Policy Recommendations For a More Circular Aquaculture

The following policy recommendations aim to help the EU aquaculture sector to apply a circular-economy approach in order to participate in the green transition set by the European Green Deal:

- Define circularity in aquaculture
- Define a common methodology to measure circularity in aquaculture
- Increase circularity in aquaculture production by increasing circularity in feed production and by valorising aquaculture wastes (effluent and sludge)
- Encourage sectorial and cross-sectorial co-governance

Context

Authors

Sandra Balsells, Tamás Bardócz, Killian Chary Daniel Checa Alias, Eva Enyedi, Björgolfur Hávardsson, Frank Kane, Antti Kause, Dorinde Kleinegris, Peter Lengyel, Szilvia Mihalffy, Dannie O'Brien, Elisa Ravagnan, Lola Rodríguez, Inmaculada Sanchez, Marie Shrestha, Dorothy Jane Dankel.

Context of the current policy recommendations for circular aquaculture

As stated in the Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030[*1], "the EU aquaculture sector, like other sectors of the EU economy, has to participate in the green transition set by the European Green Deal. This sector has a particular role to play in contributing to the transition to sustainable food systems, but also to the development of the bioeconomy and the circular economy". Traditional aquaculture technologies, like polyculture pond production of fish, as well as new production methods, like Integrated Multi Trophic Aquaculture (IMTA) approach and Recirculating Aquaculture Systems (RAS), already integrate principles of circular economy. The improvement of these technologies and the increased circularity in predominant aquaculture production systems (open-cages), in which waste collection is challenging, might increase the compatibility between sustainable aquaculture and environmental protection. Considering the need to discuss and identify ways forward in which circularity can be developed within production in a practical, efficient and economically sound way, the H2020 iFishIENCi project organised the "Aquaculture Going Circular" **event** in November 2021. The outcome of this event aims to share co-created policy recommendations to ensure regulators, officials, and the European Commission can support actions to make aquaculture more circular.

Contributors endorsing the current policy recommendations

H2020 AquaIMPACT[*3], H2020 AquaVitae[*4], H2020 ASTRAL[*5], H2020 FutureEUAqua[*6], H2020 GAIN[*7], H2020 iFishIENCi[*8], H2020 IMPAQT[*9], H2020 NewTechAqua[*10] Evagoras Isaias, IsaiaSEA.com; Mohammad Nadjib, INVENDO; Abderrahim Ouaach, Polydisciplinary Faculty of Larache, Abdelmalek Essaadi University; Tamara Rubilar, CESIMAR-CCT CENPAT-CONICET; Koukaras Konstantinos; Benoît Wuatelet, Blue Economy Team leader – SwitchMed, Department of Environment, United Nations Industrial Development Organization; Anwarullah Khan; Luis Poersch, Federal University of Rio Grande, Institute of Oceanography. These Projects, organisations and persons have endorsed this document.

[*1] *Communication from the Commission to the European Parliament, the Council, the Euroepan Economic and Social Committee and the Committee of the Regions. Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030. COM/2021/236 final*

[*3] *AquaIMPACT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818367.*

[*4] *AquaVitae project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 818173.*

[*5] *ASTRAL project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 863034.*

[*6] *FutureEUAqua project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 817737.*

[*7] *GAIN project project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773330.*

[*8] *iFishIENCi project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818036.*

[*9] *IMPAQT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774109.*

[*10] *NewTechAqua project has received funding from the European Union's Horizon 2020 Programme under grant agreement No 862658.*

Recommendation 1

Define Circularity in aquaculture

1

"William Richardson / stock.adobe.com" Offshore Aquaculture

Context and Challenge linked to the definition of circularity in aquaculture

- Circular Economy in the aquaculture sector is tackled under different angles in terms of waste management namely reuse, recycle or valorisation, leading to different understanding.

- In the frame of the "Aquaculture Going Circular" event, the understanding of circularity in aquaculture was enquired. The graphical representation in Fig.1. shows that circularity in aquaculture is very broad and encompasses a variety of different concepts.

- Recently, science and industry actors in the iFishIENCi project identified 53 targets (of the 169 targets in total) of the United Nations Sustainable Development Goals (SDGs) that have direct or indirect relevance to recirculating aquaculture systems (RAS). In that sense, circular aquaculture has clear relevance to sustainability but more knowledge-based development of specific indicators is needed for companies and municipalities to create time series to measure sustainable actions through new aquaculture technologies in Fig.2.

- The connection between the aquaculture sector going circular and climate change is not explicit and needs to be defined - i.e. what would circularity mean in terms of emissions adaptation and how would this make the businesses more resilient.

What key words come to your mind on the topic of Circularity in Aquaculture? (1 word)

Fig.1 - Outcome of the inquiry about understanding of circularity in aquaculture during the "Aquaculture Going Circular" event .

Fig.2 - An illustration of the 169 targets of the UN SDGs, with the 53 targets highlighted that are relevant to Recircultating Aquaculture Systems (RAS), found across 14 of 17 SDGs. No real indicator exist yet for these 53 targets, so much work remains.

Recommendations

Objective of the recommendation

- Develop a common definition or approach as the basis for models, strategies, and plans leading to future recommendations toward circular economy business models in the aquaculture sector, with clear indicators for reporting on relevant SDG targets and climate change.

"Chiccaderrico / stock.adobe.com" Aquaculture under water view

1. **Agree on a common definition of circularity in aquaculture.**

The context to provide a definition was given by a coordinated answer of H2020 projects AquaIMPACT, ASTRAL, iFishIENCi and IMPAQT in 2020 to the consultation regarding the update of strategic guidelines for sustainable development of EU aquaculture:

- Considering circularity from the aquaculture point of view - in a food production system, the definition needs to address the strengths of circularity considering, but not limited to, the importance of biological flows within aquaculture production systems.

- Within circular economy the value of the products, materials, and resources last within the economy for as long as possible, which aims to minimize waste generation. The circular economy as it may be applied to aquaculture, aims to produce renewable biological resources, facilitating a conversion of these resources and waste streams into value added products, such as food, feed, biobased products, and bioenergy.

- Given this specific dimension to circular economy, when addressing the nutrient flow mass and assessing the impacts of recirculating them from one biological species to another, or capturing them to be recirculated as new feed, the circular economy in aquaculture can also be defined and described as a circular bioeconomy.

2. **Capitalise on this definition by developing quantifiable indicators to report on relevant SDG targets of the UN Agenda 2030, in order to measure sustainability in preparation for the EU Taxonomy.**

Recommendation 2

Define a common methodology to measure circularity in aquaculture

2

Context and Challenge linked with the measure of circularity in aquaculture

- European Commission has already identified the needs for developing updated environmental indicators to determine the impacts of aquaculture production. However, there is no reference to circularity indicators as part of the recommended actions to promote the green transition*[11].

- A harmonized way to measure circularity in a quite diverse sector is a challenge. There is no harmonized way of measuring circularity at the micro level since there are no industry-specific indicators. Methodologies available do not have the capacity to capture the entire circular economy performance of products (Kristensen and Mosgaard, 2020)*[12].

- The methodology should allow assessing several scenarios of feed formulation, fish production and efficiency of the valorisation routes (collection system, sludge and wastewater treatment, and efficiency of the substrate for cultivation). Therefore, different feed formulations and fish production systems should be comparable under a circular and zero-waste perspective.

*[11] *https://eur-lex.europa.eu/resource.html?uri=cellar:bab1f9a7-b30b-11eb-8aca-01aa75ed71a1.0022.02/DOC_2&format=PDF*

*[12] *Heidi Simone Kristensen, MetteAlberg Mosgaard, A review of micro level indicators for a circular economy –moving away from the three dimensions of sustainability?, Journal of Cleaner Production, Volume 243, 2020,*

Objective of the recommendation

- Evaluate circularity performance of aquaculture production systems derived from a common definition and indicators that policymakers can use to make informed decisions.

- Define a new adapted method to address indicators of circularity in the context of different aquaculture systems. The elaboration of this methodology should also consider the evaluation of circularity in a wider perspective, integrating the zero-waste approach in the assessment to evaluate circular routes within and outside of the aquaculture sector.

"Ludmila / stock.adobe.com" Fish Farm

Recommendations

1. **Develop circularity indicators** to report how aquaculture production performs in the context of a circular (bio)-economy. Therefore, indicators should provide information on circular practices, beyond waste management.

2. **Encourage the aquaculture sector to report circularity indicators** as industrial KPIs and with a broader perspective (in the context of new EU indicators to be developed).

'Alexkarankevich / stock.adobe.com" Aquaponics Europe

Some Examples:

- Indicators of linearity of the feed (applicable to closed, semi-closed and open feeding systems)*13.
- Indicators of feeding efficiency (applicable to closed, semi-closed and open feeding systems), aiming at:
  - Monitoring losses
  - Monitoring nutrient assimilation
- Indicators of closing-the-loop strategies, to recovery nutrients:
  - Monitoring the approach to zero-waste concept. For instance, valorisation of new feed formulation (iFishIENCi concept) (applicable to closed and semi-closed systems, where effluent and waste can be collected).
  - Monitoring the bioremediation effects (IMTA concepts / macroalgae cultivation) (applicable to closed, semi-closed and open systems with fed and extractive species).

3. **Encourage the display of circularity indicators in final products for the consumer** alongside environmental impact following examples such as the Eco-impact label*14

*13 *A product is called linear if it is made purely from virgin material (adapted definition sourced from: https://emf.thirdlight.com/link/3jtevhlkbukz-9of4s4/@/preview/1?o)*

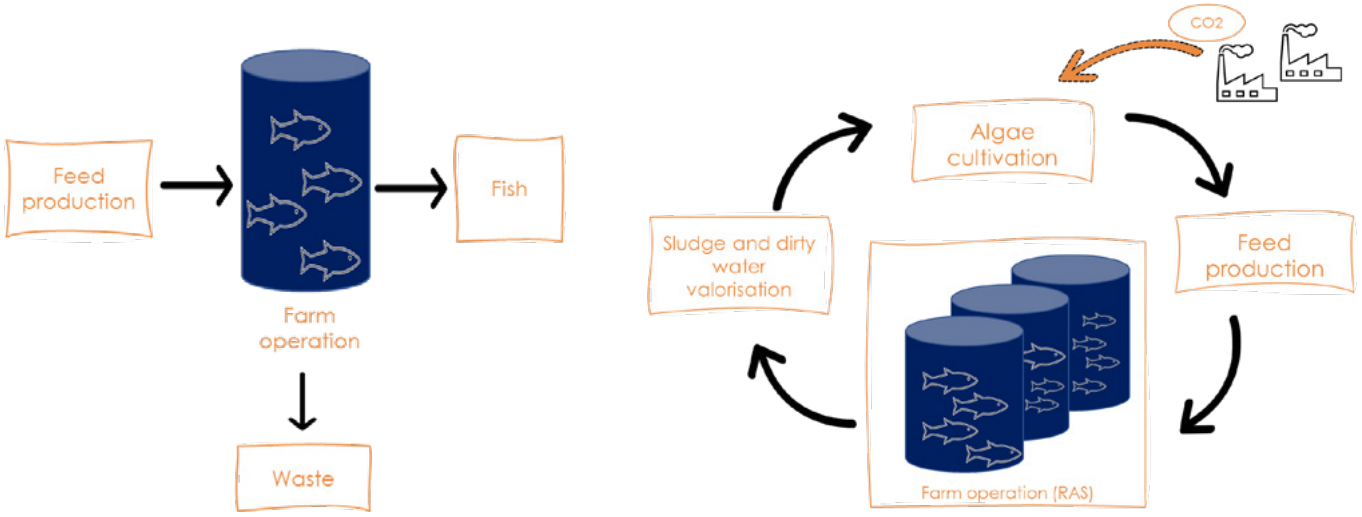
*14 *Pilot Launch - Foundation Earth Environmental Scores (foundation-earth.org)*

Recommendation 3

Improve circularity in aquaculture production

3

iFishIENCi from linear to circular

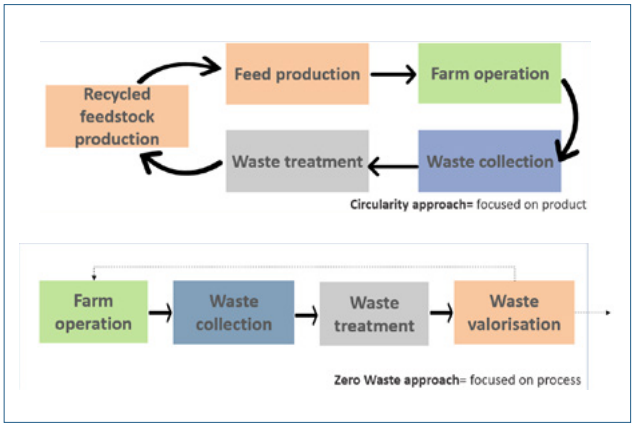


3.1 Increase Circularity in Feed production

Context and Challenge of circular feed production in aquaculture

- Feed production is a critical area of the overall environmental impact of the aquaculture sector (Bohnes et al 2019), Sustainable source of proteins are required to meet the growing demand for feed production (Senthil Nagappan, 2021).
- Circularity does not necessary imply a reduction on the environmental footprint (Blum et al., 2020). Circularity KPIs have the potential to increase environmental impacts if they focus narrowly on only specific economic flows and on a particular stage of production or mainly on nutrients flows.
- Currently, legislation does not allow all options of circular feed production mainly due to safety reason. For example, the use of aquaculture waste for microalgae cultivation as ingredients of fish feed is not allowed.
- No more than 35 percent of feed contains by-products of fish processing (SOFIA FAO 2020).

iFishIENCi, circularity and zero waste approach of the methodology



Recommendations

1. **Improve resource efficiency of feed production**
(all feeding systems: closed, semi-closed, open)

   - Promote the development of new feeding formulations incorporating resource efficiency principles in the manufacturing process: novel energy-intensive process, bad locations, etc.

2. **Improve circularity of feed ingredients**
(all feeding systems: closed, semi-closed, open)

   - Define circular ingredients and supplements, coming from new value chains based on the valorisation of production waste (waste water or sludge). Therefore, facilitating the exclusion of linear ingredients such as fishmeal and fish oil (not produced from by-products of fish processing) or conventional agriculture products - without waste-based substrate. The use of 'wastes' from other production processes is very common in agriculture for example:

Objective of the recommendation towards improving circularity feed production

- Joint efforts to design strategies that enhance high-level impacts in aquaculture through circular feeding management systems.

Fish nutrition / experimental feed production

  - If formulations are plant-based, emphasise the need of cultivation in substrate from aquaculture waste streams (closing the loop).

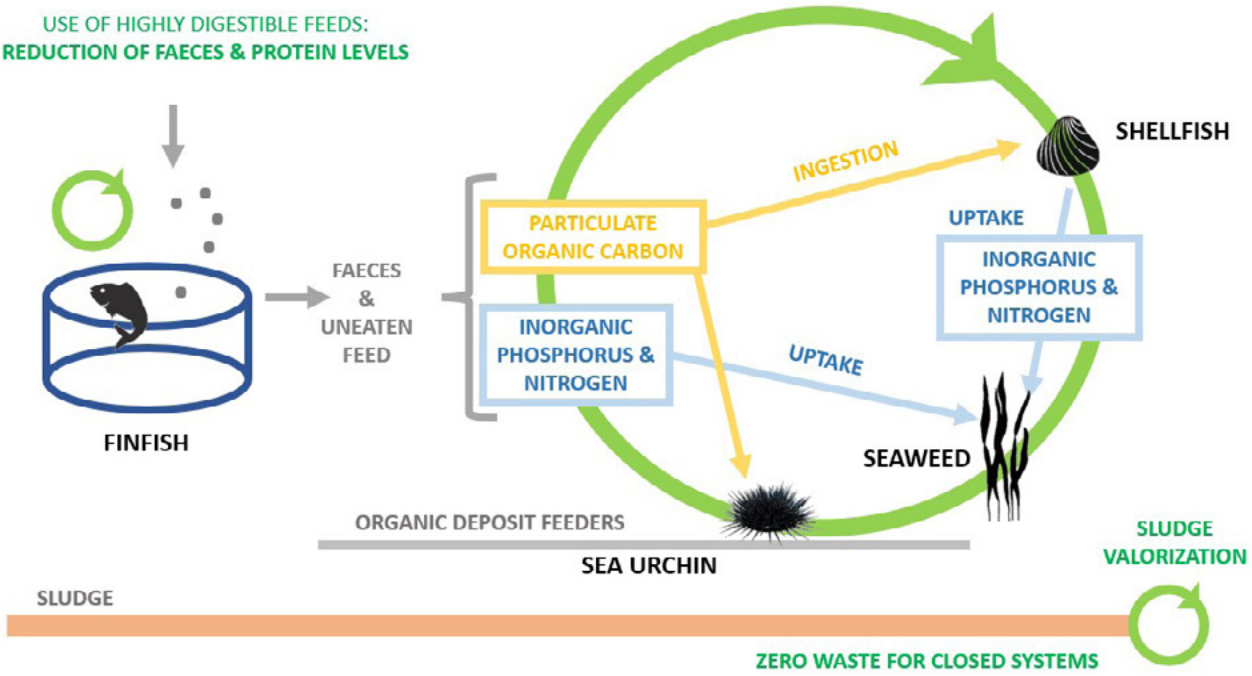
  - Promote the production and use of microalgal biomass as sustainable source of alternative proteins in the feeding of aquaculture animals provided the ingredient complies with rules determining criteria for safety, marketing and use of feed.

- Facilitate and incentivise the local market of circular ingredients and circular supplements:

  - Facilitate most promising non-linear feed ingredients (alternative proteins) and feed supplements.

  - Promote a policy dialogue to incentivize a broader adoption of circular fish feed in countries that still do not legally authorize the adoption of alternative proteins for the aquaculture industry.

  - Explore possibility of nutrient credits for aquaculture companies where nutrients are recovered through valorisation of effluent or waste (including IMTA concept) and / or companies that use feed with "circular nutrients".



3. **Improve circularity of feeding**

- Incentivise the implementation of circular practices such as: Using feed-use efficiency control systems to reduce losses: if we don't measure, we cannot control.
- Matching the aquaculture feed energetically to the type, stage of life and housing facility.
- Improving digestibility in order to minimize nutrient excretion.
- Generating stable faeces (very difficult with warm water species such as carp and catfish, easier with cold water species such as salmon and trout), in order to be able to remove them more easily via mechanical filters and to further utilise them (e.g. fertilizer, biogas).
- Using the dissolved nutrients in aquaponics or algae cultivation.
- In the case of open systems, promote the use of agroecological practices, valorising ecosystem services and functions: Increase species and genetic diversity, increase beneficial biological interactions.
- Test the potential of selective breeding and genomics to increase resource efficiency of farmed species in novel circular systems, e.g. adaptation and feed efficiency in RAS.

4. **Use common KPIs to report circular feeding** (all feeding systems: closed, semi-closed, open)

- Measuring nutrients recovered efficiency
- Measuring nutrient's assimilation (resource efficiency)

5. **Improve funding possibilities to enable holistic approach of the whole value chain and ascertain adequate safety assessment.**

3.2 Valorise aquaculture wastes (effluent and sludge)


Algae production in Bioreactors

Context and Challenge of aquaculture waste valorisation

- The feed introduced into fish farms is either consumed or remains uneaten, together with by-products from fish metabolism such as ammonia and faecal solids.
- Open systems, such as sea-net-pen cages and ponds, have little to no physical barrier to prevent uneaten feed and excreted nutrients from entering directly into the surrounding environment.
- Land-based recirculating aquaculture systems (RAS) and (semi)closed sea farms offer a high degree of containment, easing waste management of effluents (waste water) and sludge.
- The Water Framework Directive and some national regulations, foresee the reutilisation of treated waste water for certain applications such as irrigation or street cleaning. However, regulations do not deal with other aspects related to the use of water within aquaculture facilities, such as the recycling of water within aquaculture operations or the reutilisation of effluents. Aquaculture legislation in Europe in general is large and comprehensive, but it is not specific for the case of RAS waste water reuse.
- Presently, only waste treatment options, such as landfill, incineration, biogas production, ensilage and composting, are allowed for sludge (Regulation (EC) No 1069/2009)*[15]. Sludge from freshwater recirculating systems RAS, may be treated in regional waste treatment facilities or biogas plants, but generally the amount of sludge is not enough for RAS farms to have their own methane bio-digester. Sludge from biogas reactors may be also used for agricultural purposes because nutrient content is appropriate to be used as fertilizers. However, differences in rules and in quality and environmental standards hamper the circulation of fertilizers based on recycled nutrients in the EU.
- Waste streams are rich in organic matter and constitute part of the natural diet of filter feeders. Nevertheless, Regulation (EC) No. 767/2009 on the placing on the market and use of feed, prohibits the use of animal waste to feed any other animal and invalidates the Integrated Multitrophic Aquaculture (IMTA) schemes on fish tank waste.

*[15] *Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation) (europa.eu)*

Algae production in Bioreactors

"daisuke kurashima/EyeEm / stock.adobe.com" Oyster Farm

- Nutrient discharges from aquaculture may contribute to unwanted environmental impacts. However, nutrients discharged may also be considered as potentially useful economic flows, since they could be used as inputs to other processes such as the production of microalgae for new feeds in aquaculture and thus, transformed into marketable products. However, it is not clear under what conditions, algae grown and harvested using wastes as inputs are considered as waste (see ESPP-EABA-EurEau letter from November 2021 to the European Commission concerning End-of-waste for algae grown using waste inputs) here*[16].

- The use of wastewater from aquaculture for the culture of microalgae intended for feed production appears promising since microalgae is already widely used in bivalve and live feed culture. However, it is unclear if this would be allowed under current legislation.

- Microorganisms, heavy metals and Persistent Organic Pollutants (POPs), which include a broad range of halogenated carbon structures contaminants and medicines, are globally dispersed and not readily degraded in the environment. They pose a technical barrier for waste valorisation and towards zero waste strategy.

Objective of the recommendation towards waste valorisation

- Develop a common approach to promote the reuse of waste streams from aquaculture, while supporting a coherent framework within EU for waste reuse and harmonised legislative framework to valorise nutrients within aquaculture.

Recommendations

1. **Support aquaculture systems offering high waste valorisation potential**

- Land-based RAS system, and to some degree (semi) closed sea farms, offer a high degree of containment and thus, great opportunities for waste valorisation.
- IMTA schemes offer alternatives/solutions for sea cage production systems.

Recirculation Aquaculture System - Norway

2. **Promote the mapping of waste flows**

- Engage fish farms to elaborate inputs and outputs at their fish sites to trace the flows (type of waste stream, uneaten feed, waste streams volumes, general characteristics).
- Promote research on data for traceability on microorganisms, heavy metals and Persistent Organic Pollutants (POPs) in the different waste streams, to support and achieve circularity within aquaculture, and make feasible the valorisation of waste products and side -streams generated by the aquaculture supply chains.

3. **Promote the valorisation of the different waste streams from aquaculture industry**

- Promote implementation of innovative technologies to recover nutrients to grow algae, not only from water, but also from sludge. Nutrients from water can be up taken by algae but nutrients from sludge are more challenging because they are bound to solids. Treatments are needed to solubilise nutrients from sludge so that they can be up taken by algae.
- Promote complementary valorisation routes e.g. for agriculture sector, towards zero waste.

Recommendation 4

Encourage sectorial and cross-sectorial co-governance

4

"Bart / stock.adobe.com" Mussels farming

Context and Challenge of circular feed production in aquaculture

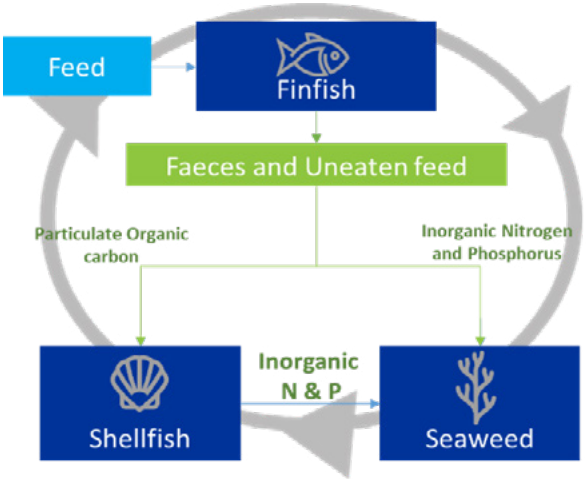
- Governance regarding aquaculture is complex in most geographies at this time. A more uniform set of tools for delegating space and licences is necessary in order to promote both traditional as well as novel aquaculture. Streamlining the application process, building on marine data, coastal plans and clear guidance is necessary since continuous suitable areas might be intersected by national borders (France/Spain, France/Netherlands,Netherlands/Belgium/Germany/Denmark; countries around the Baltic Sea) and uniform governance and disease/welfare control is necessary to maintain sustainable production.

- There are significant benefits in increased integration of the agriculture and aquaculture food systems. There is little doubt that agriculture can benefit from aquaculture, and vice versa, especially in the context of circularity and sustainability.

- Cross-cutting innovation can generate new valuable feed raw materials from agricultural waste, increasing the value base for the agricultural industry complex, as well as creating further valuable food. In the same way, it has been proven that products from aquaculture, such as kelp farming, can benefit the present day, and support parts of the agriculture industry towards increased sustainability, as an example, marine kelp production has shown a potential to mitigate methane production in ruminants. There is a significant space here to research further the effect this can have, and how to increase production and stabilisation of kelp products.

- Without comprehensive industry cooperation, the European food industry could lose out in the competition with other countries, in both the Americas as well as Asia.

IMPAQT - IMTA Concept



- Structures that need to be put into place are both of governance as well as financial character. Specific Blue/Green calls, highly focused on focused challenges must be put in place within the next round of calls. Early-stage industry processes (TRL 4-6) should receive support through catapults, clusters and governmental industrial funding schemes - bio refineries being one of the most limiting of the necessary infrastructure.

- One might imagine funding a number of European "Circular institutes" in close cooperation with or within research institutions with good connection with both industries already. The role of those to be an agency of specialists connecting blue and green industries, innovative companies and financial institutions with interest in the new cross cutting circular industry.

- At present day, funding schemes for aquaculture have a very wide scope. There is the need to refine and focus the attention to specific topics generating from the current status and considering targeted future challenges. A more efficient way is to refocus and address highly related issues, that reflect the current situation and related future challenges. One could very well see kelp/blue mussel research bunched together; there is synergy in the research on location, oceanography and societal impact, while the biology diverges.

- Fish health and welfare is cross cutting between a range of species, as well as being quite relevant for marine and freshwater farming.

- New feed raw materials are the largest single bottleneck the industry is facing presently and the one that needs to be resolved for many of the European finfish aquaculture species alike to increase sustainability and enable future growth. By exploring the use of material from both sectors, unused possibility for crossover effects as well as synergies between blue and green food sector.

- Digitalisation transformation cuts across all the areas of research, both as industry metrics, foundation for future research, as well as becoming the core in future management systems, akin to systems appearing in some fish farming territories.

Objective of the recommendation

- Promote cross-sectorial cooperation to enable integrated implementation of circular principles in the aquaculture sector and beyond.

Barramundi produced in recirculating aquaculture

Recommendations

1. **Review national legislations and EU regulation to support circular solutions in aquaculture**

   - Simplify and streamline the application process for setting up aquaculture operations which plan to use circular technologies.

   - Encourage to give specific highlight for circularity in national aquaculture strategies.

Fish Pond Hungary

2. **Facilitate cooperation between agriculture and aquaculture** ex: AGRI-AQUA circular institutes.

   - Incentivise the intersectoral circularity in national projects in EU member states supported by European Maritime, Fisheries and Aquaculture Fund (EMFAF) and European agricultural fund for rural development (EAFRD).

3. **Re-design present day research calls for aquaculture projects,** to specifically address unique issues on a co-creative and cross-sectorial level.

   - Integrate better the circularity in EU Mission: Restore our Ocean and Waters.

"zilvergolf / stock.adobe.com" Tilapia

AQUACULTURE GOING CIRCULAR

Related events

"Aquaculture Going Circular" was an online webinar hosted in November 2021 organised by H2020 Project iFishIENCi in collaboration with the endorsing organisations of this document. Recording of this event can be viewed **here.**

iFishIENCi

Email: info@ifishienci.eu | Web: www.ifishienci.eu

All the partners and collaborators logo:

FUTURE EUAQUA

eit Climate-KIC

Co-funded by the European Union

GAIN Green Aquaculture Intensification

INVENDO Akuakultur

INSTITUTO DE OCEANOGRAFIA

switchmed

Funded by the European Union

NewTechAqua

ASTRAL

CIRCLE ECONOMY

IMPAQT Intelligent Management System for Integrated Multi-trophic Aquaculture

AquaVitae

AquaIMPACT Nutrition and breeding