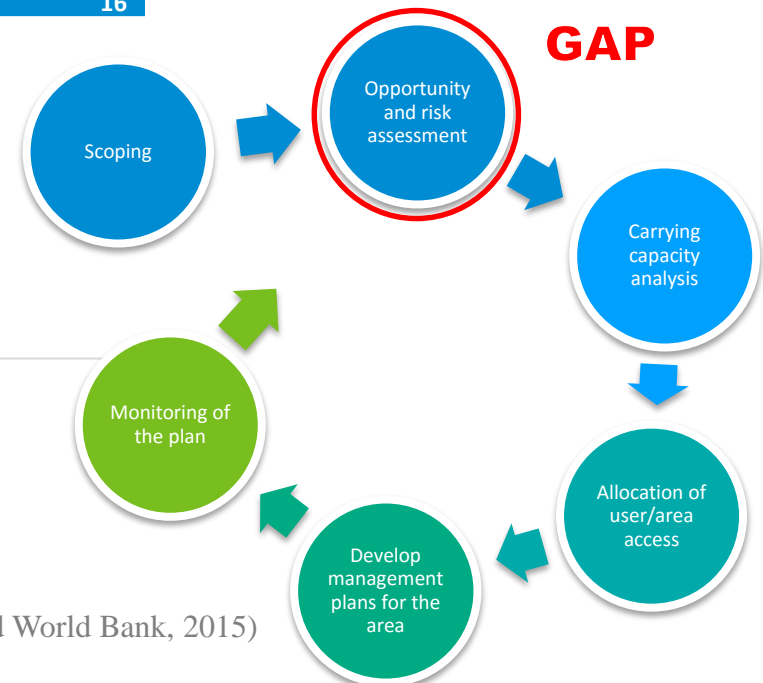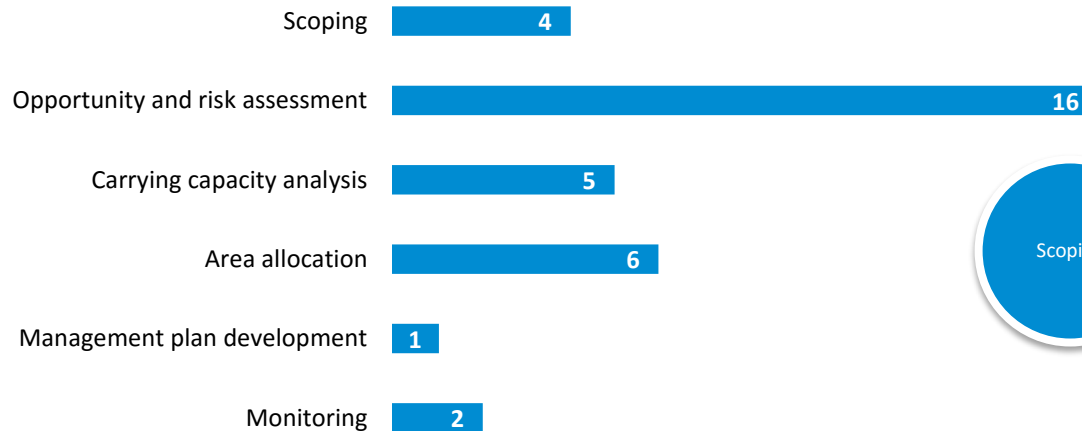
D3.3 AquaSpace tool to support Marine Spatial Planning (MSP) (2017)

(FAO and World Bank, 2015)

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Performance assessment of MSP

Ehler (2014)
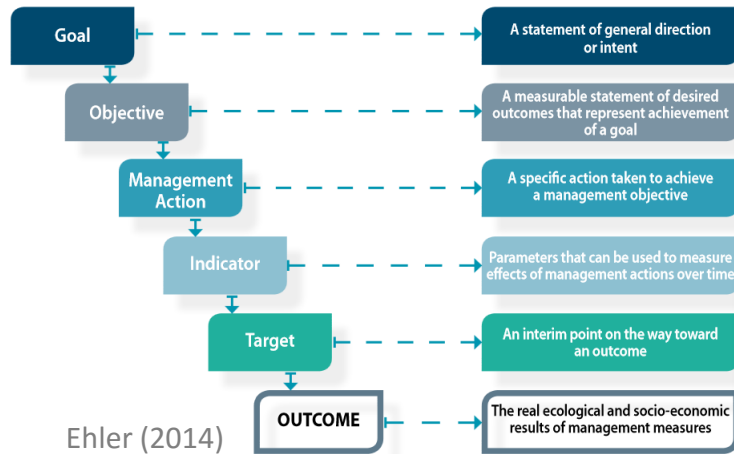
A performance assessment of Marine Spatial Planning (MSP) requires clear objectives and indicators!
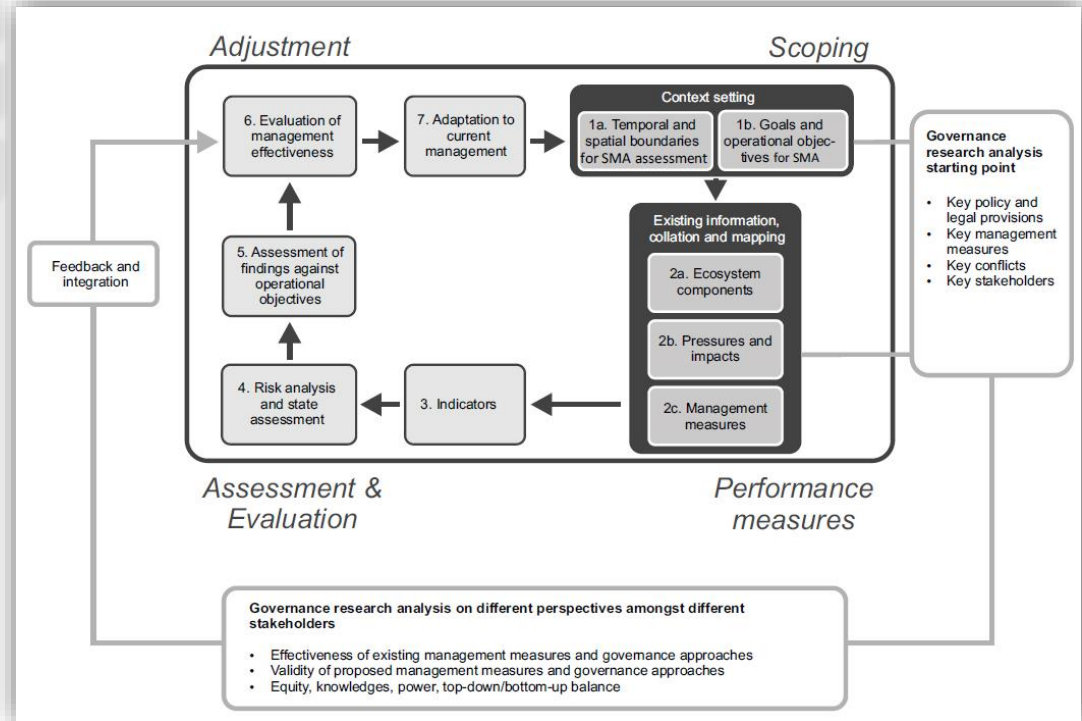
Stelzenmüller et al. (2013)

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Evaluating the risks and opportunities of EAA with aquaculture

A performance assessment of the EAA requires GIS-based tools for an integrated assessment of spatially explicit indicators

- Industry-specific and multiple-use planners rely heavily on spatially-referenced data and Geographic Information System (GIS) -based analytical tools
- Accounting for stakeholder needs in the EU project AquaSpace we developed a GIS based MSP tool to explore the risks and opportunities of planning options for aquaculture

D3.3 AquaSpace tool to support Marine Spatial Planning (MSP) (2017)

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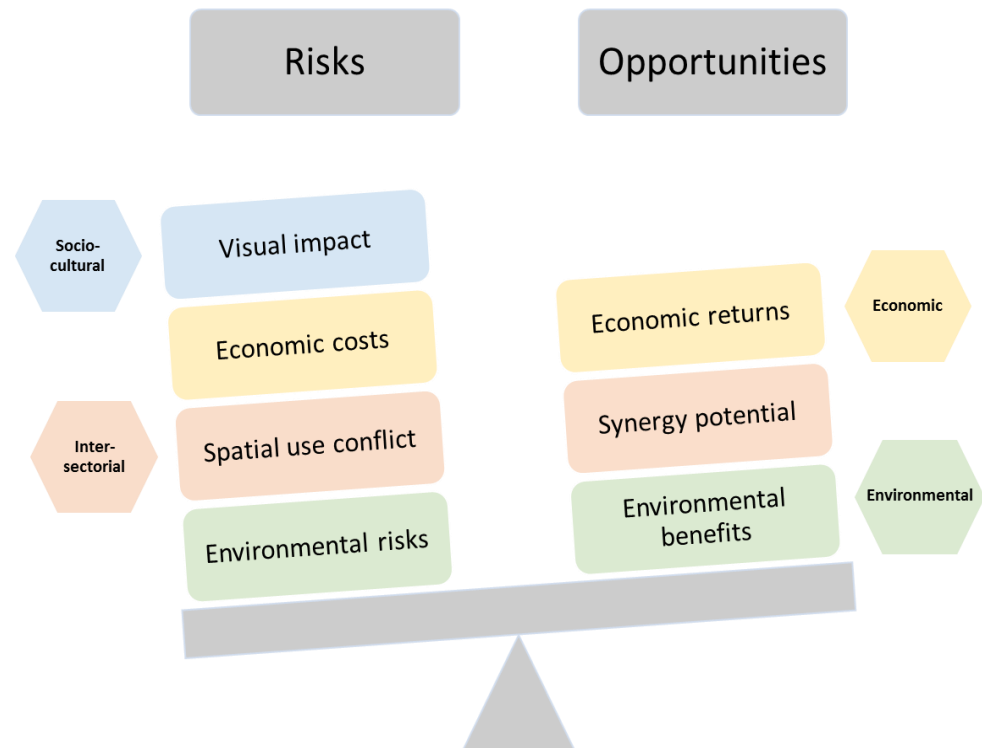
What means integrated?

Aquaculture intensification has to be sustainable!

- 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 Common Fisheries Policy (CFP)

- The EAA should form the basis for development of spatial planning under the Ecosystem Approach within the EU (O'Hagan et al., 2017)

- The objective is to fulfil the socio-economic targets for the area as well as the protection and conservation goals

- An integrated assessment means to take into account different environmental, social and economic components of the ecosystem

- Such an assessment should typically promote the coexistence of marine activities (e.g. windfarms and aquaculture) - and should be consistent with other sectors' objectives (Galparsoro et al., 2017)

Categories describing risks and opportunities

- **Inter-sectorial:** for a cohesive approach, in which aquaculture is an equal partner in development decisions - in the best interest of aquaculture as a sector

- **Environmental:** in order to consider any conditions aquaculture candidates and systems have to experience in nature, based on a mix of physical and environmental factors

- **Economic:** 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

- **Socio-cultural:** the local 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

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Definition of indicators (representing categories)

Inter-sectorial

- Spatial conflict potential (highest conflict score with other human uses)*

- Spatial synergy potential (highest synergy score with other human uses)*

- Integrated Multi-Trophic Aquaculture potential (IMTA; Yes or No, recommended IMTA species)

- Risk of disease spread (based on minimum distance between aquaculture sites)

Economic

- Economic performance (revenue, added value)

- Economic effectiveness (benefits, return on fixed tangible assets, opportunity cost)

- Economic efficiency (net present value)

- Economic impact (induced impact, indirect impact)

- Tourism

*in combination with Fisheries, Ocean energy, Platforms, Cables, Pipelines, Sediment extraction, Marine traffic, Waste disposal, Marine Protected Areas (MPA).

Environmental

- Aquaculture suitability (low to high)

- Wave height specific exposure of the site (m)

- Current velocity (m/s)

- Sediment type

- Chlorophyll a (mg/m³; surface)

- Temperature (°C)

- Salinity (PSU)

- Nitrogen (mol/L NO3; surface)

- Phosphorus (mol/L PO4; surface)

- Cumulative pressure (1 - 8; 8 = high magnitude)

- Habitat vulnerability (1- 3, 3 = highly vulnerable)

- Water depth (m)

- Water quality (level of background pollution)

Socio-cultural

- Visual Impact (landscape, seascape, distance to populated areas)

- Cultural heritage (shipwrecks, archaeological sites, distance calculation)

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Further information of importance

Site specific information

- Ecosystem (country; marine or freshwater)

Management information

- UNCLOS area
- Conservation area

Aquaculture specific information

- Aquaculture (finfish, shellfish or algae)
- Species to be cultivated (species name)
- Culture system (cage, longline, bottom, trestles; culture system size in m³/ha)
- Stocking density (per m³/ha)
- Production cycle (years)
- Production (tons)

Development of the AquaSpace tool

A GIS-based tool for an integrated assessment of spatial planning trade-offs with aquaculture

Built on indicators required and data freely available to do an integrated assessment
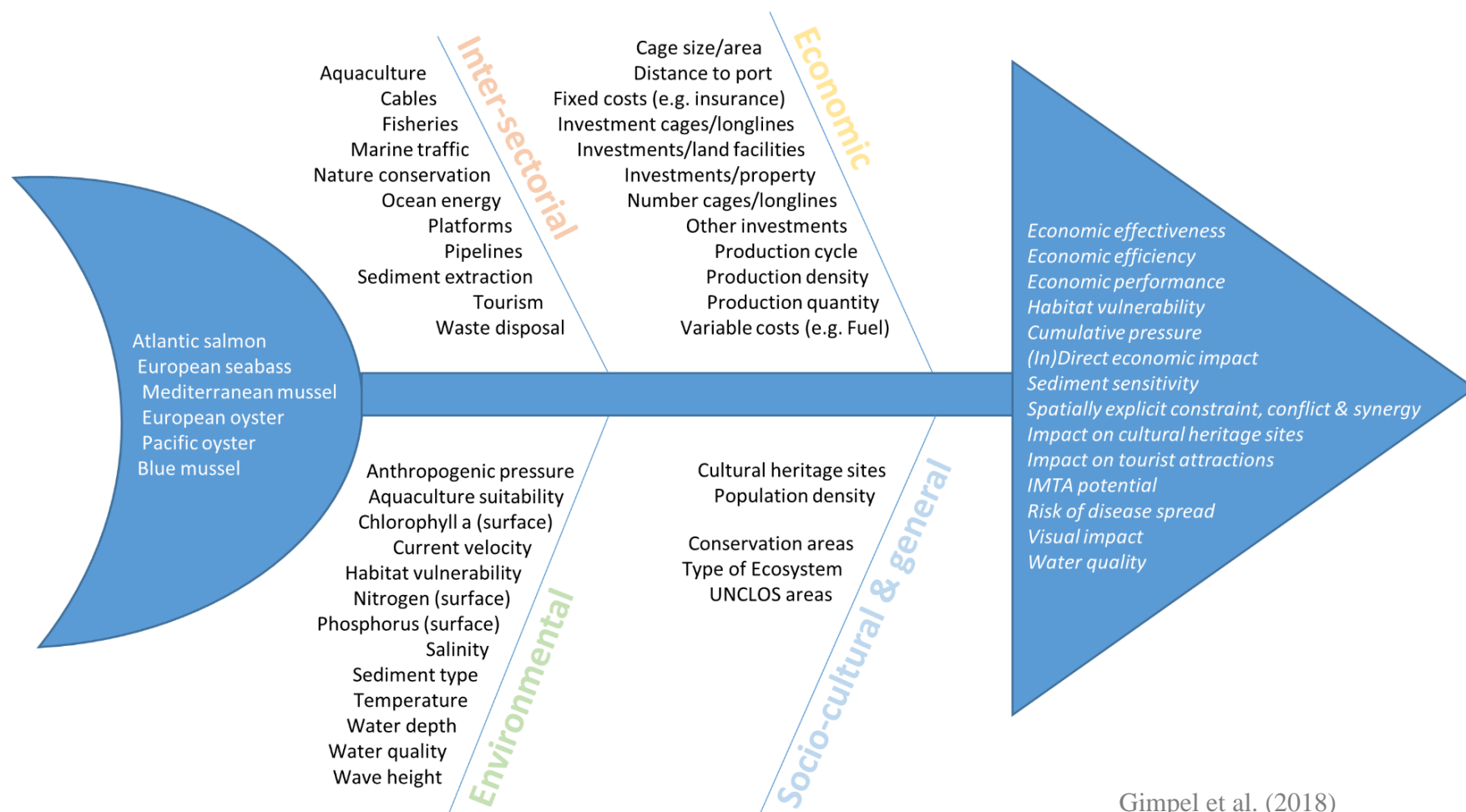
Gimpel et al. (2018)

AquaSpace tool – Process view
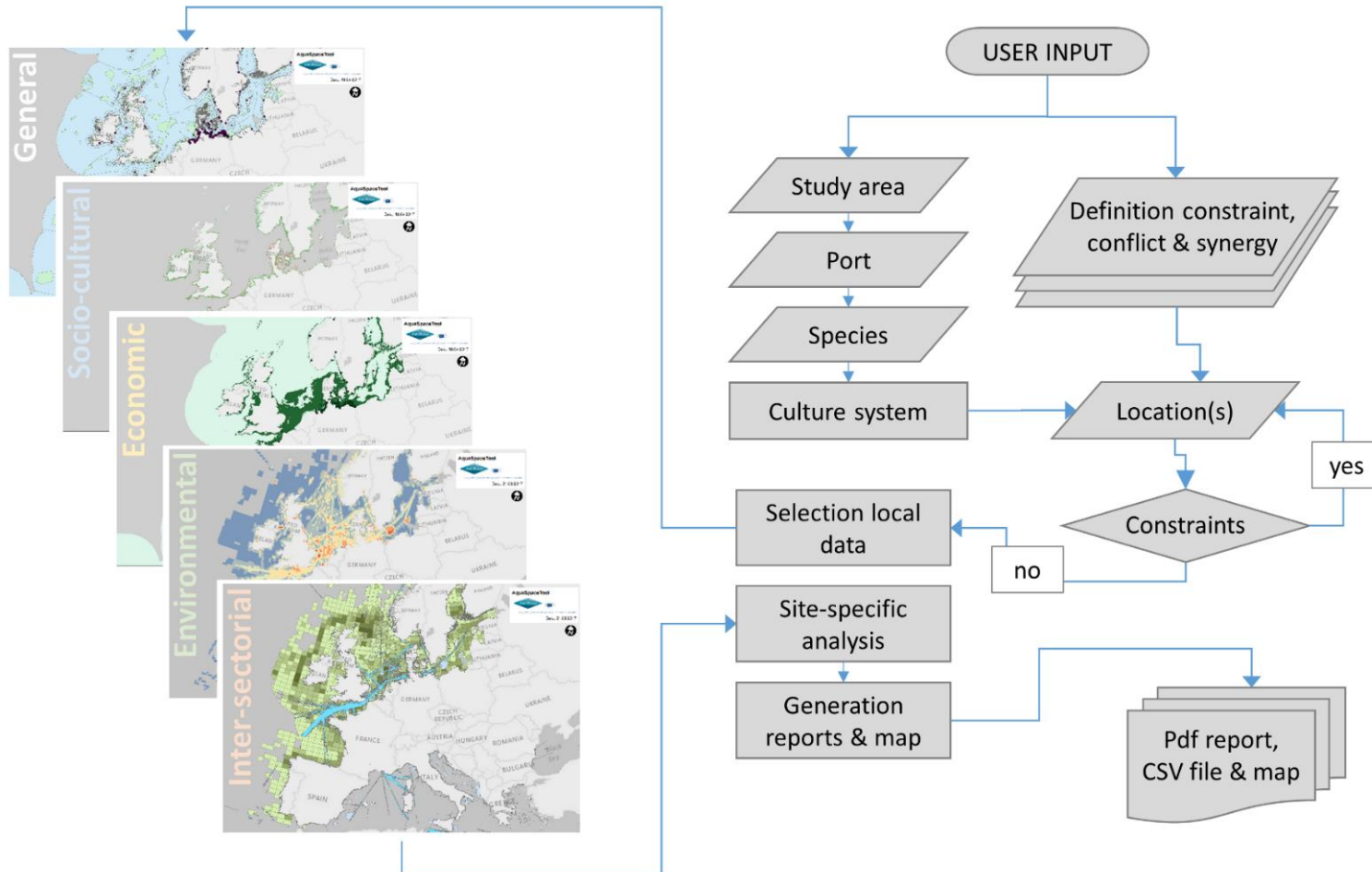
Depending on the specified aquaculture system for each planning scenario an integrated assessment of ecological, economic and social indicators is computed (Gimpel et al., 2018)

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AquaSpace tool – GIS AddIn mxd view

Gimpel et al. (2018)

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AquaSpace tool – PDF Output

AquaSpace tool – PDF Output incl. map
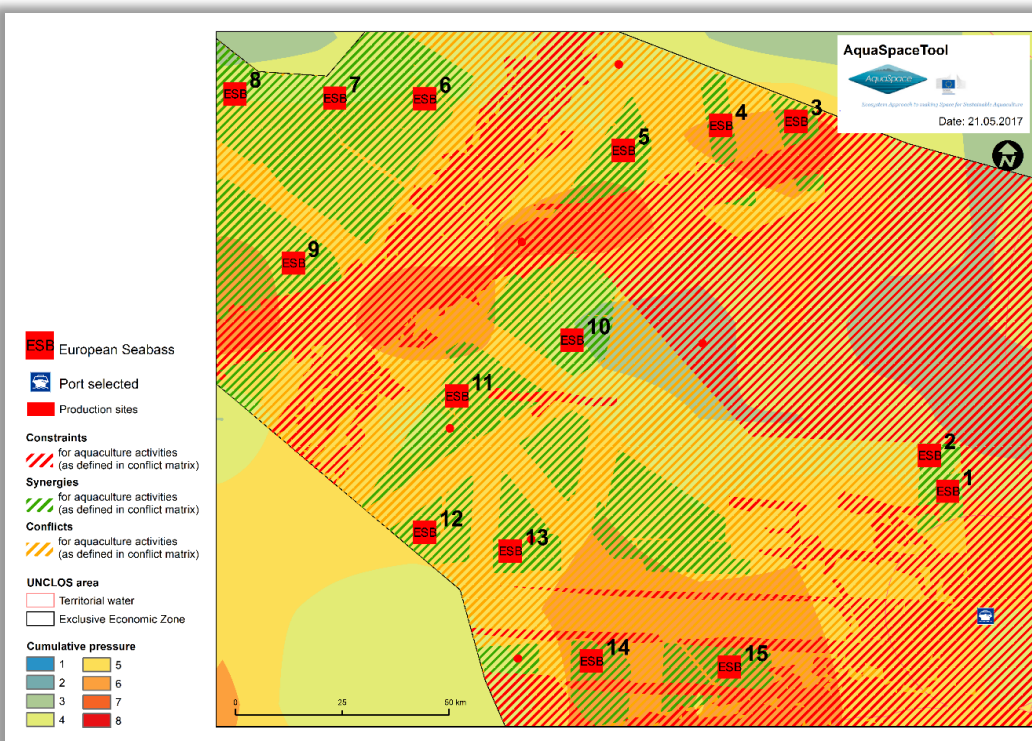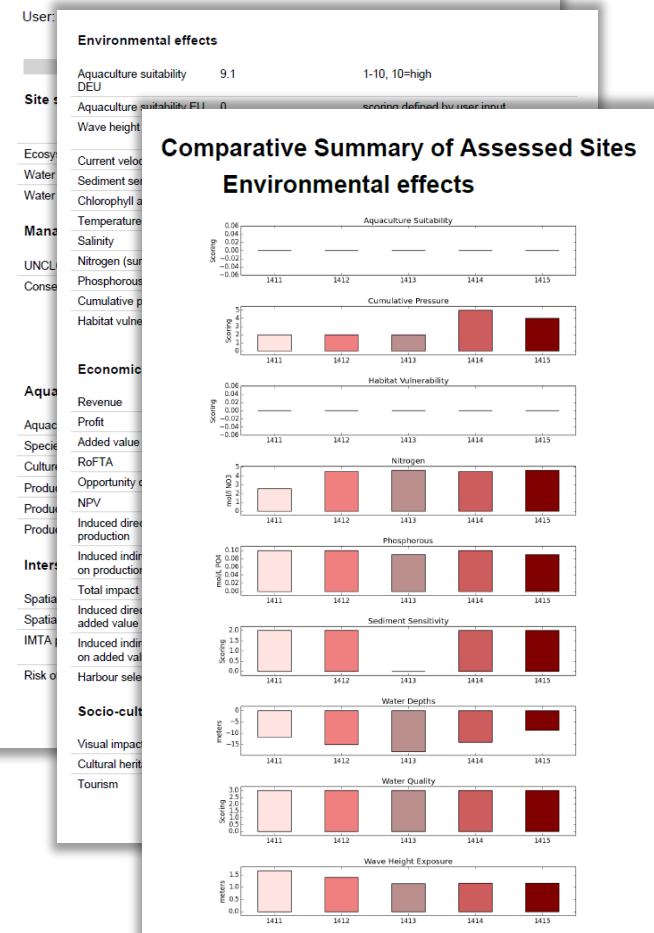
Constraints mapping based on user specified scoring of constraint, conflict and synergy potential

AquaSpace tool – Scenario & trade-off assessment
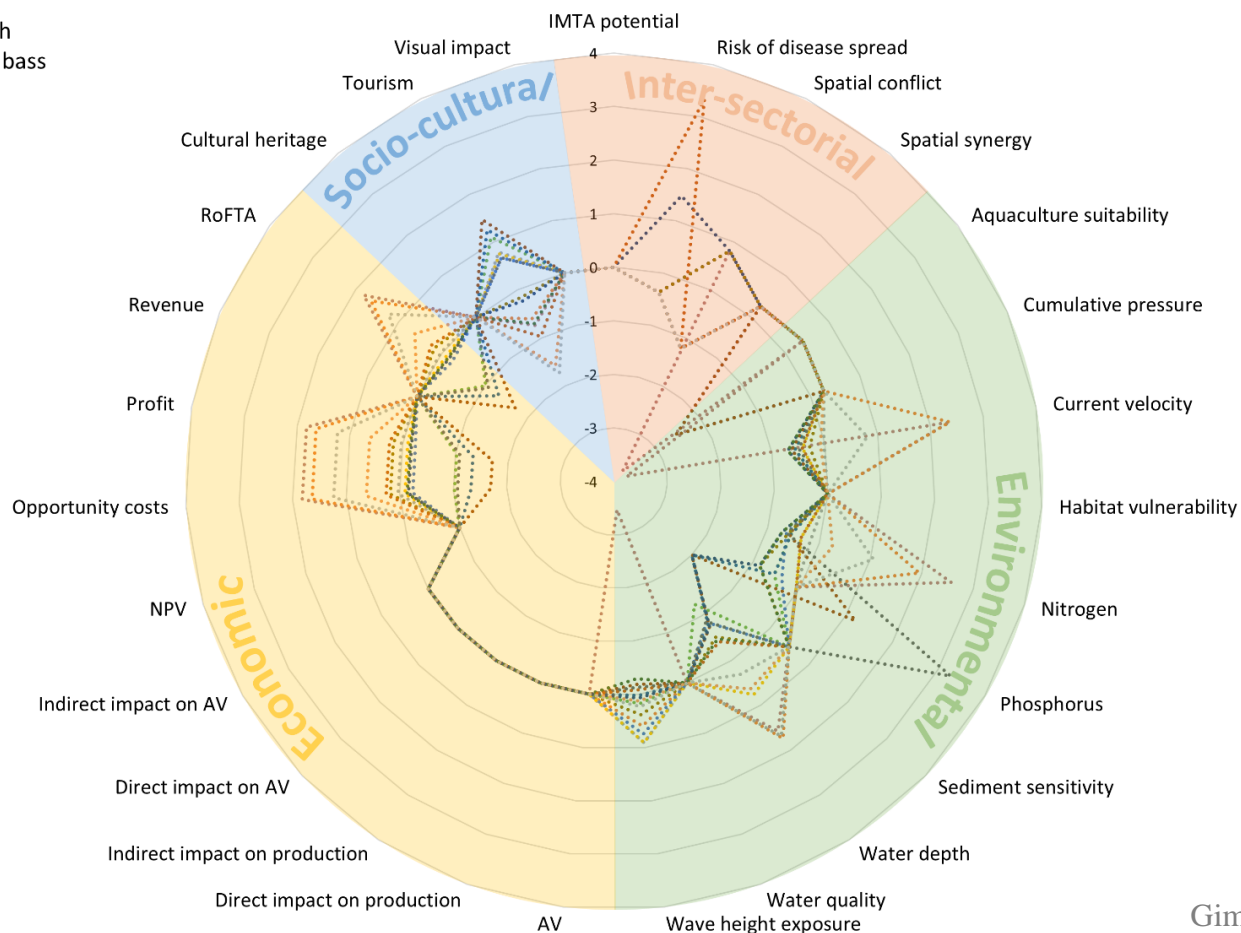
Gimpel et al. (2018)

Graphical comparison of indicators for each planning site and export of assessment results (template provided online)

The AquaSpace tool: a brief insight

The AquaSpace tool enables the user to assess individual marine site locations planned for aquaculture in terms of essential biological, ecological, economic, physical and social aspects. It is implemented as an AddIn for ArcGIS Desktop (from 10.3.1 and ArcGIS Basic with Spatial Analyst). The initial installation of the AquaSpace tool is a manual process of copying/pasting of file packages provided. All steps are precisely described in Gimpel et al. (2017) => Install the AquaSpace tool files.

Important to mention is that the AquaSpace tool comes initially with an EU-wide data package, provided as file GDB 10.3. Implemented are basic settings for test runs at German case study level, allowing the check if the installation procedure was performed properly. Ensuing from that, the user can customise the tool settings individually and even replace datasets. Those procedures are explained in Gimpel et al. (2017) => Customization options but require a minimum of ArcGIS usage skills. Register via https://gdi.thuenen.de/geoserver/sf/www/aqspce.html) to get access to comprehensive video instructions for installation process and usage of the tool - provided online (https://free-redmine.saas-secure.com/projects/aqua).

AquaSpace tool components

The user receives via => https://gdi.thuenen.de/geoserver/sf/www/aqspce.html access to the AquaSpace Redmine website, where all AquaSpace tool files, technical documents as well as video instructions are provided, facilitating the installation and testing of the AquaSpace tool. The current status of technical documentation can be found under => Documents. In addition, user requests (in particular regarding tool bugs, data hints or support requests) can be placed under => New Issue.

The tool is composed of:

- The mxd (ArcGIS format) project
- The tool bar
- The Geodatabase (GDB)

The Arc GIS mxd file visualises the spatial extent of the tool in terms of a background map (esri bg map), all data sets required to run the tool and the respective symbology. Therefore, it ensures the correct symbolisation and paths' availability when using the tool.

AquaSpace tool - Step by step application
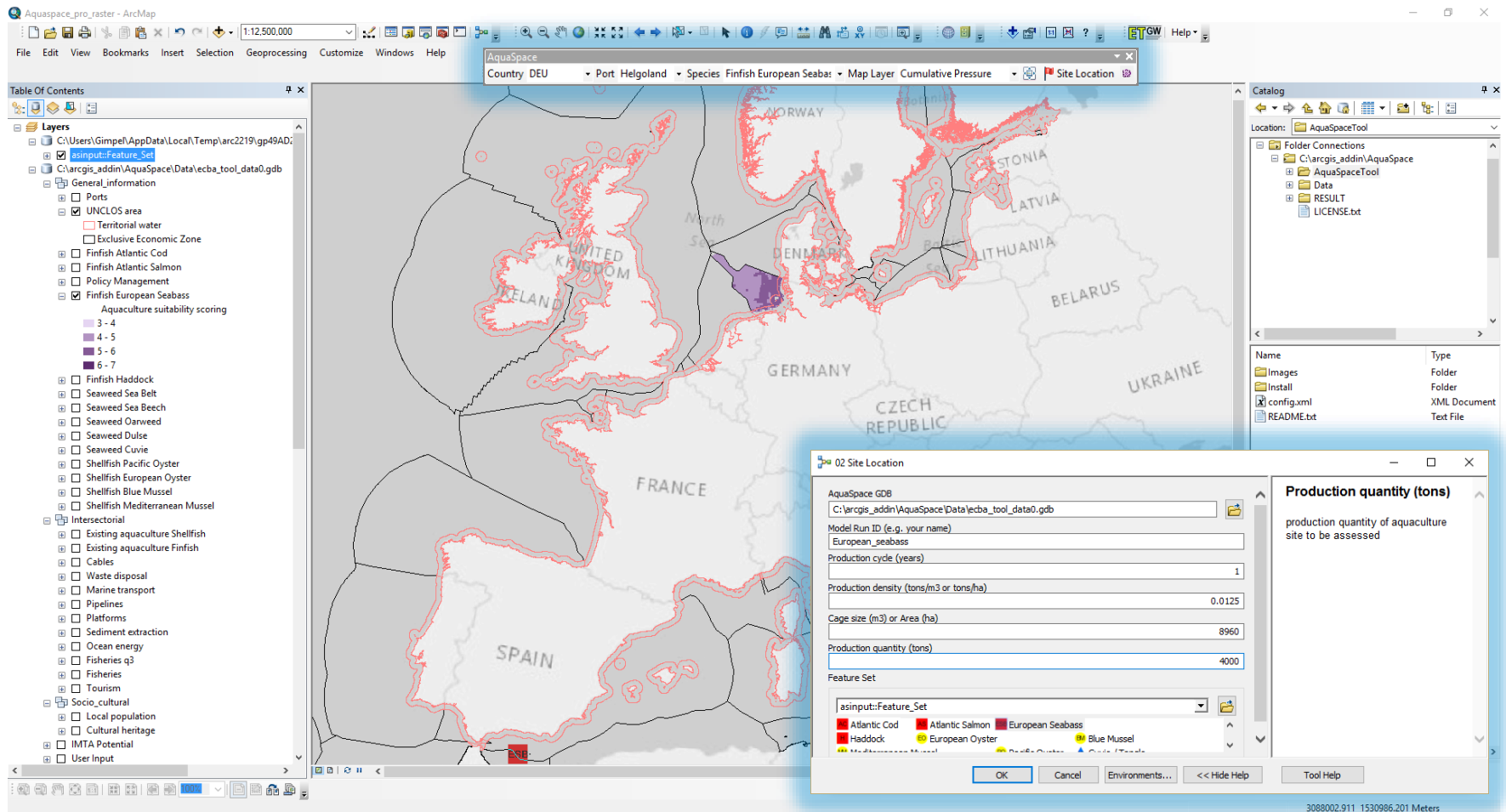
The AquaSpace mxd, including the table of contents (left), the AquaSpace toolbar (top) and the Arc GIS catalog window (right), showing the AquaSpace Geodatabase.

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AquaSpace tool - Step by step application

*Quick start guide**

1. Part of AquaSpace tool Installation

- Check the AquaSpace tool system requirements carefully, see [[http://free-redmine.saas-secure.com/documents/83]]
- Watch the video of installation process, see [[http://free-redmine.saas-secure.com/documents/85]]
- Get the latest version under => **News**, consider your ArcGIS version and follow the installation/update instructions carefully, in case you have questions please do not hesitate to place your support request under => **New issue**
- Watch the video for AquaSpace tool usage, see [[https://free-redmine.saas-secure.com/documents/91]]
- Test your local installation by a test run using the default GDB (German case study) simply by starting the **Aquaspace_pro.mxd** file under => C:\arcgis_addin\AquaSpace\Data, if you get an error or warning, please check the track list under issues [[https://free-redmine.saas-secure.com/projects/aqua/issues]] and place a new issue here in case you could not find the support you need

2. Part of GDB Data Adjustments for your AquaSpace case study area

- **Clip your country data set / case study area:** this step is recommended in case there is no case study area listed under prepared country datasets, see: [[https://free-redmine.saas-secure.com/news/46]]. In this context, by offering an EU-wide data package we aim to minimize the user effort of data harmonization and data adding. But for ArcGIS performance issues it is highly recommended to clip your country/ case study data set, see video instructions [[http://free-redmine.saas-secure.com/documents/82]]. This step is completed as soon as your clip result is stored under => C:\arcgis_addin\AquaSpace\Data and is renamed by the standard **ecba_tool_data0.gdb**
- Add your own data to the AquaSpace GDB, see [[https://free-redmine.saas-secure.com/documents/92]]
- Create your individual interaction conflict matrix, see Tool use case: create interaction matrix
- Now you are ready for using the AquaSpace Tool for your case study, please go to Tool application

*The user receives via => https://gdi.thuenen.de/geoserver/sf/www/aqspce.html access to the AquaSpace Redmine website

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Install the AquaSpace tool files

1. Store the downloaded files on your PC
AquaSpace Tool expects the following storage path => **C:\arcgis_addin\AquaSpace**. Different storage paths would require more adjusting configuration work at the tool installation.
Go to => C:\arcgis_addin\AquaSpace\AquaSpaceTool and double-click the "AquaSpaceTool Esri Addin file"

2. Adjust the PC Python Library
Backup the current Python Installation => C:\Python27\ArcGIS10.3 – copy folder (this avoids losing the original scripts that come with ArcGIS) and name it ArcGIS10.3_ESRI
In C:\Python27 overwrite the ArcGIS10.3 folder with the new folder "ArcGIS10.3" PLEASE NOTE both installation procedures for python library transfer – one for ArcGIS 10.3 and another for ArcGIS 10.4 - depending on your local ArcGIS version

3. Adjust ArcGIS Map Style
Transfer the Legend Item "IMTA" from the source file => ArcGISMapStyleToCopy_IMTA.style ("Style Manager": „Styles" / "Add Style to list") to your personalized ArcMap Style => C:\Users\<USER_NAME>\AppData\Roaming\ESRI\Desktop10.3\ArcMap with copy&paste by using the ArcMap Style Manager (menu "Customize"=>"Style Manager") (Fig. 14)

4. Add the AquaSpace toolbar to your mxd
Open "Aquaspace_pro_raster.mxd". The layer data sources will be invalid for Constraints, Conflicts and Synergies (those will re-connected under Gimpel et al. (2017) => Create interaction matrix)
Choose the toolbar via => Customize => Toolbars => "AquaSpace"
Drag and drop the toolbar on the top of your mxd

AquaSpace tool - Step by step application

Perform site assessment

The AquaSpace AquaSpace toolbar simplifies to perform a site assessment. Follow the toolbar inputs from left to right (excl. the purple button 'create interaction matrix') and make your choices (which need to be renewed for each tool run) regarding:

The selection of the extent (Country) => selection is optional, you can also zoom into the mxd to choose your favoured site

The harbour from which the aquaculture site will be supplied (Port) => selection required

The aquaculture species you want to assess (Species) => selection required

The background layer which shall be highlighted in the result map (Map Layer) => selection optional

The extent defined for the assessment (blue button) => selection required

The provision of sites to be assessed using the siting tool (Site Location)
- Choose a => Model Run ID (e.g. your name)
- Choose a => Production cycle (years)
- Choose a => Production density (tons/m³ or tons/ha)
- Choose a => Cage size (m³) or Area (ha)
- Choose a => Production quantity (tons)
- Click on the feature set of the species you want to assess and click a point on the map to define the site to be assessed
- Click "Ok"

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Software availability

Name of software: AquaSpace tool - a GIS AddIn

Developers: Antje Gimpel, Sandra Töpsch, Vanessa Stelzenmüller

Email: antje.gimpel@thuenen.de

Year first available: 2017

Operating System: Microsoft Windows 7, Windows 8/8.1 (32 or 64 bit) or Windows 10

Processor/CPU: 2.7 GHz Intel Core i5 processor or equivalent (4 cores) (hardware below/above will increase/decrease tool run times)

System RAM: 4 GB total minimum, 16 GB recommended

Windows Feature .NET Framework: .NET 4.6 Framework

ESRI ArcGIS license needed: ArcGIS Desktop Basic, Standard or Advanced with Extension Spatial Analyst, installation 10.3 and higher

Python Environment: Standard Python library 32bit of ArcGIS installation 10.3 and higher

Program size: 1.7 MB; GDB 400 MB

Availability: https://gdi.thuenen.de/geoserver/sf/www/aqspce.html

Cost: nil

Summary AquaSpace tool application

✓ Integrates robust indicators to give a first overview
✓ Informs about the spatial extent of management effects
✓ Allows holistic scenario comparison and trade-off assessments
✓ Facilitates the presentation of associated opportunities and risks / management decisions
✓ Tool settings can be changed individually and datasets replaced

– Limited data availability at EU level (low resolution)
– AquaSpace tool currently presents a static GDB (response of WFS too slow)
– Temporal aspects only considered indirectly ('annual mean values')
– Most economic indicators driven by 'distance to port' calculations

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Outlook

- Ecosystem-based MSP processes will have to account for existing and emerging activities such as fisheries and aquaculture
- Spatial planning based on EAA would:
  - simplify licensing process
  - promote sustainable development
  - mitigate spatial use conflicts
- Practical planning tools are emerging
- Need to promote the uptake of decision-support tools in the MSP processes

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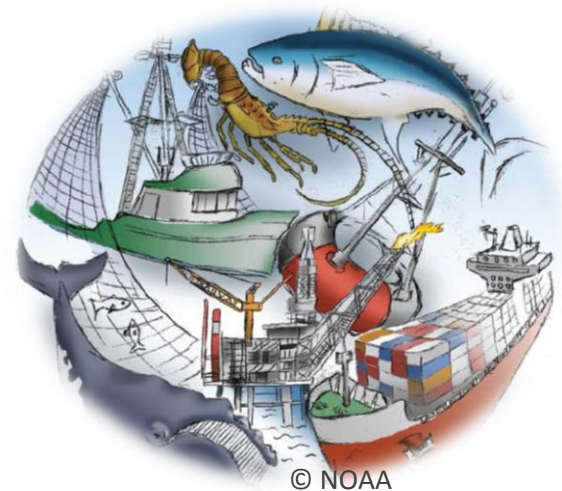
AquaSpace tool – Current implementations
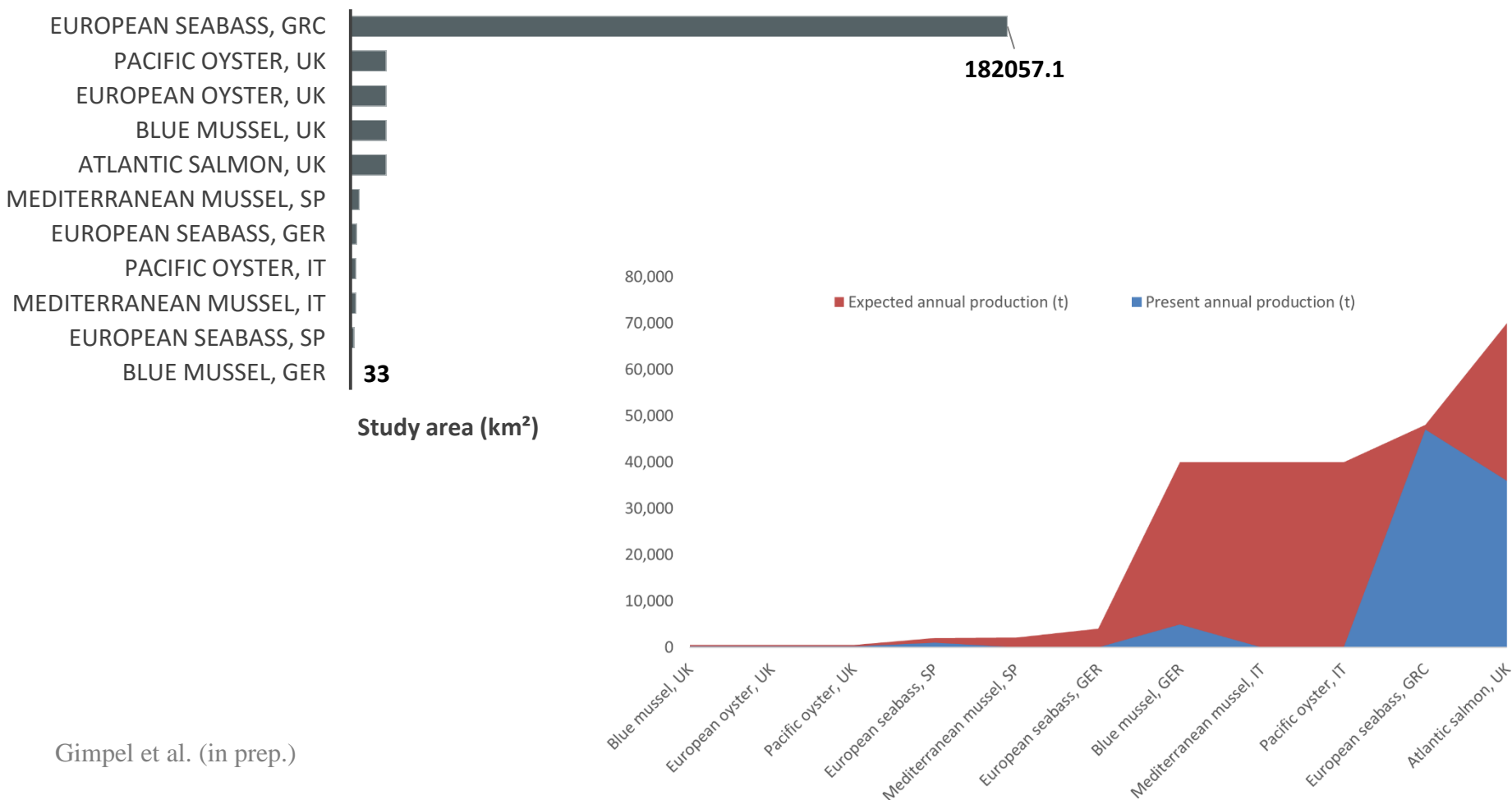
Gimpel et al. (in prep.)

References related to the AquaSpace tool

Published (or under revision):

Gimpel, A., Stelzenmüller, V., Töpsch, S., Galparsoro, I., Gubbins, M., Miller, D., et al. 2018. A GIS-based tool for an integrated assessment of spatial planning trade-offs with aquaculture. Science of the Total Environment. DOI 10.1016/j.scitotenv.2018.01.133

Gimpel, A., Stelzenmüller, V., Marbà, N., Aguilar-Manjarrez, J., Arantzamendi, L., Asplin, L., Black, K., et al. 2016. Tools and Methods to support an Environmental Approach to Aquaculture (EAA) – practical needs. Thünen Institute, Hamburg and AquaSpace project (H2020 no. 633476), Oban. Deliverable 3.1. Pdf obtainable from http://www.aquaspace-h2020.eu/wp-content/uploads/2016/10/Tools-and-methods-supporting-EAA.pdf.

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Pınarbaşı, K., Galparsoro, I., Borja, Á., Stelzenmüller, V., Ehler, C., and Gimpel, A. 2017. Decision Support Tools in Marine Spatial Planning: Present Applications, Gaps and Future Perspectives. Marine Policy, 83: 83-91.

In preparation:

Galparsoro et al. Basque country case study

Galparsoro et al. AquaSpace synthesis: lessons learnt and recommendation towards MSP and aquaculture

Gimpel, A., Stelzenmüller, V., Töpsch, S. et al. In prep. The AquaSpace tool. Experiences, key issues, short comings

Watret, R., Gubbins, M., Gimpel, A., et al. (in prep.). Multicriteria evaluation GIS applied to aquaculture in a Scottish Marine Region. A comparison of approaches (The AquaSpace tool vs MARS)

Exercises*

1) Calculation of an environmental, an economic and a social scenario for **European seabass in Germany** (use of interaction matrix, economic input table and user-specific input as provided)

2) Calculation and interpretation of a trade-off assessment comparing the environmental, economic and social scenario created in task 1 for **European seabass in Germany** (use of template under https://free-redmine.saas-secure.com/documents/139)

3) Calculation of an environmental, an economic and a social scenario for the **Mediterranean mussel in Spain**

   • Download of Spanish GDB under http://free-redmine.saas-secure.com/news/64

   • Adaption of interaction matrix → supplementary information A

   • Adaption of economic input table → supplementary information B

   • User-specific input → supplementary information C

*ESRI ArcGIS license required: ArcGIS Desktop Basic, Standard or Advanced with Spatial Analyst Extension

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FAO, World Bank. 2015. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. Policy brief. Rome, Italy.

Foley, M. M., Halpern, B. S., Micheli, F., Armsby, M. H., Caldwell, M. R., Crain, C. M., Prahler, E., et al. 2010. Guiding ecological principles for marine spatial planning. Marine Policy, 34: 955-966.

Galparsoro, I.; A. Murillas, K. Pinarbasi, Á. Borja, A. M. O´Hagan E. MacMahon, A. Gangnery, R. Corner, J. Ferreira, R. Ferreira, A. Gimpel, A. Boyd, J. Icely, Ø. Bergh, C. Donohue, H. Lui, S. Billing, J. M. Garmendia, L. Lagos and L. Arantzamendi. 2017. Synthesis of the lessons learned from the development and testing of innovative tools to support ecosystem-based spatial planning to aquaculture. Deliverable 5.1; AquaSpace: Ecosystem Approach to making Space for Aquaculture. EU Horizon 2020 project grant nº. 633476. 103 pp.

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Good luck!

URL AquaSpace tool:
https://gdi.thuenen.de/geoserver/sf/www/aqspce.html

„Easy to understand"- MSP brochure ; Baltic Sea Plan (WWF)

Supplementary Information - A

OID	USE_A	USE_B	CONFLICT_S	SAFETY_BUF	COMBINATIO	GEOMETRY
0	Aquaculture	Aquaculture finfish	1	0	01	PG
1	Aquaculture	Aquaculture shellfish	1	0	02	PG
2	Aquaculture	Platform	6	0	03	PT
3	Aquaculture	Cable	6	0	04	PL
4	Aquaculture	Pipeline	0	0	05	PL
5	Aquaculture	Sediment extraction	6	0	06	PG
6	Aquaculture	Shipping	5	0	07	PG
7	Aquaculture	Waste disposal	6	0	08	PT
8	Aquaculture	Policy Management	6	0	09	PG
9	Aquaculture	Ocean energy	6	0	10	PG
10	Aquaculture	Fisheries q3	0	0	11	PG
11	Aquaculture	Fisheries	0	0	12	PG
12	Aquaculture	Tourism	3	0	13	PG

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Supplementary Information - B

OID	NAME	PARAMETER	UNIT	VALUE
0	ui1	Investment equipment (per cage/trestle/longline)	Euro	18875.72
1	ui2	Other investments (excl. Equipment, land facilties and properties)	Euro	253650
2	ui3	Investment land facilties	Euro	0
3	ui4	Investment property	Euro	0
4	ui5	Market value culture species per ton	Euro/tons	650
5	ui6	Annual expenditure on wages/salaries	Euro	174000
6	ui7	Annual intermediate costs (variable, e.g. juveniles/seeds/food)	Euro	35.17
7	ui8	Annual rate on capital resources (e.g. 1%=0,01)	%	0
8	ui9	Annual intermediate costs (fixed, e.g. insurance/maintenance and repair ship)	Euro	145265
9	AER	Interest rates (e.g. 1%=0,01)	%	6
10	ui10	Other costs (variable)	Euro	3500
11	ui11	Other costs (fixed)	Euro	29500
12	ui12	Average no. of days at sea/culture site	days	240
13	ID	Induced direct impact multiplier (e.g. 1%=0,01)	%	0.49
14	II	Induced indirect impact multiplier (e.g. 1%=0,01)	%	0.9
15	OM	Output multiplier (e.g. 1%=0,01)	%	1.94
16	IM	Income multiplier (e.g. 1%=0,01)	%	0.28
17	IE	Income effects (e.g. 1%=0,01)	%	0.51
18	ui13	Average fuel costs	Euro/km	4.58

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Supplementary Information - C

Description	Unit	Quantity
Production cycle	years	1
Production density	tons/m³/ha	42
Cage size/area	m³/ha	0.34
Production quantity	tons	420

CPD online material

For more information about

the AquaSpace Masters module

and spatial planning toolbox,

visit our website:

www.aquaspace-h2020.eu

Horizon 2020