GENIALG

GENetic diversity exploitation for Innovative macroALGal biorefinery

Deliverable 7.7

E-learning course on sustainable seaweed farming practices

Planned delivery date (as in DoA): M36 January 2020

Actual submission date: M54 June 2021

Workpackage: WP7 - Dissemination, Stakeholder Engagement, Knowledge Transfer, Outreach and Capacity Building

Workpackage leader: AquaTT (Ireland)

Deliverable leader: CIIMAR (Portugal)

Version: 1.0

Project co-funded by the European Commission within the Horizon 2020 Programme (2014 - 2020)	
Dissemination Level	
PU Public	**PU**
CI Classified, as referred to Commission Decision 2001/844/EC	
CO Confidential, only for members of the consortium (including the Commission Services)	

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Summary

Objective:

The aim of this course was to address environmental benefits and risks of seaweed farming and suggest good practices to ensure a sustainable growth of the activity. This course is addressed to students within the academic partnership, to professionals and local coastal communities willing to develop seaweed farms. Such a support will also be transferred to policy makers in order to bring knowledge for future legislation on control and impact assessments.

Rationale:

The main driving force behind the development of this course was the need to make society aware of the advantages from seaweed cultivation. Social acceptance is an essential topic and can be reached through the promotion of socio-environmental benefits of seaweed farming and activities to support/encourage dissemination, knowledge transfer, outreach and capacity building. It is also important to be aware that successful seaweed cultivation must be "climate- and water-smart." For this, proper selection of site, seaweed species and propagation, and cultivation techniques are essential specific elements that determine control for each situation. Unfortunately, due to the scarcity of some resources, pandemic situation caused by COVID 19 and complete lockdown, the e-Learning course was not carried out in the format that was originally planned, and was completed on M54 (June 2020) instead of M36 (January 2020). To get around the situation, a set of self-assessed power point documents with associated quiz was developed.

Team involved in Deliverable writing:

- Jean-François Arbona, C-Weed Aquaculture (France)
- Jose M. Fariñas-Franco, National University of Ireland Galway/Galway-Mayo Institute of Technology (Ireland)
- Rosa Melo, Isabel Costa and Isabel Sousa Pinto, CIIMAR (Portugal)
- Sebastián Villasante, University Santiago de Compostela (Spain)
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- Suzannah-Lynn Billing, Paul Tett and Julie Rosten SAMS (UK).

E-Learning Course Overview

Sustainable Seaweed Farming Practices: Course Introduction

This course introduces participants to the latest research connected to best practices for sustainable seaweed farming. The course addresses the environmental benefits and risks of seaweed farming, suggesting good practices to ensure a sustainable growth of the seaweed farming industry. Core topics cover key sustainable practices such as: monitoring and cultivation protocols; ecosystem services valuation; advanced methods for breeding seaweeds; and seaweeds and society.

This course has been developed by the GENIALG project as part of **Work Package 7: Dissemination, Stakeholder Engagement, Knowledge Transfer, Outreach Capacity Building.** The coordinators of the course are CIIMAR and AquaTT with module contributions from CIIMAR, CNRS, C-Weed Aquaculture, Galway-Mayo Institute of Technology, NUI Galway, AquaTT, SAMS and Seaweed Solutions.

The course is completely free of charge, access the content via **https://genialgproject.eu/e-learning-course/**

Target audience

This course is aimed at people with a professional or personal interest in seaweed farming. Key target audiences for the course include students, current practitioners within the seaweed industry and people interested in entering the seaweed industry. The course is also relevant to policy makers tasked with planning and implementing future legislation on control and impact assessments for seaweed farms.

- Third level teachers and students – interested in using the material for teaching key principles of sustainable seaweed farming practices or for self-directed learning for students
- Seaweed farmers – interested in improving and/or expanding their farming activities
- Seaweed breeders – interested in optimising breeding and growing conditions for increased production
- Seaweed entrepreneurs – professionals thinking of getting into the seaweed business or those who want to improve/expand their sustainable practices
- Anyone with an interest in sustainable seaweed farming!

Course content

This course is divided into four modules, representing an approximate total of 20 hours of learning. Module content includes PowerPoint presentations of lessons, videos, recommended reading and references to articles, books, reports etc. Modules begin with a short introduction containing practical information and learning objectives. This is followed by lessons with specific content and recommended readings related to the module. Each module ends with a quiz for a self-assessment of your learning.

Summary of Modules

Module 1: Seaweed Cultivation and Monitoring Protocols

Seaweeds are extremely diverse. In addition to their ecological relevance, there is an increasing industrial use of seaweed. In this module, you will learn about the main farmed seaweed, related principles and associated problems. You will acquire knowledge about the main techniques for seaweed farming, species and the variation in productivity. Additionally, you will learn about a seaweed farm's associated biodiversity and how to measure the effects and provision of additional services of a seaweed farm on the ecosystem and its biodiversity.

Module 2: Ecosystem Services of Seaweed Farming

In addition to seaweed farming generating valuable biomass and contributing to economic activity, growing seaweed and its associated infrastructure also provides valuable socio-environmental benefits. This module demonstrates the ecosystem services valuation methodology and how to incorporate it into policy and decision making.

Module 3: Advanced Methods of Breeding Seaweeds

This module provides guidelines to improve seaweed breeding programmes, by demonstrating how to optimise breeding and growing conditions for various seaweed species leading to greater production.

Module 4: Seaweeds and Society

This module introduces the social theory of aquaculture-society relationships and the practice of gaining social license to operate (SLO) with some practical examples from GENIALG.

Accessibility

Content for all modules are available for free on the dedicated course page on the GENIALG project website. The course has been designed to be taken both online and offline and participants can take the course anytime. All resources are available for download (for free also), so that participants can take the course at a time and pace that suits them. While modules are available in isolation, we recommend that participants follow each module in sequence to gain the most complete learning experience.

The course has been widely promoted once it became available, through means of a dedicated Press Release (June 2021), which was distributed online through the project's internal and external channels. The course pages on the GENIALG website (https://genialgproject.eu/e-learning-course/) received over 150 visitors in the month of June 2021 [152 visitors as of 29/06] The course was promoted in the June 2021 GENIALG newsletter (over 650 recipients), on Facebook and Twitter (over 3,000 impressions on twitter as of 29/06/21). The press release for the course published on Alpha Galileo had a reach of over 4.74k and was disseminated directly to over 3,700 journalists.

Expected outcomes from this course

GENIALG expects that learners will acquire the following learning outcomes:

- Improved knowledge and understanding of sustainable seaweed farming and its implications for science, policy, industry and society;
- Practical knowledge about seaweed breeding and how to increase production/cost efficiency;
- Knowledge and skills for entrepreneurs interested in creating or improving their own seaweed business;
- Boost the seaweed industry in Europe to meet rising market demand for existing and new applications while ensuring environmental sustainability.

E-Learning Course Modules: details

Module 1: Seaweed Cultivation and Monitoring Protocols

Introduction to the module

Authors:

Jean-François Arbona, C-Weed Aquaculture (France)

Jose M. Fariñas-Franco, National University of Ireland Galway/Galway-Mayo Institute of Technology (Ireland)

Rosa Melo, CIIMAR (Portugal)

Isabel Costa, CIIMAR (Portugal)

Isabel Sousa Pinto, CIIMAR (Portugal)

Practical information: This module is divided into four, one-hour lessons.

- Lesson 1 – Seaweed Cultivation
- Lesson 2 – Techniques and Protocols
- Lesson 3 – Opportunities and Future Prospects
- Lesson 4 – Monitoring Protocols for Seaweed Farming

Module description:

Seaweeds are extremely diverse. In addition to their ecological importance, there is an increasing industrial use of seaweed. In this module participants will learn about the main farmed seaweed related principles and associated problems. Particiants will acquire some knowledge about the main cultivation techniques, species and the variations in productivity. Additionally, they will learn how to record and quantify the biodiversity associated with seaweed farms, monitor their effects on the environment and evaluate the ecosystem services they provide.

Expected learning outcomes are:

- Lesson 1 – Identify the best cultivation methods for various seaweed species and understand common cultivation barriers
- Lesson 2 – Apply the recommended cultivation processes and techniques to each seaweed species
- Lesson 3 – Explore and acquire knowledge on the potential range of opportunities in the seaweed farming industry along with the advantages and disadvantages of seaweed

farming in the community. Apply this knowledge for various applications throughout the biorefinery process

- Lesson 4 – Acquire knowledge of how to measure the environmental impact seaweed farms might have on the surrounding environment. Apply this knowledge to quantify the ecosystem services they provide, for example enhancing marine biodiversity.

Lesson 1 - Seaweed Cultivation

Content: PDF document with 24 slides.

Associated Reading:

Mahalik, N.P. & Kim, K. (2014). Aquaculture Monitoring and Control Systems for Seaweed and Fish Farming. World Journal of Agricultural Research. 2 (4): 176–82. DOI: https://doi.org/10.12691/wjar-2-4-7

Radulovich, R., Neori, A., Valderrama, D., Reddy, C.R.K., Cronin, H. & Forster, J. (2015). Farming of Seaweeds. In Tiwari, B. K. & Troy, D. J. [Eds.] Seaweed Sustainability Food and Non-Food Applications. 1st ed. 14th September 2015, London, pp. 27–59. DOI: https://doi.org/10.1016/B978-0-12-418697-2.00003-9

Additional resources:

Organic Seaweed cultivation in Brittany, all cultivation steps explained in a 10-minute video by C-Weed Aquaculture: https://www.youtube.com/watch?v=7RCC6u7uRYo

GENIALG Final Conference, Seaweed for the Future: Scaling-up the European Sector. Session 2: Saccharina latissima Value Chain: Saccharina latissima Seaweed Offshore Cultivation presented by Frank Neumann, Seaweed Solutions, Norway.

- Recording link: https://youtu.be/ZNZZnKjVj44?t=4h17m57s
- Presentation link: http://genialgproject.eu/wp-content/uploads/2021/01/9.-Saccharina-latissima-Seaweed-Offshore-Cultivation.pdf

ALGAplus – Marine Agronomists, promotional video: https://www.youtube.com/watch?v=V1VFm2xfiDw; https://www.algaplus.pt/en/

What is Integrated Multi Trophic Aquaculture? Sara Barrento: https://www.youtube.com/watch?v=AwQFZVe1tHw

Low Trophic Life Webinar: “Advances in IMTA & Biofloc Research at UFSC” by AquaVitae project: https://www.youtube.com/watch?v=Ir8pS7LI_DM

Lesson 2 – Techniques and Protocols

Content: PDF document with 26 slides.

Associated Reading:

Mahalik, N.P. & Kim, K. (2014). Aquaculture Monitoring and Control Systems for Seaweed and Fish Farming. World Journal of Agricultural Research. 2 (4): 176–82. DOI: https://doi.org/10.12691/wjar-2-4-7

Radulovich, R., Neori, A., Valderrama, D., Reddy, C.R.K., Cronin, H. & Forster, J. (2015). Farming of Seaweeds. In Tiwari, B. K. & Troy, D. J. [Eds.] Seaweed Sustainability Food and Non-Food Applications. 1st ed. 14th September 2015, London, pp. 27–59. DOI: https://doi.org/10.1016/B978-0-12-418697-2.00003-9

Additional resources:

Seaweed Solutions – The Future of Farming is at Sea, promotional video: https://youtu.be/LZ3olmIkTTk; https://seaweedsolutions.com/

Coastal Fisheries Training | 5.2 – Seaweed farming in Pacific Island countries: https://www.youtube.com/watch?v=d1A-1JIumKk

Other European research projects focusing on seaweed aquaculture:

- AquaVitae: https://aquavitaeproject.eu/
- BIOSEA: https://biosea-project.eu/
- EnAlgae: http://www.enalgae.eu/
- Global Seaweed Star: https://www.globalseaweed.org/
- KELPPRO: https://kelppro.net/
- IMPAQT: https://impaqtproject.eu/about-impaqt/
- MACRO CASCADE: https://www.macrocascade.eu/
- SolKelp: https://www.solkelp.net/
- VALUEMAG: https://www.valuemag.eu/

Successful seaweed farming with SAMS: https://www.youtube.com/watch?v=twGeE3PtVXo

Experimental seaweed farms: https://www.sams.ac.uk/facilities/seaweed-farms/

Lesson 3 – Opportunities and Future Prospects

Content: PDF document with 17 slides.

Associated Reading:

EU's Aquaculture Advisory Council has published its first general recommendation on seaweed farming and its high potential in Europe: https://genialgproject.eu/2021/01/20/eus-aquaculture-advisory-council-has-published-its-first-general-recommendation-on-seaweed-farming-and-its-high-potential-in-europe/. Link to document: https://www.aac-europe.org/images/jdownloads/AAC_Recommendation_-_Seaweed_I_2021_02.pdf

The Seaweed Manifesto:

- Towards implementation: https://genialgproject.eu/2020/09/30/the-seaweed-manifesto-towards-implementation/
- Link to recording: https://www.youtube.com/watch?v=PNQWa8pcN1M&feature=youtu.be.
- Link to Seaweed Manifesto: https://ungc-communications-assets.s3.amazonaws.com/docs/publications/The-Seaweed-Manifesto.pdf.
- Seaweed Manifesto website: http://www.seaweedmanifesto.com/

Additional resources:

Algaia – We Create Value from the Sea, corporate video: https://www.youtube.com/watch?v=Ex0E95zlG3s&feature=youtu.be ; https://www.algaia.com/

Olmix Group, For a Better Life, https://youtu.be/zIGg3ARDE-c ; https://www.olmix.com/

Other European research projects focusing on seaweed opportunities and future prospects:

- ABACUS: https://www.abacus-bbi.eu/
- BioBridges Project: https://www.biobridges-project.eu/
- CtLight: http://www.cesam.ua.pt/index.php?menu=82&language=eng&tabela=projectosdetail&projectid=958
- MAGNIFICENT ALGAE: https://magnificent-algae.eu/
- SABANA: http://www.eu-sabana.eu/
- ValorMar: https://valormar.pt/en/home-2/
- VALUEMAG: https://www.valuemag.eu/
- Safe Seaweed Coalition: https://seaweedrevolution.live.ft.com/

Seaweed: sustainable crop of the future? | FT Food Revolution: https://genialgproject.eu/2020/12/11/seaweed-sustainable-crop-of-the-future/ . Video link: https://www.youtube.com/watch?v=Y3zlloRFC8g

Case Study Meeting – Offshore Macroalgae Cultivation by AquaVitae project: https://www.youtube.com/watch?v=O2uQsygNN7U

Lesson 4 – Monitoring Protocols for Seaweed Farming

Content: PDF document with 16 slides.

Associated Reading:

Bernard, M. S., Tonk, L., de Groot, G. A., Glorius, S., & Jansen, H. (2019). Biodiversity monitoring in seaweed farms by DNA metabarcoding using settlement plates and water samples. (Wageningen Marine Research rapport; No. C070/19). Wageningen Marine Research. DOI: https://doi.org/10.18174/496237

Campbell, I., Macleod, A., Sahlmann, C., Neves, L., Funderud, J., Øverland, M., Hughes, A. D., & Stanley, M. (2019). The Environmental Risks Associated With the Development of Seaweed Farming in Europe – Prioritizing Key Knowledge Gaps. Frontiers in Marine Science, 6, 1. DOI: https://doi.org/10.3389/fmars.2019.00107

Hasselström, L., Visch, W., Gröndahl, F., Nylund, G. M., & Pavia, H. (2018). The impact of seaweed cultivation on ecosystem services – a case study from the west coast of Sweden. Marine Pollution Bulletin, 133, 53–64. DOI: https://doi.org/10.1016/j.marpolbul.2018.05.005

Radulovich, R., Neori, A., Valderrama, D., Reddy, C.R.K., Cronin, H. & Forster, J. (2015). Farming of Seaweeds. In Tiwari, B. K. & Troy, D. J. [Eds.] Seaweed Sustainability Food and Non-Food Applications. 1st ed. 14th September 2015, London, pp. 27–59. DOI: https://doi.org/10.1016/B978-0-12-418697-2.00003-9

Teagle, H., Hawkins, S. J., Moore, P. J., & Smale, D. A. (2017). The role of kelp species as biogenic habitat formers in coastal marine ecosystems. Journal of Experimental Marine Biology and Ecology, 492, 81–98. DOI: https://doi.org/10.1016/j.jembe.2017.01.017

Visch, W., Kononets, M., Hall, P. O. J., Nylund, G. M., & Pavia, H. (2020). Environmental impact of kelp (Saccharina latissima) aquaculture. Marine Pollution Bulletin, 155, 110962. DOI: https://doi.org/10.1016/j.marpolbul.2020.110962

Walls, A., Kennedy, R., Edwards, M., & Johnson, M. (2017). Impact of kelp cultivation on the Ecological Status of benthic habitats and Zostera marina seagrass biomass. Marine Pollution Bulletin, 123(1–2), 19–27. DOI: https://doi.org/10.1016/j.marpolbul.2017.07.048

Wood, D., Capuzzo, E., Kirby, D., Mooney, K. & Kerrison, P. (2017). UK macroalgae aquaculture: What are the key environmental and licensing considerations? Marine Policy 83: 29-39. https://doi.org/10.1016/j.marpol.2017.05.021.

Ecosystem services and environmental impacts associated with commercial kelp aquaculture: http://hdl.handle.net/10379/6913

Additional resources:

GENIALG Final Conference, Seaweed for the Future: Scaling-up the European Sector. Session 3: Social-environmental Benefits of Seaweed Farming: Ecological Impact of Seaweed Cultivation presented by Jose Maria Fariñas-Franco, Galway-Mayo Institute of Technology, Ireland.

- Recording link: https://youtu.be/ZNZZnKjVj44?t=6h50m46s.
- Presentation link: https://genialgproject.eu/wp-content/uploads/2021/01/16.-Ecological-impact-of-seaweed-cultivation.pdf

Self-Assessment Quiz:

1. What are the three technical variation factors on which cultivating seaweed depends?
2. What are the important parameters of seaweed cultivation?
3. What is the difference between seeding and planting?
4. When would you carry out a total harvest?
5. How can seaweed be used in industry?
6. What are some of the obstacles that need to be overcome in seaweed farming?
7. What type of survey design principle should guide environmental monitoring programs for seaweed farms?
8. How can the effect of seaweed farms as Essential Fish Habitats be monitored and quantified?
9. What techniques would you use to monitor the effect of seaweed farms on biophysical seabed attributes?

Module 2: Ecosystem Services of Seaweed Cultivation

Introduction to the module

Authors:

Sebastián Villasante, University Santiago de Compostela,

Rosa Melo, CIIMAR, Portugal

Isabel Costa, CIIMAR, Portugal

Isabel Sousa Pinto, CIIMAR, Portugal

Practical information: This module is divided into two, one-hour lessons.

Lesson 1 – Ecosystem Services and Nature Contributions to People from Seaweed Cultivation.

Lesson 2 – Valuation, Practical Approaches and Challenges Applying Ecosystem Services from Seaweed Cultivation.

Module description:

In addition to seaweed farming generating valuable biomass and contributing to economic activity, growing seaweed and its associated infrastructure also provides valuable socio-environmental benefits. This module demonstrates the ecosystem services valuation methodology and how to incorporate it into policy and decision making.

Expected learning outcomes are:

- Lesson 1 – Understand what marine ecosystem services are and understand how they are produced and can be operationalized.
- Lesson 2 – Apply the different methodologies for the estimation of the value of the different types of ecosystem services and identify the challenges of ecosystem frameworks operationalization.

Lesson 1 - Ecosystem Services and Nature Contributions to People from Seaweed Cultivation

Content: PPT document with 20 slides.

Associated Reading:

Christie, M., & Rayment, M. (2012). An economic assessment of the ecosystem service benefits derived from the SSSI biodiversity conservation policy in England and Wales. Ecosystem Services, 1(1), 70–84. DOI: https://doi.org/10.1016/j.ecoser.2012.07.004

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., & Grasso, M. (2017). Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services, 28, 1–16. DOI: https://doi.org/10.1016/j.ecoser.2017.09.008

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A., Portela, R., Rodriguez, L. C., ten Brink, P., & van Beukering, P. (2012). Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services, 1(1), 50–61. DOI:https://doi.org/10.1016/j.ecoser.2012.07.005

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R. T., Molnár, Z., Hill, R., Chan, K. M. A., Baste, I. A., Brauman, K. A., Polasky, S., Church, A., Lonsdale, M., Larigauderie, A., Leadley, P. W., van Oudenhoven, A. P. E., van der Plaat, F., Schröter, M., Lavorel, S., Shirayama, Y. (2018). Assessing nature's contributions to people. Science, 359(6373), 270–272. DOI: https://doi.org/10.1126/science.aap8826

Farber, S. C., Costanza, R., & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. Ecological Economics, 41(3), 375–392. DOI: https://doi.org/10.1016/s0921-8009(02)00088-5

Outeiro, L., Ojea, E.,Garcia Rodrigues, J., Himes-Cornell, A., Belgrano, A., Liu, Y., Cabecinha, E., Pita, C., Macho, G., Villasante, S., (2017). The role of non-natural capital in the co-production of marine ecosystem services, International Journal of Biodiversity Science, Ecosystem Services & Management, 13:3, 35-50, DOI: 10.1080/21513732.2017.1415973

Palomo, I., Felipe-Lucia, M.R., Bennett, E.M., Martín-López, B., Pascual, U., (2016) Disentangling the Pathways and Effects of Ecosystem Service Co-Production, Advances in Ecological Research, (Eds Woodward, G., Bohan, D.A.,) Academic Press, Vol.54, Pgs 254-283 https://doi.org/10.1016/bs.aecr.2015.09.003

TEEB (2010). The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. Available in multiple languages online: http://www.teebweb.org/our-publications/teeb-study-reports/synthesis-report/

Additional resources:

EU Environment: Ecosystem Services and Biodiversity – Science for Environment Policy video: https://www.youtube.com/watch?v=D6luBEJfi3s

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES): https://ipbes.net/about

Ecosystem Services Partnership: a worldwide network to enhance the science, policy and practice of ecosystem services for conservation and sustainable development: https://www.es-partnership.org/

EU Environment: Ecosystem services video: https://www.youtube.com/watch?v=wMlUglBligI

Lesson 2 - Valuation, Practical Approaches and Challenges Applying Ecosystem Services from Seaweed Cultivation

Content: PPT document with 36 slides.

Associated Reading:

Cabral, P., Levrel, H., Viard, F., Frangoudes, K., Girard, S., & Scemama, P. (2016). Ecosystem services assessment and compensation costs for installing seaweed farms. Marine Policy, 71, 157–165. DOI: https://doi.org/10.1016/j.marpol.2016.05.031

Grabowski, J. H., Brumbaugh, R. D., Conrad, R. F., Keeler, A. G., Opaluch, J. J., Peterson, C. H., Piehler, M. F., Powers, S. P., & Smyth, A. R. (2012). Economic Valuation of Ecosystem Services Provided by Oyster Reefs. BioScience, 62(10), 900–909. DOI: https://doi.org/10.1525/bio.2012.62.10.10

Kim, Jank K. & Yarish, Charles (2014). Development of a sustainable land-based Gracilaria cultivation system The Korean Society of Phycology, 29(3), 217-225. DOI: https://doi.org/10.4490/algae.2014.29.3.217

La Barre, S., & Bates, S. S. (Eds.). (2018). Blue biotechnology: production and use of marine molecules. John Wiley & Sons. Access online: https://books.google.ie/books?hl=en&lr=&id=elpuDwAAQBAJ&oi=fnd&pg=PR17&dq=La+Barre+et+al.,+2018+ecosystem+services&ots=PD1sAsw0EM&sig=KlCM8btuZSAg9mpHfxQj7GGl3Co&redir_esc=y#v=onepage&q=La%20Barre%20et%20al.%2C%202018%20ecosystem%20services&f=false

van den Burg, S.W.K, van Duijn, A.P., Bartelings, H., van Krimpen, M.M. & Poelman, M. (2016). The economic feasibility of seaweed production in the North Sea. Aquaculture Economics & Management, 20:3, 235-252, DOI: https://doi.org/10.1080/13657305.2016.1177859

Alleway, H. K., Gillies, C. L., Bishop, M. J., Gentry, R. R., Theuerkauf, S. J., & Jones, R. (2018). The Ecosystem Services of Marine Aquaculture: Valuing Benefits to People and Nature. BioScience, 69(1), 59–68. DOI: https://doi.org/10.1093/biosci/biy137

Custódio, M., Villasante, S., Calado, R., & Lillebø, A. I. (2019). Valuation of Ecosystem Services to promote sustainable aquaculture practices. Reviews in Aquaculture, 12(1), 392–405. DOI: https://doi.org/10.1111/raq.12324

Duarte, C. M., Wu, J., Xiao, X., Bruhn, A., & Krause-Jensen, D. (2017). Can Seaweed Farming Play a Role in Climate Change Mitigation and Adaptation? Frontiers in Marine Science, 4, 100. DOI: https://doi.org/10.3389/fmars.2017.00100

Gentry, R. R., Alleway, H. K., Bishop, M. J., Gillies, C. L., Waters, T., & Jones, R. (2019). Exploring the potential for marine aquaculture to contribute to ecosystem services. Reviews in Aquaculture, 12(2), 499–512. DOI: https://doi.org/10.1111/raq.12328

Grebe, G. S., Byron, C. J., Gelais, A. S., Kotowicz, D. M., & Olson, T. K. (2019). An ecosystem approach to kelp aquaculture in the Americas and Europe. Aquaculture Reports, 15, 100215. DOI: https://doi.org/10.1016/j.aqrep.2019.100215

Hasselström, L., Visch, W., Gröndahl, F., Nylund, G. M., & Pavia, H. (2018). The impact of seaweed cultivation on ecosystem services – a case study from the west coast of Sweden. Marine Pollution Bulletin, 133, 53–64. DOI: https://doi.org/10.1016/j.marpolbul.2018.05.005

Kim, J. K., Yarish, C., Hwang, E. K., Park, M., & Kim, Y. (2017) Seaweed aquaculture: cultivation technologies, challenges and its ecosystem services. ALGAE, 32(1), 1–13. DOI: https://doi.org/10.4490/algae.2017.32.3.3

Additional resources:

The Economics of Ecosystems and Biodiversity (TEEB) Training resources: http://www.teebweb.org/resources/training-resource-material/

Conservation Strategy Fund: Valuation of Ecosystem Services: Intro to Valuation video: https://www.youtube.com/watch?v=0CHIs9dLvxA

GENIALG Final Conference, Seaweed for the Future: Scaling-up the European Sector. Session 3: Social-environmental Benefits of Seaweed Farming: Ecosystem Services Assessment for Seaweed Farms presented by Sebastián Villasante, CIIMAR, Portugal.

- Recording: https://www.youtube.com/watch?v=ZNZZnKjVj44&t=27420s
- Presentation:https://genialgproject.eu/wp-content/uploads/2021/06/GENIALG_finalconf_session3_SVillasante.pdf

The Seaweed Platform: https://www.noordzeeboerderij.nl/en/community/seaweed-platform

Other European research projects evaluating seaweeds and aquaculture:

- EnAlgae (France): http://www.enalgae.eu/
- KELPPRO (Norway): https://kelppro.net/publications
- AquaVitae (Atlantic): https://aquavitaeproject.eu/

Self-Assessment Quiz

1. What is the definition of Ecosystem Services?
2. What are the four types of ecosystem services?
3. What is the definition of Nature Contributions to People (NCP)?
4. Name five Nature Contributions to People (NCPs) from Seaweed Farming
5. What is the difference between valuation and monetization of NCPs from seaweed farming?

Module 3: Advanced methods of Breeding Seaweeds

Introduction to the module

Authors:

Station Biologique de Roscoff: Zofia Nehr, Komlan Avia, Stéphane Mauger, Bertrand Jacquemin, Emilie Gouhier, Delphine Scornet, Jérôme Coudret, Stéphane Loisel, Susana M. Coelho, Christophe Destombe, Philippe Potin, Myriam Valero, J. Mark Cock

Practical information: This module is divided into two, one-hour lessons.

- Lesson 1 – Breeding as a tool for optimization of seaweed cultivation.
- Lesson 2 – Advanced methods for seaweed breeding.

Module description

This module provides guidelines to improve seaweed breeding programmes, by demonstrating how to optimise breeding and growing conditions for various seaweed species leading to greater production.

Expected learning outcomes are:

- Lesson 1 – Develop an understanding of breeding as a tool for optimization of seaweed cultivation.
- Lesson 2 – Develop an understanding of the seaweed breeding process.

Lesson 1 - Breeding as a tool for optimization of seaweed cultivation.

Content: PPT document with 11 slides.

Lesson 2 - Advanced methods for seaweed breeding

Content: PPT document with 28 slides.

Associated reading:

Campbell, I., Kambey, C.S.B., Mateo, J.P., Rusekwa, S.B., Hurtado, A.Q, Msuya, F.E., Stentiford, G.D., Cottier-Cook, E.J. (2019). Biosecurity policy and legislation for the global seaweed aquaculture industry. Journal of Applied Phycology, 32, 2133–2146. DOI: https://doi.org/10.1007/s10811-019-02010-5

Ward, G.M., Faisan, J.P., Cottier-Cook, E.J., Gachon C., Hurtado A.Q., Lim P.E., Msuya F.E., Bass D., Brodie J. (2020). A review of reported seaweed diseases and pests in aquaculture in Asia.

Journal of the World Aquaculture Society, 51, 815– 828. DOI: https://doi.org/10.1111/jwas.12649

Tourneroche, A., Lami, R., Burgaud, G., Domart-Coulon, I., Li, W., Gachon, C., Gèze, M., Boeuf, D., Prado S. (2020). The Bacterial and Fungal Microbiota of Saccharina latissima (Laminariales, Phaeophyceae). Frontiers in Marine Science, 7, 1081. DOI: https://doi.org/10.3389/fmars.2020.587566

Murúa, P., Müller , D.G, Etemadi, M., van West, P., Gachon, C.M.M. (2020). Host and pathogen autophagy are central to the inducible local defences and systemic response of the giant kelp Macrocystis pyrifera against the oomycete pathogen Anisolpidium ectocarpii. New Phytologist, 226(5), 1445-1460. DOI: https://doi.org/10.1111/nph.16438

Policy brief: Cottier-Cook, E.J., Nagabhatla, N., Badis, Y., Campbell, M., Chopin, T, Dai, W, Fang, J., He, P, Hewitt, C, Kim, G. H., Huo, Y, Jiang, Z, Kema, G, Li, X, Liu, F, Liu, H, Liu, Y, Lu, Q, Luo, Q, Mao, Y, Msuya, F. E, Rebours, C, Shen, H., Stentiford, G. D., Yarish, C, Wu, H, Yang, X, Zhang, J, Zhou, Y, Gachon, C. M. M. (2016). Safeguarding the future of the global seaweed aquaculture industry. United Nations University (INWEH) and Scottish Association for Marine Science Policy Brief. ISBN 978-92-808-6080-1. 12pp. https://www.sams.ac.uk/t4-media/sams/pdf/globalseaweed-policy-brief.pdf

Additional resources:

Algaculture for Biotechnology Online Training Course by SAMS:
https://www.sams.ac.uk/algaculture-training-course/

Self-Assessment Quiz

1. What is the main purpose of seaweed breeding?

   A: the main purpose of breeding is to select among the natural intraspecific biodiversity some genomic features that are interesting for cultivation.
2. What are the two methods that allow to associate a phenotype to genotype?

   A: Linkage mapping/association mapping (slide 6 lesson 1)
3. What kind of phenotypical trait could be relevant?

   A: Heat stress resistance; Blade length; Stipe Length; Growth rate; Concentration of a compound of interest, etc (Many possible answers)

Module 4: Seaweeds and Society

Introduction to the module

Authors:

Suzi Billing, SAMS (UK)

Paul Tett, SAMS (UK)

Julie Rosten, SAMS (UK)

Practical information:

Lesson 1 – Social licensing at seaweed farming

Module description:

This module introduces the social theory of aquaculture-society relationships and the practice of gaining social license to operate (SLO) with some practical examples from GENIALG.

Expected learning outcomes are:

- Lesson 1 – Define social license to operate and understand its relevance to seaweed aquaculture in Europe.

Lesson 1 - Social licensing at seaweed farming

Content: PPT document with 13 slides.

Associated Reading:

Mateo, J.P., Campbell, I., Cottier-Cook, E.J., Luhan, M.R.J., Ferriols, V.M.E.N., Hurtado, A.Q. (2021). Understanding biosecurity: knowledge, attitudes and practices of seaweed farmers in the Philippines. Journal of Applied Phycology. DOI: https://doi.org/10.1007/s10811-020-02352-5

Suyo, J.G.B., Le Masson, V., Shaxson, L., Luhan, M.R.J., Hurtado, A.Q. (2021). Navigating risks and uncertainties: Risk perceptions and risk management strategies in the Philippine seaweed industry. Marine Policy, 126. DOI: https://doi.org/10.1016/j.marpol.2021.104408

Rebours, C., Marinho-Soriano, E., Zertuche-González, J.A. et al. (2014). Seaweeds: an opportunity for wealth and sustainable livelihood for coastal communities. Journal of Applied Phycology 26, 1939–1951. DOI: https://doi.org/10.1007/s10811-014-0304-8.

Hussin, H. & Khoso, A. (2017). Seaweed cultivation and coastal communities in Malaysia: An overview. Asian Fisheries Science, 30, 87-100. https://www.researchgate.net/profile/Abdullah-Khoso/publication/318224745_Seaweed_Cultivation_and_Coastal_Communities_in_Malaysia

_an_Overview/links/5976c3720f7e9b4016bc50d4/Seaweed-Cultivation-and-Coastal-Communities-in-Malaysia-an-Overview.pdf

Seaweed Cultivation in Scotland: A guide for community participation in seaweed farm applications funded by the Sustainable Inshore Fisheries Trust (SIFT): https://www.sift.scot/wp-content/uploads/2021/03/SIFT-Seaweed-Guide.pdf

Social licence key to EU aquaculture growth: http://genialgproject.eu/2019/03/08/social-licence-key-to-eu-aquaculture-growth/

Billing, S.-L., Rostan, J., Tett, P., & Macleod, A. (2021). Is social license to operate relevant for seaweed cultivation in Europe? Aquaculture, 534, 736203. DOI: https://doi.org/10.1016/j.aquaculture.2020.736203

Msuya, Flower. (2006). The Impact of Seaweed Farming on the Social and Economic Structure of Seaweed Farming Communities in Zanzibar, Tanzania. In A.T. Critchley, M. Ohno & D.B. Largo, eds. World seaweed resources: an authoritative reference system. Amsterdam, ETI BioInformatics.

van den Burg, S., Dagevos, H. and Helmes, R. (2019). Towards sustainable European seaweed value chains: a triple P perspective. ICES Journal of Marine Science fsz183. DOI: https://doi.org/10.1093/icesjms/fsz183

ICES (2020). Working Group on Social and Economic Dimensions of Aquaculture (WGSEDA). ICES Scientific Reports. 2:78. 11 pp. http://doi.org/10.17895/ices.pub.7500 https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/ASG/2020/WGSEDA%20Report%202020.pdf

Krause, G., Billing, S.L., Dennis, J., Grant, J., Fanning, L., Filgueira, R., Miller, M., Pérez Agúndez, J.A., Stybel, N., Stead, S.M., Wawrzynski, W. (2020). Visualizing the social in aquaculture: How social dimension components illustrate the effects of aquaculture across geographic scales. Marine Policy, 118. DOI: https://doi.org/10.1016/j.marpol.2020.103985

Mikkelsen, E., Fanning, L., Kreiss, C.M., Billing, S.-L., John, D., Filgueira, R., Grant, J., Krause, G., Lipton, D., Miller, M., Perez, J., Stead, S., Villasante, S. (2020). Availability and usefulness of economic data on the effects of aquaculture: A North Atlantic comparative assessment. Aquaculture Reviews. DOI: https://doi.org/10.1111/raq.12488

Additional resources:

Tanzanian Fishing Villages Turn to Seaweed to Grow Incomes: https://www.worldbank.org/en/news/video/2015/09/15/tanzanian-fishing-villages-turn-to-seaweed-to-grow-incomes

Sowing in the Seas: Aquaculture for Coastal Restoration in Belize: https://www.nature.org/en-us/about-us/where-we-work/latin-america/belize/sustainable-aquaculture-a-viable-economic-alternative-to-fishing/

GENIALG Final Conference, Seaweed for the Future: Scaling-up the European Sector. Session 3: Socio-environmental Benefits of Seaweed Farming: Social Licensing at Seaweed Farm Sites by Suzi Billing, Scottish Association of Marine Science, UK.

- Recording link: https://youtu.be/ZNZZnKjVj44?t=7h18m21s
- Presentation link: http://genialgproject.eu/wp-content/uploads/2021/01/17.-Social-Licensing-at-Seaweed-Farm-Sites.pdf

Seaweed Aquaculture | Dr. Carly Daniels & Dr. Katie Orchel
https://www.youtube.com/watch?v=F4YyW5eg1ck

Social licence for aquaculture by Dr Suzannah-Lynn Billing (Aquaculture Research Collaborative Hub UK) presentation:
https://static1.squarespace.com/static/59662d71197aea598d1455a0/t/5b3f9e02758d46ba99be061e/1530895878402/Suzi+Billing.pdf

Seaweed Farming Feasibility Study for Argyll & Bute a report by SRSL for Argyll & Bute Council: https://www.argyll-bute.gov.uk/sites/default/files/seaweed_farming_feasibility_study_for_argyll_and_bute_report_december_2019.pdf

PDF of the Handbook on Social License to Operate with more details of the studies on social license that conducted in GENIALG. - Handbook on Social License to Operate for Seaweed Cultivationv4(2)

AquaSpace project: http://www.aquaspace-h2020.eu/

BlueGrowth Farm project: http://www.thebluegrowthfarm.eu/

SeaPoWer project: http://cecilebrugere.com/?p=783

TRAHESA project: https://www.norad.no/en/front/funding/norhed/projects/capacity-building-for-training-and-research-in-aquatic-and-environmental-health-in-eastern-and-southern-africa-trahesa/

Self-Assessment Quiz:

1. Name three components of social license to operate for any industrial activity.
2. Provide a short overview of how a lack of social license can impact an aquaculture activity.

3. Provide one example of how a seaweed cultivation organization can start to develop relationships with stakeholders for the purposes of developing social license to operate for their sites.