Recommendation on Promoting Low-trophic Aquaculture (LTA) and Low-Impact Aquaculture (LIA)

AAC 2024-12

October 2024

The Aquaculture Advisory Council (AAC) kindly thanks the EU for its financial support

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1. Background

This recommendation highlights the potential of low trophic aquaculture (LTA) and low environmental impact aquaculture (LIA) in the European Union; it defines these concepts and explains their current limits when applied to fed aquaculture species. Mapping is provided for regarding the LTA sectors.

For several years, public policy considerations for developing LTA and LIA have been increasing due to opportunities to align sustainability and food production efficiency. Through the Guidelines for Sustainable EU Aquaculture,[1] the European Commission highlighted the necessity 'to promote the development of organic aquaculture and other **aquaculture systems with a low environmental impact**, such as energy-efficient recirculating aquaculture systems, integrated multi-trophic aquaculture (IMTA) systems, as well as **diversification towards species at lower trophic levels** (molluscs and other invertebrates, as well as herbivorous fish and algae)'.

Multiple reports, such as EU Industrial Policies: The solution to various dilemmas[2] have also recognised the importance of the development of these aquaculture forms to reverse the current decrease in European aquaculture: 'Serious efforts are needed to diversify aquaculture production methods, developing in particular multi-trophic approaches, as well as diversifying the species farmed, expanding the **production of non-fed and low trophic species**, such as shellfish, seaweed and small pelagic fish'.

The 2022 European Parliament resolution on 'Striving for sustainable and competitive aquaculture in the European Union: the way forward'[3] includes the following elements:

[The European Parliament] believes that **LIA** (such as low trophic, multi-trophic or organic aquaculture) and **the environmental services of aquaculture** can, if developed, contribute significantly to the Green Pact for Europe, the Farm to Fork strategy and a sustainable blue economy.

Recently, the European Commission reaffirmed its willingness to strengthen the development of **LTA by supporting** new research projects as **AQUAVITAE**[4] , **ULTFARMS**[5] **and others.** Indeed, LTA contains many promising outcomes in terms of having a low carbon footprint, biomass that is underexploited but technically available with lower energy requirements and zero feed or fertiliser inputs, as they extract dissolved nutrients or planktonic/detrital foods directly from the marine environment, and yet are nutrient-dense food sources rich in protein, unsaturated fats and micronutrients (Wright et al., 2018; Hallström et al., 2019; Naylor et al., 2021).

This document aims to streamline the vast and complex information on European LTA and LIA, trying to provide a common understanding of the concept as a definition and to recommend means, actions and policies that could unlock their potential. **First, we will introduce LIA's main fields of application, and we will define what LTA is regarding the state-of-the-art concept of the 'trophic level' in both natural food webs and aquaculture systems. Then, after looking at the several main concerned types of LIA, we discuss how to unlock their potential.**

[1] https://www.eesc.europa.eu/en/our-work/opinions-information-reports/opinions/strategic-guidelines-sustainable-development-eu-aquaculture

[2] https://www.eca.europa.eu/en/publications/JOURNAL-2024-02

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022IP0334

[4] https://aquavitaeproject.eu/low-trophic-aquaculture-on-the-spotlight-in-new-eu-funded-project/

[5] https://maritime-spatial-planning.ec.europa.eu/projects/circular-low-trophic-offshore-aquaculture-wind-farms-and-restoration-marine-space

2. Justification

A. Low-impact Aquaculture

It can be accepted that LIA concerns **all aquaculture activities where, based on common sustainability indicators, the environmental impact is negative or low**. Most of these systems also provide 'ecosystem services' that should be assessed, measured and recognised[6]. LIA includes, but is not limited to, the following main systems:

- **LTA** (non-fed species belonging to the lower levels of a trophic chain). This concept refers mainly to monospecific productions that are often produced directly in natural environments (see the **mappings below**).
- **Land-based extensive and/or integrated aquaculture systems** whose final impact is low independently of the position in the food chain of the grown and harvested species and independently of the feed used.
- **Integrated systems (e.g., IMTA)** in coastal, offshore or freshwater conditions.
- **Restorative and regenerative aquaculture.**
- **Fed fish farming systems with a light environmental footprint, like most of organic ones and other with particularly low environmental impacts practices**.

It must also be mentioned that these different concerns can be interconnected.

While the shellfish sector is abiding by the strictest sanitary standards and deploying significant efforts to prevent consumer contaminations by investing in improved monitoring and purification solutions, tackling the problem at the source is indispensable and consistent with polluters pays principle.

The contamination of shellfish by norovirus is only one example of the impact of water pollution on shellfish. Chemical contaminants such as dioxins, polychlorinated biphenyls, heavy metals (particularly lead, mercury, cadmium and arsenic) and polycyclic aromatic hydrocarbons from the surrounding waters are also problematic for shellfish health and their sanitary quality. There is also increasing evidence of the impact of micropollutants on shellfish health and growth[7].

A suitable treatment of urban wastewater and preventing discharges of untreated or insufficiently treated wastewater into the environment has the potential to tackle these issues and greatly improve the quality of water in shellfish production areas.

[6] AAC Recommendation on Ecosystem Services, June 2021 - (AAC 2021–08). https://aac-europe.org/en/publication/aac-recommendation-on-ecosystem-services/

[7] Microplastics and seafood: lower trophic organisms at highest risk of contamination, 2020, Chris Walkinshaw et al.

Impact of polyester and cotton microfibers on growth and sublethal biomarkers in juvenile mussels, 2023, Chris Walkinshaw et al.

On the horns of a dilemma: Evaluation of synthetic and natural textile microfibre effects on the physiology of the pacific oyster *Crassostrea gigas*, 2023, Camille Détrée et al.

B. Low Trophic Level: Context and Application to Aquaculture Context

The term 'trophic level' comes from various studies carried out to characterise natural food chains. These include all the transfers, transformations and storage of energy between each member of the network in an ecosystem (Elton, 1927; Lindeman, 1942).

The *'trophic level'* corresponds to the number of intermediates between an organism and the sources of organic matter in the food web. Therefore, it can be used to describe diet in terms of proximity to sources of organic matter. By construction, the sources of organic matter constitute the first trophic level, then the primary consumers occupy the second level and so on. (Hette-Tronquart and Belliard, 2014).

In natural food webs, the vast majority (about 90% on average) of the energy captured by primary producers is lost through energy expenditure (such as growth, reproduction, predation avoidance and other mechanisms) and only a small fraction passes to the trophic level above. The inherent inefficiency of trophic transfers through natural food webs means that the higher the trophic level of an animal eaten by humans, the more ecosystem energy is embodied in its production (Aubin et al., 2021).

There is a **consensus in the literature on categorising LTA species as Level 1 and 2 species (or a little over two).** These are the primary producers and first consumers of trophic chains.

Application to Aquaculture

Several scientific publications have estimated that LTA concerns non-fed species at a low trophic level and/or extensive farming (Tang et al., 2018; Krause et al., 2022).

Among these forms of aquaculture, we find, by increasing trophic levels, algae cultures, bivalve molluscs cultures, and certain species of finfish. In this last case, it should be noted that the upper limit of the 'trophic level' may be less easy to precisely define. Other new promising species, such as echinoderms or certain invertebrates, should not be forgotten. In fact, as well as fully meeting the criteria of low trophic levels, these species have their place in European aquaculture today and in the future.[8]

It is important to point out that, while LTA is by nature the best representative of LIA, in particular, because of the non-use of feed, other forms of aquaculture can be included in this category, depending on the environmental indicators selected.

Concerning this last point, it must be pointed out that the metric of the 'trophic level' is not always transposable for all aquaculture systems. Furthermore, this species-based metric is not always compatible with one aquaculture system but with one species of a specific aquaculture system. This is why it is easier to apply the 'trophic level' concept to single-species cultures.

That is why, for **fed aquaculture species, an effective** aquaculture policy needs to avoid overly simplistic sustainability indicators, such as 'trophic level'. Instead, employing empirically derived metrics based on the specific farmed properties of species groups, management techniques and advances in feed formulation will be crucial for achieving truly sustainable options for farmed seafood through low-impact practices.

[8] https://oceans-and-fisheries.ec.europa.eu/news/new-sustainable-food-oceans-eu-funds-holofarm-sea-cucumber-farming-2021-03-26_en

At the same time, this AAC document aims to bring to the attention of the European Commission and the Member States that fed farmed fish and fed invertebrate species are produced in controlled environments using human-made compound feeds that differ markedly from the diet of the same species in the wild, blurring their natural trophic position. For this reason, the application of the 'trophic level' concept to fed aquaculture species becomes inappropriate, and the use of its value for assessing sustainability is further complicated by the continual reformulation of feeds. For this reason, policies that aim to develop these types of fed aquatic farmed species should be shifted towards improving LIA practices.

Fed aquaculture species that can be classified as LIA allow for light environmental footprints, while at the same time, the controlled feeding of animals contributes to ensuring their food safety and nutritional values. Therefore, policy guidance based on wild trophic position or historical resource use may be misleading for fed aquaculture.

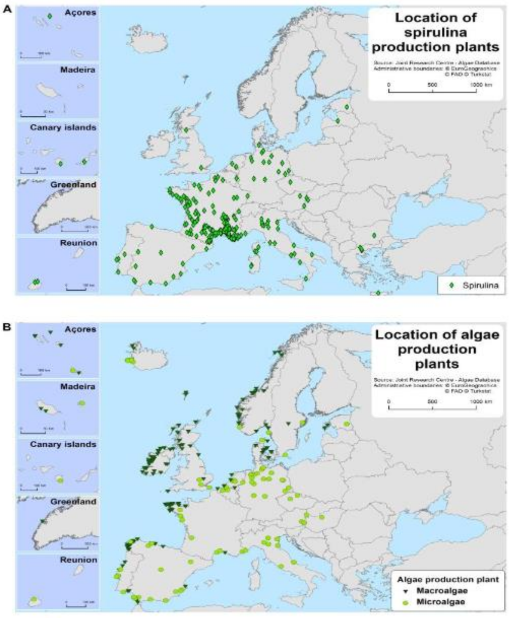
C. LTA Mappings and LIA Systems

i. Algae and Aquatic Plant Mapping (i.e., LTA)

This category covers all species of seaweed and marine plants produced by algaculture. Macroalgae (red, brown and green) and phytoplankton (microalgae and cyanobacteria) are included. They are considered the lowest trophic level at Level 1 (Trites, 2019). Some microalgae and phytoplankton have lower trophic levels. This lower level consists of green algae and plants (the producers), also known as autotrophs. They use solar energy through photosynthesis and do not depend on other animals or energy sources to fulfil their food requirements.

Mapping of Algae Production

We will draw mainly on recent work carried out by the Commission to illustrate what is known about spirulina and micro and macroalgae production at the European level.



Source: JRC

Figure 1. Locations of algae production plants

Map extracted from the Directorate-General for Research and Innovation ([Horizon 2020](), European Commission) et al. (2023):

Although algae production facilities are spread across 23 countries, some have notably larger numbers of facilities. Spain, France and Ireland are the countries in Europe with the largest number of macroalgae companies (more than 20 producers each)[9].

France, Ireland and Spain have the highest number of macroalgae production units (more than 20 producers each). The largest seaweed biomass volumes are produced by Norway, France and Ireland, while Germany, Spain and Italy are the biggest producers of microalgae.

Spirulina producers seem to be predominantly located in France, Italy, Germany and Spain (Directorate-General for Research and Innovation (European Commission) et al., 2023). In this same study, several data were gathered on the production volumes at the European scale, showing an approximate production of 182 tonnes dry weight (DW) of microalgae and 142 tonnes (DW).

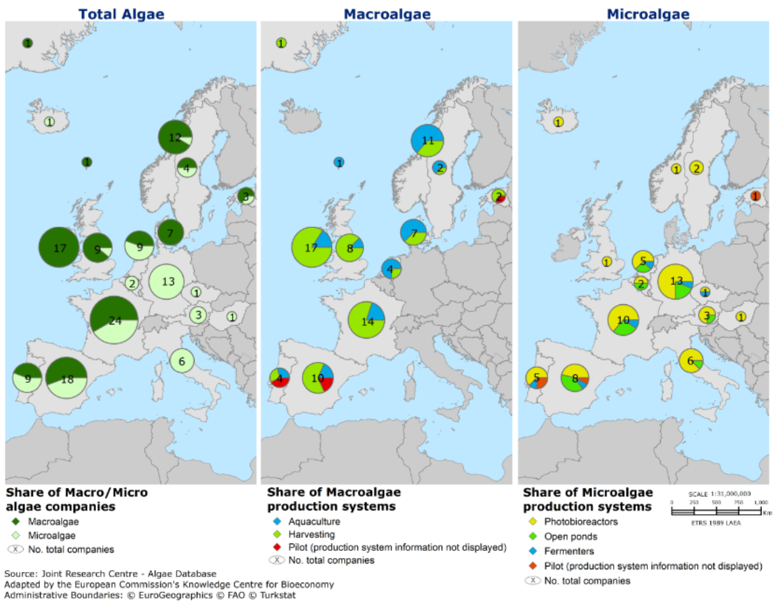


Figure 13: Number of companies producing algae biomass in Europe, (a) share between macroalgae and microalgae and production systems for (b) macroalgae and (c) microalgae, as of December 2019. Source: JRC - Algae Database.

Current Status of the Algae Production Industry in Europe: An Emerging Sector of the Blue Bioeconomy (Araújo R, et al., 2021). Front. *Mar. Sci.* 7:626389. doi: 10.3389/fmars.2020.626389

Seaweed production in Europe (considering harvesting from wild stocks and aquaculture) is primarily concentrated in the Atlantic region, with limited companies producing macroalgae in the Mediterranean area.

Seaweed aquaculture is seen as a possible way to meet the increasing demand from the processing industry for traceable, high-quality, predictable biomass yields. Furthermore, it is widely recognised that a transition from wild stock seaweed harvesting to aquaculture is needed to meet growing demand while avoiding the overexploitation of wild seaweed resources.

[9] Please, note that this study has been conducted for several EUROPAN Countries, and not member states.

Limits of the Mapping

Official statistics on algae (micro- and macroalgae) production volumes are almost non-existent at the European scale and the data available from FAO or Eurostat are limited and fragmented. It is still therefore difficult to estimate the quantity of algae production because of the missing data.

The STECF 2022 faced trouble in naming them (European Commission. Joint Research Centre. and Scientific, Technical and Economic Committee for Fisheries., 2023).

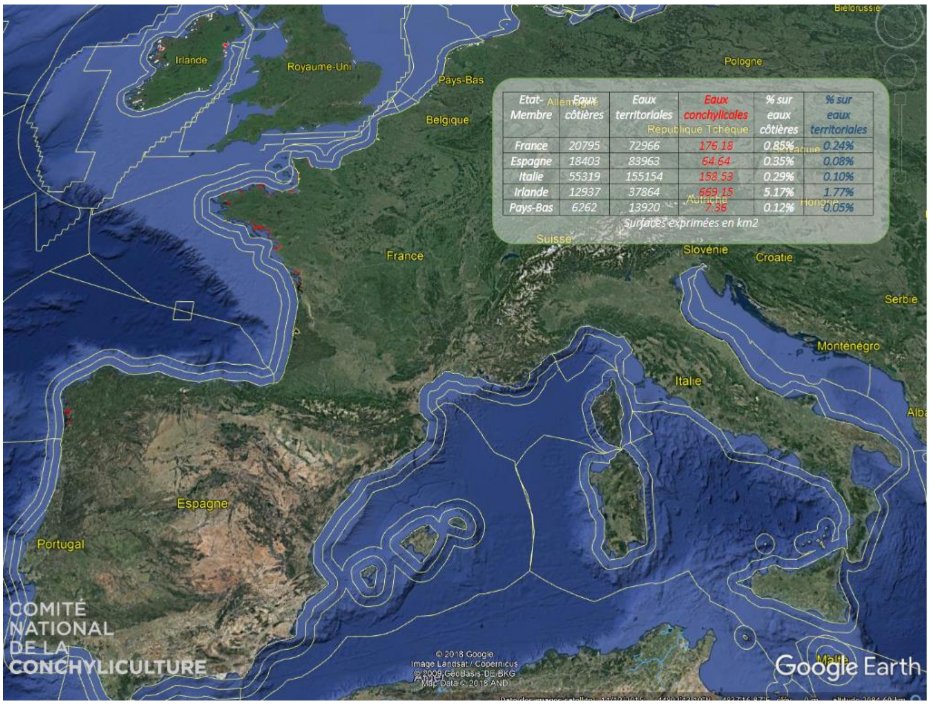
One of the reasons for this is the lack of a structured sector in the Member States and the difficulties in quantifying the mosaic of initiatives and different approaches in these same Member States.

ii. Shellfish Mapping (LTA)

This category includes all the shellfish species cultivated by shellfish farmers, such as bivalve molluscs (mussels, oysters, cockles, clams, abalone, etc.) but also other invertebrates (holothurian, shrimps, etc.). Nearly all shellfish belong to low-trophic marine aquaculture.

Bivalve molluscs are filter feeders and are therefore non-fed species. The literature therefore recognises they have a level close to 2 (Arbach Leloup et al., 2008) while some others have shown that some species also ingest zooplankton. This suggests that this level may be slightly above 2 (Lehane and Davenport, 2006).

Other shellfish and invertebrates (shrimps, holothurian, etc.) may have higher trophic levels depending on their diet. The latter are not always non-fed species.



Map of shellfish farming waters (the figures in red represent the surface area dedicated to shellfish waters in 2018 (Source: EMPA)

The shellfish waters of the main producer Member States represent only a minuscule percentage of coastal waters (less than 1%, except for Ireland), even though this is the largest segment of all European aquaculture, with more than 584,000 tonnes in 2020 and a total value of 1.17 billion. It is also the aquaculture sector that employs the most people directly (40,620 people) with 6183 companies (European Commission. Joint Research Centre. and Scientific, Technical and Economic Committee for Fisheries., 2023).

However, it is important to emphasise that this leading brand has been in slow decline for more than 20 years, which has led to a half-decrease in production. Additionally, this sector is currently facing a more radical production crisis (invasive species and climate change impact/ mussel collapse), particularly in the South Atlantic and Mediterranean Sea.

iii. LTA Finfish Mapping (LTA)

This category includes the farmed fish species which are in a low position in the food chain like fish herbivorous or detritivores fish non-fed or partially fed, usually inland. They may be characterised by low exploitation of the ecosystem and, in the case of pond fish farming, by the use of a polyculture of species to use all trophic levels and mimic the natural ecosystem. Their trophic levels are between 2 and 3. For example, some cultures of cyprinidae in a traditional 'pond culture' and ecosystem management in 'Valliculture' (Italy) or in "Esteros" (Southern Spain) may be recognised as LTA.

iv. Other LIA Systems (LIA)

An exhaustive list of LIA is beyond the scope of this recommendation. As explained above, dealing with trophic levels for fed finfish species is particularly complex. Consequently, it is important to keep in mind that being considered or not as an LIA system also depends on an adequate performance on the associated sustainability indicators.

Moreover, IMTA or restorative and regenerative aquaculture, or some fed-fish systems may allow for light environmental footprints and provide ecosystemic services. Therefore, if the trophic level is relevant for non-fed species, it is also important to highlight that other criteria must be considered for fed aquaculture systems.

v. Discussion of the Development of LTA and Other LIA in the EU

In January 2023, a first presentation of the results of the 'Biomass production, supply, uses and flows in the European Union. First results from an integrated assessment" were presented to the AAC to discuss the potential of LTA in the EU.

The AAC highlighted the following:

- The AAC agreed with the discussions that have been held, stressing that the results of 10 million tonnes of aquaculture products from the LTA **are overestimated.** Indeed, it seems nearly impossible to reach this production, while shellfish farming (the biggest segment of European aquaculture) struggles to reach 600 thousand tonnes.
- The AAC also stressed the importance of considering the feasibility of other parameters. For example, local parameters (socioeconomic and environmental) as well as constraints of maritime affairs (safety, navigable corridors, etc.) are particularly relevant and discriminating for LTA development.

- The AAC agreed with the insufficient availability of data on both shellfish and algae production.

To this, the AAC adds the following:

- LTAs provide multiple ecosystemic services[10] even if they are difficult to precisely quantify.
- LTAs can improve the contribution of phytoplankton and increase energy transfer to ecosystems (Han et al., 2017).
- LTA development will only be possible with local community involvement and consultation.

3. Recommendations

The AAC recommends:

To the European Commission:

- **Regarding the Strategic Guidelines/ Multi-annual National Strategic Plan (MNSP):**
    - Monitor the assessment progress of MNSP and the Strategic Guidelines regarding LTA development;
    - In a short- and long-term strategy, set quantitative production objectives per Member State for LTA and other LIA as well as indicators, including leading ones for monitoring their timely achievement;
    - Integrate quantifiable environmental sustainability indicators to all aquaculture types, including the current and potential forms of LTAs, and LIA.

- **Regarding Research Priority in Aquaculture**
    - Improve data collection on LTA feasibility while considering the capacity of the field, industry needs and the impact of global warming on the LTA and LIA ecosystems.
    - Promote and finance the quantification of ecosystem services (such as nitrogen sequestration[11]) provided by LTA and LIA.
    - Support LTA and other LIA systems in scaling up their activities technically (where possible).
    - Promote and finance research on LTA and LIA, including feed performance for aquatic species and lowering the overall carbon footprint.

- **To the Member States:**
    - **Regarding the Multiannual National Strategic Plans (MNSP):**

[10] https://aac-europe.org/wp-content/uploads/2021/07/FR_AAC_Recommendation_-_Ecosystem_Services_2021_08_revised.pdf

[11] https://aac-europe.org/wp-content/uploads/2021/06/AAC_Recommendation_-_Ecosystem_Services_2021_08_revised2.pdf

- Determine quantified targets in MNSP based on the Strategic Guidelines recommendations for developing their national LTA and other LIA.
- Identify the existing and potential areas suitable for aquaculture, including the Natura 2000 areas for LTA and LIA.
- Create a national administrative framework for algae and aquatic plants that is coherent with the aquaculture sector.

➢ **Regarding National Support**

- Support the environmental impact assessment required for LTA and LIA and adopt a 'basin approach'[12] where appropriate.

[12] In other words, an approach to watershed management that takes account of the natural functioning and continuity of terrestrial and marine aquatic ecosystems

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