Introduction and Study Guide for a Masters Module on PLANNING AND MANAGING THE USE OF SPACE FOR AQUACULTURE

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Abstract

The aims of the H2020 AquaSpace project (contract no.633476; 2015-2018) were "to provide increased space of high water quality for aquaculture by adopting the Ecosystem Approach to Aquaculture, and Marine Spatial Planning". One of its outputs was a set of on-line materials corresponding to a 10 ECTF credit Masters-level (EQF 7) module in 'Planning and Managing the Use of Space for Aquaculture'. This document introduces these materials, which are AquaSpace project deliverable 6.1 and can be found at www.aquaspace-h2020.eu. *They may be used under a* Creative Commons Attribution-ShareAlike 4.0 International License.

Contents

1 What this is

Aquaculture is the cultivation or farming of aquatic organisms, including fish, invertebrates and algae. What you are reading is an introduction to web-based material that makes up an advanced course on *Planning and Managing the Use of Space for Aquaculture*.

These materials are freely available to

- any teacher who wishes to construct, validate and deliver such a course, or use any part for teaching;
- any person who wishes to learn more about the planning of aquacultural development.

You can study these materials if you wish to develop a detailed and critical knowledge of societal and environmental contexts for the use of space by aquaculture, including

- an understanding in principle of how to develop and apply national and regional spatial planning and management frameworks for aquaculture;
- a critical understanding of social and environmental concepts relevant to planning and managing space for aquaculture;
- the knowledge needed to understand and critically select tools from the Aquaspace toolbox and other sources of tools.

2 Academic level, credits, and prior requirements

The material has been planned as:

- a Masters level module, corresponding to European Qualification Framework (EQF) level 7, Republic of Ireland NFQ level 9, or Scotland SCQF level 11;
- about 250 study hours, corresponding to 10 European Credit Transfer Framework (ECTF) credits, or in Scotland 20 SCQF credits.[1]

[1] Note that the actual award of credit will require the course to be validated and examined by a university.

Education includes the teaching of skills or competencies (*techne*) as well as knowledge (*episteme*). The main focus of this module is on knowledge. So far as this is concerned, EQF level 7 specifies (European Commission, 2008) that the content shall be of *"highly specialised knowledge, some of which is at the forefront of knowledge [about the topic], as basis for original thinking and/or research"* and that the level requires "*critical* awareness of knowledge issues within the [topic] and at the interface between fields [of knowledge]". The user of this material should be aware of the need for critical thinking, which is further discussed in section 5.

Finally, the material in this module draws on the academic disciplines of economics, ecology, planning and social sciences. The authors of this material assume that someone using it for teaching purposes will have an advanced qualification in at least one of these academic disciplines, but we don't require specialised prior knowledge of someone using this material to learn. Nevertheless, the content is intellectually demanding and requiring of an educational level equivalent to an honours degree (EQF level 6).[2]

3 The AquaSpace project

This material is a product of the AquaSpace project which was operational between 2015 and 2018. Core funding for the project was provided by contract no.633476 from the European Union's Horizon 2020 programme for research and development. There were 22 partners from organisations in Australia, Canada, China, France, Germany, Greece, Hungary, Ireland, Italy, New Zealand, Norway, Portugal, Spain, UK and USA. I will explain something about the project in order to aid understanding of the choice of material for inclusion in this course.

The AquaSpace project had the goal of providing increased space for aquaculture to allow increased production of cultivated organisms in the sea and fresh-water. The context was the need to find new sources of food (especially, protein),[3] whilst ensuring economic, environmental, and social sustainability through adoption of the Ecosystem Approach to Aquaculture (EAA).

The project identified the main constraints that seemed to be impeding the development of a variety of types of aquaculture. Software and procedural tools that could help overcome these constraints were identified and

[2] Corresponding to RoI NFQ level 8 and Scotland SCQF level 10

[3] The need for new sources of food emerges from considering the expanding human population of the world, people's increasing standard of living, and the widely recognized state of the world's capture fisheries as operating at or above maximum sustainable yield.

evaluated. Some tools were tested in real case studies, and customized and improved during the project, and six new tools were created to respond to some of the requirements identified for further development and better management of aquaculture. Most of the analysed tools were related to spatial planning of aquaculture.

The application of the EAA and the utility of relevant tools was assessed in 15 case studies at 17 sites in Europe and in North America, China, Australia and New Zealand. The case studies embraced a range of spatial scales, a variety of types of aquaculture at different trophic levels with different environmental interactions, and a number of space-related development constraints as defined by local stakeholders.

The theoretical and technical knowledge gained during the project was used to assemble two sets of on-line materials, available at www.aquaspace-h2020.eu. The AquaSpace Toolbox comprises information about the tools. The educational material includes the Masters Module, to which this is an introduction, and a Continuous Professional Development (CPD) course. The ToolBox and Masters Module cross-reference each other, because the Masters Module provides background knowledge for the tools and the ToolBox provides a resource for the Masters Module. See appendix C.

4 Module structure

The Masters Module comprises a set of 12 topics or *units*, each representing 20 - 25 study hours. If taught face to face, each unit could include a 1 hour lecture, either a 1 hour tutorial or 3 hours practical, and up to 23 personal study hours. The material presented here is intended to allow a lecturer to prepare such a module or an interested person to study one or more units. Please note that no support can be provided for use of this material.

For each unit we provide:

- a set of slides
- a written text
- other items, which might include suggestions for practical work, links to videos, further reading.

The relationship between the text and the slides varies. As a minimum, the text always includes:

- a study guide with learning outcomes

- a set of self-assessment questions to assess achievement of those outcomes

In some cases the text is long and is the main study material for the unit. In other cases it is the slides that perform this function.

The text in Unit 11 links to:

- sets of slides that can be drawn on to illustrate local applications, using findings from the Case Studies carried out during the Aquaspace project.

Appendix A lists the units and summarises their contents. It will be seen that the module 'tells a story', comprising three main parts:

- An *Introduction* to aquaculture, the Ecosystem Approach, (marine) spatial planning, and the theory needed to integrate knowledge from the natural sciences with that from the social sciences - for we see the constraints on aquacultural expansion being derived from society as much as they are derived from environmental limitations.
- Accounts of the principles behind many of the *Tools* developed and tested during AquaSpace.[4]
- A final pair of units, introducing the *case studies* and discussing *the way forward* for aquaculture on the basis of what was learnt during the AquaSpace project.

5 Criticality

This is a Masters level module, and EQF level 7, specifying the learning outcomes for this level, stresses the need for a *critical understanding* of the material. *Critical* means more than merely pointing out what is wrong with something. It means "fully informed, capable of supporting in-depth analysis and assessment".[5]

This is also a module about science and its application. Because science operates through the formulation and testing of hypotheses of general explanatory power, being *critical* requires understanding of the hypotheses and

[4] As we use it, the word *tool* has a very broad meaning: "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 other approaches that can be used or be implemented to help and support the development of aquaculture ..." (Galparsoro et al., 2017).

[5] Quote from Scottish Credit and Qualifications Framework for level 11, equivalent to EQF 7.

the theoretical framework of which they are a part, and asking whether the data presented for hypothesis testing are reliable and whether they might support alternative hypotheses. Following Popper (1959) I view scientific knowledge as always provisional, always evolving, and always open to criticism. A critical approach is especially necessary is scientific knowledge is to serve practical purposes such as the expansion or regulation of aquaculture.

In addition, the module integrates social and natural sciences. In units 2 and 12, I have drawn on the philosophical or methodological perspective called *Critical Theory* by social scientists (Moon and Blackman, 2014). This perspective requires research to be conducted with the practical aim of improving society and within a theoretical framework, whilst continuously reflecting on the validity of the aim and on the utility, consistency and verifiability of the theory.

Finally, a critical approach also requires that all factual statements can be sourced - i.e. traced to other public documents that are cited as references - so that they can, if required, be critiqued. Such citation is a normal part of scholarly custom, because it allows for verification. The reference lists included in most units are each several pages long, because there are many statements that might need to be verified. It is not intended that (excepting what is explicitly suggested for further reading) these references need to be consulted, unless the reader wishes to learn more about a particular aspect.

Wherever possible the citations are of documents published in the scientific literature after peer review and thus (in principle) satisfying their academic discipline's epistemological requirements for valid knowledge. Nevertheless, many scientific papers are published behind pay-walls, accessible only to to researchers and students belonging to organisations that pay publishers' fees. Because this module is aimed at a wider readership, its recommended readings and exercises as far as possible include some free-to-use materials, chosen on the basis that they too satisfy the relevant epistemological requirements.[6]

[6] *Epistemology* is the discipline concerned with the quality of knowledge. How do we get and verify it? What counts as valid knowledge for society, or for a group of people within society, such as an academic discipline? See Moon and Blackman (2014).

6 Module Learning Outcomes

After completing this module, a student will be able to

- understand, describe and critically evaluate issues facing the spatial expansion of aquaculture
- place those issues in a conceptual framework derived from the *Ecosystem Approach to Aquaculture*
- be able to select from a range of economic, environmental, social and integrative tools for use in dealing with these issues

In addition, the text for each unit includes a set of unit-specific learning outcomes and, in most cases, a set of Self-Assessment Questions to test attainment of those outcomes.

7 Licence and Attribution

8 In conclusion

Now that funding for the AquaSpace project has ended, the authors of this material are not unfortunately able to provide support to other teachers and learners. We may, however, be able to add additional material to the AquaSpace website. For example, if the module is validated and taught by a university, I will, if allowed, add validation documents and examples of examination papers. Additionally, if users of the material develop relevant exercises, slides or text that they are willing to share, they could be added to the website.

References

Aguilar-Manjarrez, J., Soto, D., and Brummett, R. (2017). Aquaculture zoning, site selection and area management under the Ecosystem Approach to Aquaculture. A handbook. Report ACS18071, Food and Agriculture Organization of the United Nations, and The World Bank, Rome. Available at: www.fao.org/3/a-i6834e.pdf (part 1 only) and www.fao.org/3/a-i6992e.pdf (full report).

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Galparsoro, I., Murillas, A., Pınarbaşı, K., Borja, Á., O'Hagan, A. M., MacMahon, E., Gangnery, A., Corner, R., Ferreira, J., Ferreira, R., Gimpel, A., Boyd, A., Icely, J., Bergh, Ø., Donohue, C., Lui, H., Billing, S., Garmendia, J. M., Lagos, L., and Arantzamendi, L. (2017). *Deliverable 5.1: Synthesis of the lessons learned from the development and testing of innovative tools to support ecosystem-based spatial planning to aquaculture*. H2020 project 633476 Aquaspace, Oban. Available from Library/Main Reports page of the AquaSpace website: www.aquaspace-h2020.eu.

Moon, K. and Blackman, D. (2014). A guide to understanding social science research for natural scientists. *Conservation Biology*, 28(5):1167–1177. DOI: 10.1111/cobi.12326.

Popper, K. (1959). *The Logic of Scientific Discovery*. Hutchinson & Co, London. *Logik der Forschung* first published 1935 by Verlag von Julius Springer, Vienna, Austria; most recent (English language) edition 2002 by Routledge (Part of Taylor & Francis Group), London and New York.

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A List of Units

The 'story' told in this module falls into three parts:

- an introduction to the ideas involved in spatial planning and the Ecosystem Approach to Aquaculture, which provided the theoretical framework and perspective within which AquaSpace developed and tested tools: units described in sections A.1 to A.4;
- an introduction to the tools developed and/or tested during Aquaspace: units described in sections A.5 to A.10;
- a concluding pair of units, the first (described in section A.11) providing an overview of AquaSpace case studies to allow the user to find an account that exemplifies ideas, tools, or types of aquaculture they wish to study further; the second (in A.12) providing a discussion of the course and of AquaSpace findings.

AquaSpace partner organisations that contributed to the materials are listed in table 1.

A.1 Introduction

Full title: *Introduction to aquaculture: the global and EU context*

The unit introduces the global and European contexts for aquaculture: why it is needed, the main species that are cultivated and the main technologies used. Expansion of aquaculture in the EU requires more space with appropriate assimilative and carrying capacities; spatial planning is needed to resolve conflicts with other users of marine or land space; and the Ecosystem Approach to Aquaculture is needed to ensure environmental, economic and social sustainability for the industry.

Authors: João G. Ferreira (New University of Lisbon and LLE) & Paul Tett (SAMS)

A.2 The Ecosystem Approach

Full title: *The Ecosystem Approach to Aquaculture and Spatial Planning.*

The unit describes the Ecosystem Approach, its application to Aquaculture in the EAA, and the theoretical framework needed to understand the use

of spatial planning to deal with economic and social demands, whilst ensuring activities take place sustainably and without harm to marine ecosystem health.

Author: Paul Tett (SAMS)

A.3 Implementing the EAA

Full title: *Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture: a handbook*

The short text provides the study guide to part 1 of an FAO/World Bank handbook for the spatial management of aquaculture (Aguilar-Manjarrez et al., 2017). The handbook explains the four steps of national scoping, zoning, siting and areal management.

Author of text: Paul Tett (SAMS)
Authors of handbook: JoséAguillar-Manjarrez, Doris Soto & Randall Brummett (FAO & World Bank)

A.4 Marine Spatial Planning

Full Title: *Marine Spatial Planning in Europe: Opportunities for Aquaculture*

The unit introduces the concept of Marine Spatial Planning, which is increasingly being implemented as an integrated framework for the planning and management of marine activities. The text describes MSP, the early stages of its implementation in Europe under the Maritime Spatial Planning Framework Directive, and discusses the opportunities offered by, and the challenges to, MSP in the specific context of aquaculture.

Authors: Lucy Greenhill & Paul Tett (SAMS)

A.5 Geographic Information Systems

Full Title: *Introduction to Geographic Information Systems*

This unit introduces Geographic Information Systems (GIS) to Masters students. GIS provide a framework for gathering, managing, and analyzing spatial data. They are used in relation to aquaculture for bringing together information on natural resources, protected areas and outputs of models.

They provide tools for research and to inform marine spatial planning.

Authors: David Miller, Chen Wang, Gillian Donaldson-Selby, Dave Miller, & Margaret McKeen (JHI), Antje Gimple (Thünen Institute)

A.6 Integrating Tools

Full title: *Introduction to AquaSpace integrating tools*

The text introduces the principles behind tools for Marine Spatial Planning and site selection for aquaculture. Four tools are described. The META tool assembles data on growth conditions for cultivated species. The other three are spatial tools: WATER identifieslocations (in Europe) where these species can best be grown; the Aqua Investor Index guides selection of a country for investment; and the AquaSpace Tool - considered at length and the subject of the slides - evaluates sites and scenarios.

Authors: Vanessa Stelzenmüller & Antje Gimpel (Thünen Institute), Paul Tett (SAMS)

A.7 Remote sensing

Full title: *Remote Sensing for Marine Spatial Planning and Aquaculture*

This unit introduces the use of Remote Sensing in Marine Spatial Planning and site selection for aquaculture. Brief case studies illustrate the aquacultural utility of satellite remote sensing of the coastal waters of the Algarve, the northern Adriatic Sea, and a bay in northern France; a case study in Nova Scotia illustrates the use of low altitude imaging. An exercise involves the use of the ESA SeNtinel Application Platform (SNAP) software.

Authors: Sònia Cristina, Bruno Fragoso, John Icely (SGM), Jon Grant (Dalhousie)

A.8 Disease modelling

Full title: *Sea lice and Salmon Aquaculture*

The unit describes the problem of sea-lice infestation in salmon aquaculture and how modelling can help spatial planning and site management to ameliorate the problem. It comprises a a set of slides, a commentary on the

slides, a computing exercise, and a study guide.

Author: Tom Adams (SAMS)

A.9 Visualisation

Full title: *Introduction to Visualisation Issues and Tools*

The text supports a slide sequence that introduces visualisation issues and tools in relation to planning for aquaculture. The unit includes examples of tools, and a conceptual framework to support the assessment, evaluation and interpretation of the potential visual impacts of aquaculture developments on seascapes. The data and examples are from the AquaSpace case study areas of Argyll and Bute, Scotland, UK, and south-east North Sea, Germany.

Authors: David Miller, Chen Wang, & Gillian Donaldson-Selby (JHI)

A.10 Social tools

Full title: *Social Investigation and Public Engagement Tools*

Text and slides provide an introduction to some of the social investigation and engagement tools that can be used for inquiry into public attitudes to aquaculture and thus to understand the extent to which an aquacultural enterprise has 'social licence to operate'.

Authors: Suzannah-Lynn Billing & Paul Tett (SAMS)

A.11 Case Studies

Full title: *Introduction to AquaSpace Case Studies and ToolBox*

The text provides an overview of AquaSpace Case Studies and an introduction to the Case Study slide presentations, enabling selection of Case Studies that exemplify particular tools or ideas. The slides themselves are found on the Case StudyThe text also provides a link to other resources on the AquaSpace website, including those relating to spatial planning tools and the information about them available from the AquaSpace on-line ToolBox.

Authors: Paul Tett (SAMS), Øivind Strand & Øivind Bergh (IMR)

A.12 Discussion

Full Title: *Discussion of Spatial Planning for Aquaculture*

The unit text provides a backwards look at, and a critical overview of, the course and a discussion of the way forward for spatial planning of Aquaculture.

Authors: Paul Tett (SAMS) & Ibon Galparsoro (AZTI)

Table 1: AquaSpace partner organisations contibuting to this module

AZTI	Fundacion AZTI - AZTI Fundazioa, Pasaia, Spain
Dalhousie	Dalhousie University, Halifax, Canada
FAO	Food & Agriculture Organisation of the United Nations, Rome, Italy
IMR	Havforskningsinstituttet, Bergen, Norway
JHI	James Hutton Institute, Dundee, Scotland, UK
LLE	Longline Environment Ltd, London, UK
SAMS	Scottish Association for Marine Science, Oban, Scotland UK
SGM	Sagremarisco-Viveiros de Marisco Lda., Praia de Salema, Portugal
Thünen Institute	Johann Heinrich von Thuenen-Institut, Bundesforschungsinstitut Fuer Laendliche Raeume, Wald und Fischerei

B List of Case Studies

Sets of slides are available for most Aquaspace Case studies, backed up by longer reports assembled by Strand and Bergh (2018) as Aquaspace Deliverable 4.2. The following list gives location, type of aquaculture, and main issues investigated in the Case Studies.

1. Adriatic Sea, Italy; bottom and suspended cultivation of bivalves; issues were proximity to protected area and conflicts with tourism and fisheries

2. Algarve Coast, Portugal; cage and pond cultivation of finfish and suspended and bottom culture of shellfish; issues were co-use, optimising space allocation, and disease connectivity

3. Basque County, Spain: suspended culture of shellfish; issues were making space for, and changing social attitudes to, aquaculture

4. Békés County, Hungary: freshwater fish cultivation in ponds and tanks; issues were proximity to bird reserves, availability of clean water

5. Carlingford Lough, Ireland/UK: shellfish (trestles, bottom); issues were: complex governance, co-use by several sectors.

6. Great Bay (Pisccataqua, New Hampshire) and Long Island Sound (Connecticut), USA: shellfish (trestles, bottom); issues were: legal constraints and use conflicts

7. Houtman Abrolhos Islands, western Australia: shellfish (suspended), finfish (cages); issues were: conservation area, co-use, potential for disease spread

8. Mediterranean Sea: cage culutre of warm-water finfish; issues were: co-use with other sectors; complex goverance; Multiple EEZ

9. Normandy and Cancale (the Bay of Seine and the Normandy-Brittany Gulf), France: shellfish (bottom, suspended); issues were: multiple conflicting uses, complex governance

10. North Sea (Helgoland Bight), Germany: shellfish (bottom), finfish (cages); issues were: co-use with other industry, increase of production level, complex governance

11. Norwegian (western and northern) Coast, Norway: cold-water finfish (in cages); issues were: sea lice connectivity, space availability, co-use;

12. Nova Scotia Bays, Canada: cold-water finfish (in cages); issues were: enhancing social licence; user/fisheries conflicts

13. Zhangzidao Island and Sangou Bay, China: seaweed, shellfish (suspended); issues were: competition for space with other industry; increased production

14. Argyll and Bute, Scotland, UK: cold-water finfish in cages; community opposition, space availability, landscape/seascape impacts, sea lice connectivity; increased production;

15. Pelorus Sound, Marlborough, New Zealand; shellfish (suspended); Variable production/yield.

C The Aquaspace website

Figure 1 shows the relationships between the several parts of the Aquaspace website. The document that you are now reading, comes from the page for the Masters Module; you may need to access other pages (for example to find links and materials relating to specific tools, or to find videos).

The website pages are:

Overview : of historic interest

Toolbox : includes: factsheets relating to tools tested during Aquaspace; and examples of applications of a range of tools in Aquaspace case studies

Masters Module & CPD : includes the units of the Masters Module (texts and slides), and CPD materials

Library : includes pages for: *Videos* (AquaSpace Introductory and Results videos); *Video comp* (Schools video competition results); *Main reports* (AquaSpace's main public deliverable reports)

Case Studies : includes pages describing each Case Study; these are where the Case Study slides are located

Finally, we also suggest viewing the toolbox website developed by Aquaspace's predecessor project ECASA (www.ecasatoolbox.org.uk). Although some of the regulatory material reviewed by ECASA (2004-2008) is now superceded, the site provides a good introduction to environmental sustainability issues and so complements information provided in this module and deriving from the spatial planning and management issues addressed in Aquaspace.

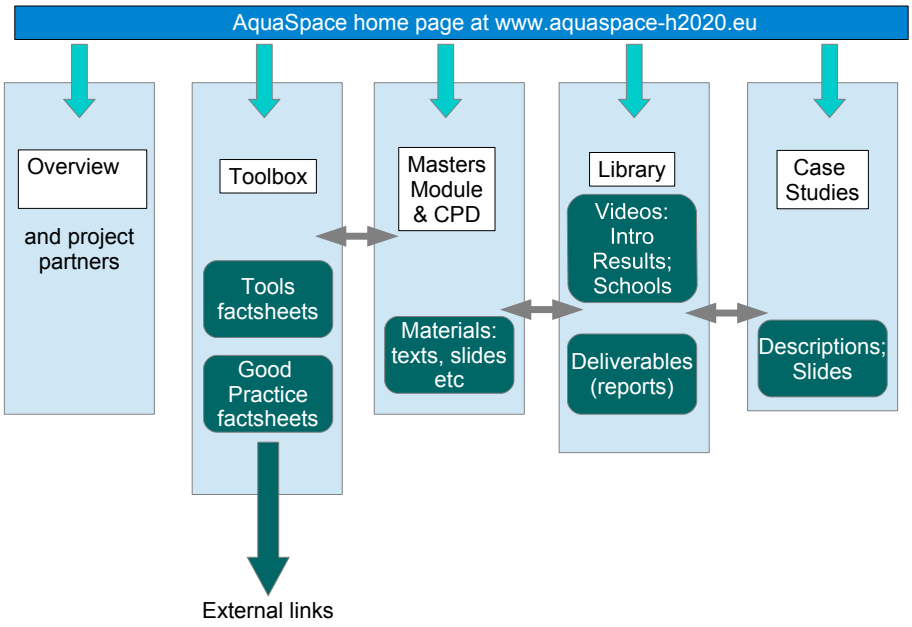

Figure 1: The Aquaspace website