# Reducing the aquatic foodprint

## Could algae and cell-cultured fish be low-impact alternatives to our current aquatic food system?

SEAS AT RISK

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# Executive summary

Meeting the increasing demand for aquatic food through high-impact fisheries and aquaculture is not sustainable, as it leads to ecosystem deterioration, overfishing, biodiversity loss, social injustice, human rights violations and economic hardship. The European Union (EU) plays a crucial role in the debate on sustainable food systems, particularly the much-needed transition towards low-impact aquatic food production.

This paper seeks to initiate an informed discussion on rethinking current approaches to aquatic food production. It assesses the ecological, social and economic impacts of emerging alternative (plant and cell-cultured) ways to produce aquatic food, in order to gain an overview of the potential – and the risks – of alternative aquatic food.

The first part of the paper takes a closer look at the impacts of our current aquatic food system, while the second then focuses on the impacts of two emerging alternative aquatic foods – cell-cultured fish and algae. Around them, new avenues of aquatic food production are developing rapidly. These alternative aquatic foods could, according to their advocates, have substantial potential to reduce animal suffering and exploitation, as well as reducing climate and other impacts of food production. Nevertheless, there are several, still largely unknown risks, particularly around upscaling of the industry, corporate power concentration, health, and the cultural dimension of food.

Drawing from a literature review and a webinar series, this discussion paper identifies relevant perspectives on developments in the alternative aquatic food (AAF) industry and their impacts on the environment, society and the economy. Some see alternatives to destructive wild capture fisheries and aquaculture (e.g. cell-based fish or algae) as a solution to provide healthy and environmentally friendly protein for the future, not only to keep pace with the growing global population's appetite for fish, but also to improve food security. In addition, alternatives could be highly beneficial to animal welfare and will move away from our current system of mass slaughtering of animals (on land and at sea) that currently serves as the motor for our animal protein consumption. Others see the developments in the AAF industry more critically and caution against trusting techno-fix single-product solutions (such as cell-cultured fish), which might impede the much-needed holistic change of the entire system. They point to the need for systemic change to encompass the food system as a whole, and to move away from corporate concentration and dependencies on a reduced number of suppliers towards a decentralised system with local value chains.

As the AAF sector is still evolving, many questions remain about upscaling and interactions with the conventional aquatic food sector. Nevertheless, given that several issues with terrestrial industrialised livestock and crop farming are increasingly repeated at sea, it is crucial for Seas At Risk and its members to work on a sustainable and just aquatic food system transition.

# 1. Introduction

## 1.1 Context and relevance

### Background

As we are in a moment of crises the COVID-19 pandemic and the war in Ukraine have starkly highlighted the severe vulnerability of our current food system. The pandemic has drawn attention to the fact that intensive industrial animal farming (land and sea) fueled by the insatiable demand for animal protein propels the emergence of resistant germs and zoonoses, which are then more prone to spreading, due to progressive environmental degradation and climate change. The war in Ukraine clearly showed the dangerous dependencies in the global food system, with significant cascade effects when disrupted. These diverse vulnerabilities make it clear that **our current food system is dysfunctional for environmental health, human health and our socioeconomic system**. We need to avoid short-sighted solutions based on conventional improvement and damage control, and instead interrogate our current system beyond business-as-usual to make it more resilient, sustainable and just.

From an aquatic food systems perspective, this means **rethinking current models of overexploitation of our oceans**. These existing models facilitate dramatic overfishing, with consequences ranging from pollution and bycatch to animal suffering and species extinction. In this context, **new alternative ways of producing food, such as algae and cell-cultured fish, are on the rise**. These completely new means of meat and aquatic food production are developing rapidly and have the potential to substitute – or at least dramatically reduce – both wild fisheries and aquaculture in the longer term.

### Landscape

**Exploratory conversations on cellular meat and seafood production have begun within the EU Food Policy Coalition**, of which Seas At Risk is a member. Those talks did not result in a joint position, however, due to **diverging views**. Some non-governmental organisations (NGOs) have started to research and develop individual ideas or positions. For example, Eurogroup for Animals (EFA) has commissioned a useful overview of cultivated meat from an animal welfare perspective. The International Panel of Experts on Sustainable Food Systems (IPES) Food is working on the political economy of alternative proteins and recently published a report on the politics of protein, outlining the dangers of corporate concentration in the emerging alternative protein sector. The Good Food Institute (GFI) has taken a rather techno-positive perspective, arguing in favor of alternative proteins by claiming that those could decrease a number of severe environmental problems resulting from food production. La Via Campesina remains strongly opposed to cell-cultured solutions, citing its fear of "the end of peasantry".

In their mission to protect and restore the marine environment, Seas at Risk and its members aim to be part of this discourse. More specifically, they seek to gain **an understanding of the potentials and risks of alternatives and to add a marine and European perspective to the discussions.** While the alternative seafood sector is still in its infancy, these developments are nevertheless well underway, with high investment, as well as increasing public interest und funding. Industry groups, such as Cellular Agriculture Europe, are preparing to promote their interests and bring their products to market as soon as possible. This necessitates an urgent deep dive into the question of alternatives to high-impact wild catch and conventional aquaculture, while also keeping in mind upcoming policy developments (e.g. Sustainable Food Systems Law).

**This discussion paper aims to initiate an informed discussion** with Seas At Risk members, as well as with other NGOs working on rethinking current approaches to aquatic food extraction. It is not intended to take a position for or against specific alternatives. It looks at reasons underlying the growing aquatic food demand, together with the impacts of our current aquatic food production in a holistic way. The focus will be on emerging alternatives to wild catch, while mapping some of the most relevant perspectives.

# 1.2 Introduction to aquatic food system developments

**As the global demand for aquatic food continues to rise, the pressures on our oceans become ever-greater.** The extraction of wild aquatic animals from the sea has particularly threatening consequences, such as species extinction, bycatch, pollution, animal suffering, and human rights violations. These serious impacts necessitate alternatives to current wild capture and unsustainable aquaculture practices. So called cell-cultured fish/in-vitro fish, as well as plant-based alternatives such as algae, are on the rise and may provide solutions to some of the biggest problems faced by our current aquatic food system (GFI, 2019).

**The world's population has almost doubled since the 1960s,** increasing the demand for food. During the same period, agricultural production has tripled and **fish utilisation has grown even fivefold, significantly outpacing the demands of population growth (FAO, 2020).** The significant increase in per capita consumption has led to a continuously growing demand for aquatic food. According to current studies, the annual average per capita fish consumption rose from 9.0 kilograms (kg) in 1961 to 20.5 kg today, with remarkable differences between developing and developed countries. While per capita consumption is highest in developed countries, at 24.4 kg – far above the World Health Organization (WHO) recommendation of 15.6 kg – it is lowest in Africa, at 9.1 kg (Marwaha et al., 2020; Food and Agriculture Organization of the United Nations (FAO) 2020).

**Global aquatic food is currently the most-traded portion of all agricultural and food commodities, and the EU plays a central role in these international dynamics. Per capita consumption in the EU averages around 24 kg per year,** with some member countries having the highest consumption rates in the world. While the EU has a relatively high demand for aquatic food, its self-sufficiency in aquatic food is only around 45%. This results in the EU being far from able to meet its fish demand from its own seas. Instead, it pays non-EU countries around €160 million annually in fishing agreements that allow the EU fleet to access their 200-mile zones. In addition, the EU imports large quantities of fish, and was the **world's largest fish importer in 2018,** followed by the United States (US) and Japan (FAO, 2020).

**With overfishing posing the most significant threat to marine biodiversity,** the increasing appetite for fish comes at a high cost to the marine environment. Across the world, destructive fishing practices and overfishing have damaged the seafloor and its carbon-storage capacity, as well as causing bycatch of sensitive species and overexploited fish populations that have **left 90% of wild fisheries classified as overfished or fished at maximal capacity (FAO, 2020).** European seas are not spared, with high overfishing levels of 50% in the EU's North-East Atlantic Ocean and Baltic waters, and over 90% in the Mediterranean and Black Seas. Our oceans are now in a precarious condition, which not only dangerously affects marine ecosystem stability, but also human health and the livelihoods that depend on ecologically diverse and healthy oceans.

**Reducing the negative impacts of our current aquatic food system is crucial** if these ocean ecosystems are to recover and if we are to achieve our biodiversity and climate goals (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019; GFI, 2019) (EEA, 2016).

Despite the pressing threats caused by aquatic food extraction, the global demand continues to increase. Current studies estimate **that global food fish consumption will increase by a further 18% by 2030** (compared to 2018). While aquaculture was optimistically viewed as an environmentally friendly alternative to wild capture, it often proved equally unsustainable, due to heavy use of antibiotics, wild fish feed, cannibalism, etc. (FAO, 2020; Marwaha et al., 2020).

With cultivated animal cells and plant-based alternatives such as algae, a completely new and promising way of aquatic food production is developing rapidly. **AAF advocates argue that it has significant potential** to reduce animal suffering and exploitation, as well as reducing climate and other impacts of food production (GFI, 2019). Nevertheless, **there are several, still largely unknown risks**, particularly corporate power concentration, health, and the cultural dimension of food. The topic thus remains polemical and continues to provoke vivid debate.

While cell-cultured and plant-based meat alternatives are increasingly analysed, **the potentials and dangers of AAF remain largely understudied.** Considering the rapid development of alternative proteins, limited public awareness, and civil society positioning (especially for cell-cultured/lab-grown fish), it is important to enter a dialogue with various stakeholders in order to exchange views and build understanding based on the best available science.

The pressures imposed by our current aquatic food system raise major questions for society: how can we **sustain the ecosystem services of our seas while producing nutritious food in a just way? Can alternatives to wild catch complement existing strategies for sustainable food production** and help the EU to adapt and transform its food system to achieve these goals? This paper seeks to inform the discussion of whether plant- and cell-cultured AAF products could be a low-impact alternative to current destructive fishing and aquaculture practices by presenting some of the major – often competing – perspectives on those questions. **It explores and assesses algae and cell-cultured fish against their ecological, social and economic impacts.**

Chapter 2 outlines the underlying causes of the high impacts of our current aquatic food system. Section **2.1 focuses on the reasons for growing seafood demand** in recent decades, while Section **2.2 takes a holistic look at the major negative effects** of this increased demand on our environment, society and economic system. **Chapter 3 briefly presents the methodology,** while **Chapter 4 focuses on two alternatives to wild catch – cell-cultured fish and algae.** An overview of both alternatives, including the status quo, is presented in Section 4.1, followed by an analysis of their major opportunities and dangers in respect of impacts on our aquatic food system. **Chapter 5 provides an overview of the major perspectives** on the emerging AAF sector, while **Chapter 6 closes the discussion paper with some conclusions.**

# 2. Global aquatic food system

## 2.1 Increasing demand for aquatic food

Recent decades have been characterised by increasing global fish consumption , at a rate significantly outpacing that of the world's population growth, as well as that of all other animal proteins (figure 1). Per capita annual fish consumption rose from 9.0kg to 20.5kg in the last 60 years, mainly driven by the Global North. Global aquatic food demand is anticipated to increase by a further 18% between 2018 and 2030, with nearly all growth projected to come from aquaculture.

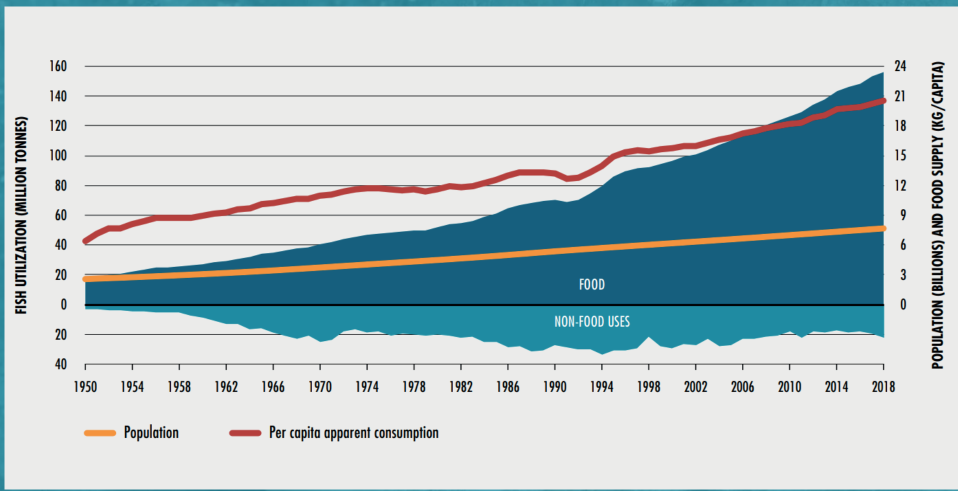
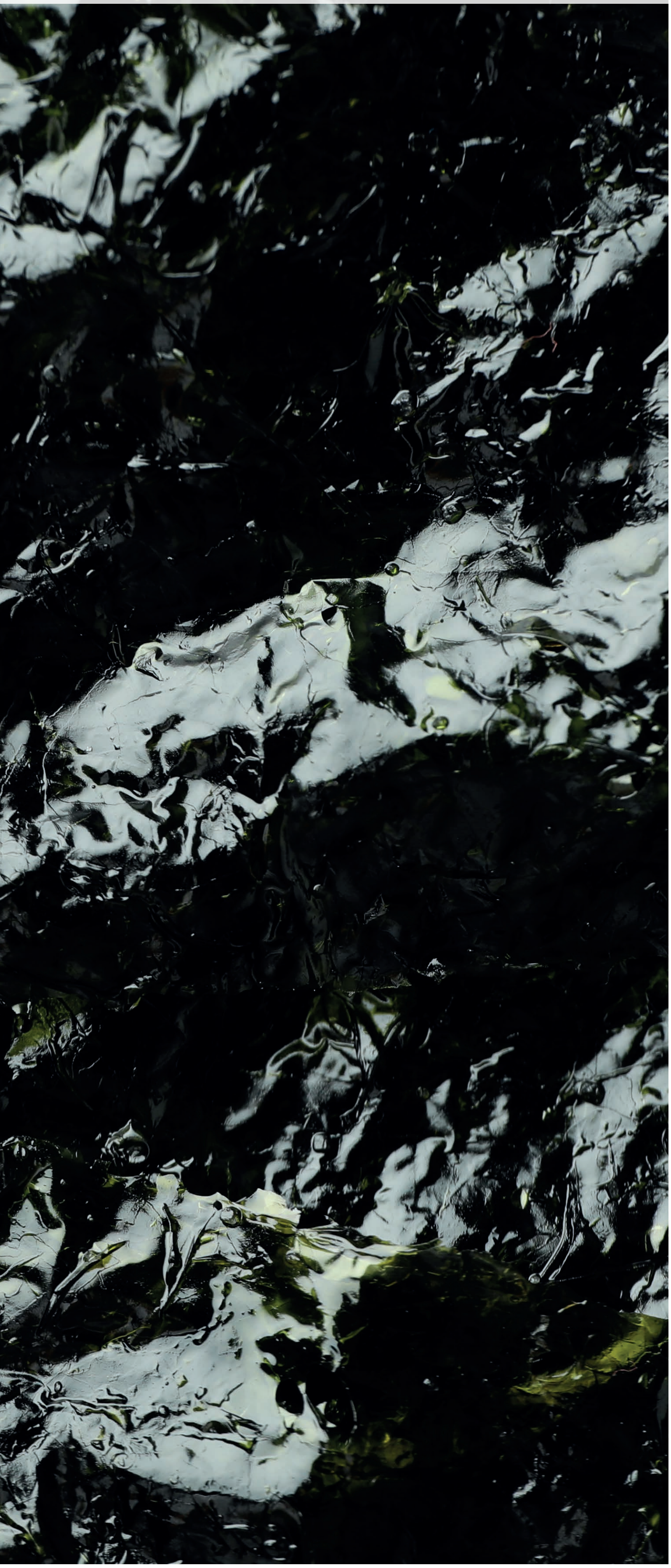



Figure 1. World fish utilisation and apparent consumption (FAO, 2020)

Global population growth, coupled with rising per capita consumption, has fueled the steadily increasing demand for aquatic food at a time of severe pressures on our oceans. Some of the major causes underpinning the increasing demand for aquatic food are briefly presented below.



## Growing world population

Since the 1960s the world population has almost doubled and is projected to increase further to 9.6 billion by 2050. Arguably, this has led – and will continue to lead – to increasing demand for food. The resulting rise in aquatic food extraction and consumption will put extra pressure on our vulnerable marine ecosystems. Nevertheless, per capita consumption plays an important role in this demand and largely outweighs the argument of the need for increased food production for food security due to the growing world population (FAO, 2020).

## Increasing wealth

Income disparity is an important factor underlying differences in fish consumption, as are the availability and price of aquatic food. Increased wealth has led to increased aquatic food consumption in recent decades (Marwaha et al., 2020).

## Increasing Aquaculture

There are considerable implications for fish distribution and consumption because aquaculture is gaining a larger share of the global fish market. The production processes can be more closely controlled in fish farming than they are in wild catches. Consequently, aquaculture has increased fish availability in regions and countries that previously had limited access (if any) to cultured species, often at lower prices. Since aquaculture production expanded in recent years, consumption of farmed species per capita has steadily increased (FAO, 2020).

## Health recommendations

Health recommendations are one of the major reasons for increased per capita aquatic food consumption.

Fish is promoted as having unique nutritional composition and a healthy and indispensable protein source for balanced diets. Aquatic food, especially small fish consumed whole, can be rich in omega-3 fatty acids, vitamins A, D and B, and minerals such as calcium, zinc, iodine and iron (FAO, 2020).

Nevertheless, the health benefits of aquatic food are more important for many low-income food-deficit countries (LIFDCs) and least developed countries (LDCs), where staple foods might not provide adequate amounts of these nutrients (Marwaha et al., 2020).

By contrast, the EU consumes more aquatic food than recommended. In fact, Member States' guidelines for weekly fish consumption are (on average) around 300g of fish per week per capita for a healthy and balanced diet, which amounts to about 15.6 kg/capita/year. However, European Commission statistics show that EU citizens eat 23.97 kg kg/capita/year, on average, 35% higher than advised in Member States' health guidelines (FAO, 2020).

Promoting the consumption of aquatic food overlooks the negative impacts on the environment and the ocean's ability to cope with climate change, as highlighted in the recent Intergovernmental Panel on Climate Change (IPCC) report. In addition, fish can pose risk to human health due to concentrations of heavy metals or plastic contamination (FAO, 2020).

## More efficient technology

Recent decades have been characterised by significant investment in improving fishing technology, including more efficient methods of finding, capturing and preserving catch at sea. Developments in transportation, cooling and techniques on board facilitate faster, easier, more efficient fishing. Although fisheries near the coasts are largely exhausted, more effective technology has seen fisheries expand to previously inaccessible offshore areas (WOR, 2013).

This increased technical effectiveness, coupled with rapidly expanded supply routes in the last century, has significantly simplified the global supply of aquatic food. This expanded the fish sales market, which was previously limited to mainly coastal regions. Today, so-called super trawlers can catch up to 6,000 tonnes of fish per trip, but need to go twice as far as in 1950, while harvesting one-third less per kilometer traveled. Global supply chains can provide supply worldwide, including to landlocked regions, where aquatic food historically was marginal (WOR, 2013).

## Urbanisation

Most countries have experienced a change in the extent and nature of fish consumption as a result of urbanization. Over half of the world's people now live in urban areas, and this trend is expected to continue. In 2018, 15 of the 33 megacities (over 10 million inhabitants) are located in developing countries. The majority of urbanites eat outside the home more often, and they have more disposable income to spend on animal proteins. Additionally, urban infrastructure enables fish and aquatic food products to be more efficiently stored, distributed, and marketed (FAO, 2020; Marwaha et al., 2020).

# 2.2 High impacts of our current aquatic food system

The current exploitation of aquatic food can threaten marine ecosystems, as well as socioeconomic systems (Figure 2).
Direct impacts include the degradation of marine habitats due to the type of gear used. Indirect impacts include exacerbating climate change due to fishing activities' high consumption of fossil fuels of many fishing activities. The latter not only results in a high carbon footprint but may also lead to indirect socioeconomic impacts as the use of fossil fuels may e.g. foster conflict.

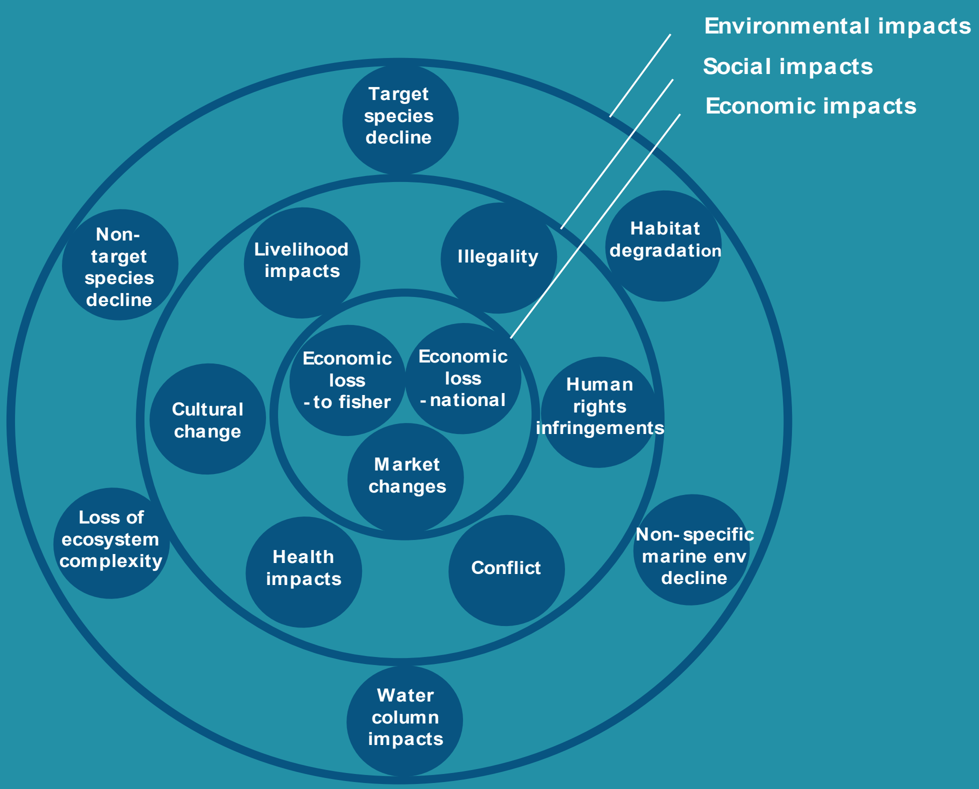



Figure 2. Environmental, social and economic impacts of destructive fisheries and aquaculture practices

Our nutrition and the way we "produce" food inevitably has a foodprint, i.e. an impact on our ecological, social and economic system. Recent years have seen a growing awareness of the interconnection of our diet with severe damage, especially to the environment. For example, food production is known to be responsible for around one-third of the world's greenhouse gas (GHG) emissions, 60% of biodiversity loss, 33% of degraded soils, and full/overexploitation of 90% of commercial fish stocks (FAO, 2020;  EEA, 2016).

The production of meat and dairy products is increasingly acknowledged as harmful to the environment. However, the same does not apply to aquatic food, especially fish, which is often classified as a low-impact protein source due to its supposedly comparatively lower GHG balance compared to meat. These calculated climate balances of wild catch often overlook severe impacts like seafloor degradation caused by bottom-trawling, which not only releases high amounts of stored carbon, but also hinders the capacity of the ocean to mitigate climate change (Luisetti et al., 2019).

Despite the many additional impacts of aquatic food production (e.g. overfishing, destruction of marine habitats, over- fertilisation, use of antibiotics in many fish farms), aquatic food is continuously promoted as low impact and beneficial to human health. However, it has also been widely criticised for the presence of heavy metals and microplastics in aquatic food, for example (GFI, 2019).

It is crucial that we move from a silo-thinking approach that only acknowledges one impact (e.g. GHG) to a holistic approach that uses a comprehensive impact assessment as the underlying framework for decision-making that looks towards a sustainable and just food system. The environmental, social and economic impacts of our current aquatic food system are explained in further detail below.

In 2018, the world's fish utilisation reached 179 million tonnes, 156 million tonnes of which were used for human consumption. 23 million tonnes were extracted for non-food-uses (e.g. fishmeal, fish oil). Aquaculture accounted for 52% of fish for human consumption and 46% of total production (FAO, 2020).

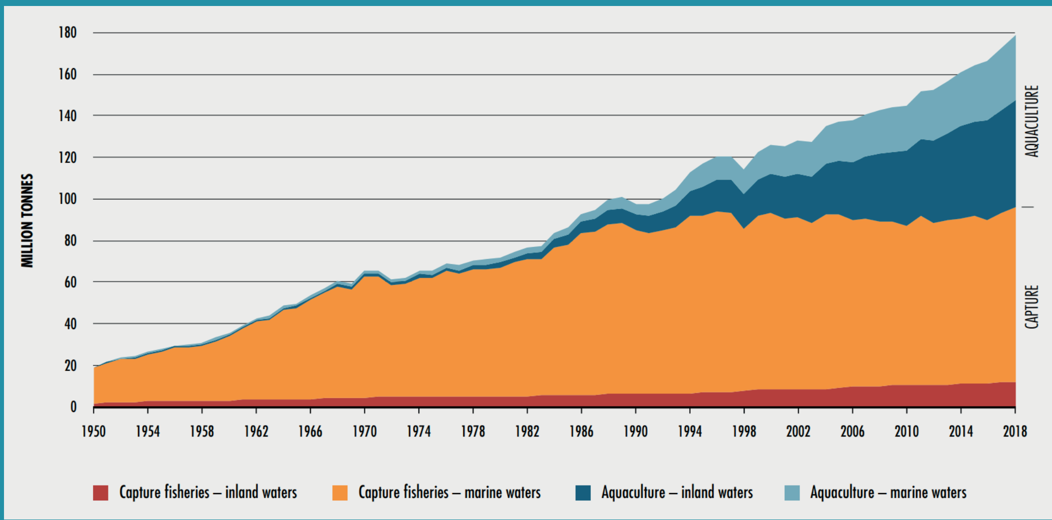



Figure 3. World capture fisheries and aquaculture (FAO, 2020)

# Environmental Impacts

## Wild capture fisheries

Fishing is the biggest threat to marine biodiversity, causing bycatch – including sensitive species – damaging the sea floor and its carbon-storage capacity, depleting fish stocks and leaving behind severely destabilised oceans (IPBES, 2019).

**Overfishing** - 30% of wild fish stocks are classified as overfished, i.e. they are exploited faster than they can recover, with 60% fished at maximum sustainable yield. It takes decades for overfished stocks to recover, as many commercial species take years to reach maturity. Overfishing can therefore cause fish populations to collapse or become extinct. Due to these highly depleted fish stocks, fleets need increasing amounts of fuel to catch lower amounts of smaller fish (GFI, 2019, Marwaha et al., 2020).

**Bycatch** - Another problem is fisheries bycatch, which refers to the capture (and often discarding) of unwanted marine animals. Bycatch impacts trophic dynamics and poses dangerous threats to marine fauna. According to FAO estimates, bycatch accounts for about 9.1 million metric tonnes, which corresponds to about 10.1% of annual catch (FAO, 2020).

**Animal welfare** - While marine animals are often excluded from animal welfare debates, they often suffer during fisheries' handling and slaughter, as they are frequently skinned, gutted or cooked while still alive. Similarly, marine animals are typically excluded from animal welfare legislation (EFA, 2021).

**Habitat degradation** – Fishing techniques such as bottom-trawling kill bottom-living organisms and ruin seafloor integrity by causing physical disturbance to bottom sediments. These destructive processes have a profound effect on oceans' carbon-storage capacity (IPBES, 2019).

## Aquaculture

The impacts of aquaculture depend on the species, location, method and management. Aquaculture can be compared to the industrialised terrestrial animal agriculture, presenting similarly severe risks, such as ependence on fishmeal and fish oil from wild fish, development of antibiotic resistant pathogens, degradation of sensitive coastal areas, non-native species, and severe threats through pollution (WOR, 2013, GFI,2019).

**Animal welfare** – Tanks are often characterised by crowding of the animals, leading to decreased animal welfare, stress, infections, cannibalism, etc. This substantially increases the risk of antibiotic resistance and zoonotic disease, which can then spread far beyond the individual tank (FAO, 2020).

**Feed** - A major part of feed contains fish oil and fish meal derived from wild fish. However, plant-based feeds are, in turn, dependent on increased need for agricultural land, freshwater, energy consumption and transportation (Boyd et al., 2015).

**Non-native species** – Non-native species are often predominant in aquaculture and may become invasive if they escape, threating their wild kin (Boyd et al., 2015).

**Pollution** – Metabolic waste, leftover food and chemicals (including medicines) are frequently released from aquaculture production units into the environment. This pollution of the water can lead to eutrophication (GFI, 2019).

**Biodiversity and coastal habitats** - Aquaculture situated in sensitive coastal areas can cause severe loss of biodiversity. It can also dangerously affect coastal protection, for example mangrove losses, which are crucial for coastal protection in many Asian countries (Marwaha et al., 2020).

# Social Impacts

**Illegal, unreported and unregulated (IUU) fishing** - IUU fishing not only causes major threats to the marine environment but also to the lives of people around the globe. The situation in West Africa is particularly critical, where IUU fishing accounts for 40% of the region's total catch, the highest level worldwide. With fish stocks in this region already heavily exploited, the situation is catastrophic, as small-scale African fishers cannot compete with the large-scale IUU trawlers. The latter also fish overfished species in Marine Protected Areas (MPAs) in order to achieve high profits, again undermining fishers on a legal basis (De Capita, 2019). IUU fisheries pose a clear threat to the most vulnerable economies. IUU fleets further deplete the seas and reduce the livelihoods of millions of subsistence fishers who highly rely on the income and food. The FAO estimates that more than 800 million people are at risk of malnutrition if fish populations continue to decline (FAO, 2020).

**Human rights infringements** - In recent years, the connection between IUU fishing and human trafficking and modern slavery is increasingly evident. In some cases, crew members (often young men) are recruited as cheap forced labour based on false facts and often have to work under inhumane conditions (Dubner and Vargas, 2017).

**Health** - Consuming aquatic food is not without risk for human health, as toxins such as heavy metals or plastic can accumulate in fish. This is particularly the case in species that feed at the top of the aquatic food web. Current studies estimate that the consumption of aquatic food accounts for up to 90% of mercury in the human body. Due to crowding in many aquacultural ponds, the risk of zoonotic diseases and antibiotic resistance also pose major threats to human health. Despite these risks, fish consumption is still recommended by many governments (GFI, 2019, Marwaha et al., 2020).

**Livelihoods** – Aquacultural ponds in sensitive coastal areas often negatively affect the resilience of coastal communities. This relates to the decreased availability of mangroves, which provide a wide array of resources and income for many coastal communities and are often crucial for coastal protection, thus their reduction has severe consequences (Marwaha et al., 2020).

# Economic Impacts

The primary sector of fisheries and aquaculture employs approximately 60 million people around the world, with two thirds employed in fisheries. According to estimates of the FAO, around 10% of the world's population depend on fisheries and aquaculture as their main source of income, which equates to about 820 million people. (FAO, 2020; (Marwaha et al., 2020).

**Economic losses** - For commercial species and ocean ecosystems to recover from decades of mismanagement and exploitation, it is critical to reduce pressure on global fisheries. For 2012, the World Bank estimates overfishing to have resulted in 88.6 billion USD annual net losses to global capture fisheries, which equates to trillions of dollars in natural capital assets (UN, 2022; Marwaha et al., 2020).

**Labour** - Low wages and poor labour right protections are characteristic of the sector due to many informal work arrangements. Fisheries in 47 countries have been reported to have suffered serious labour abuses (e.g. forced labour, child labor, forced child labour) (Marwaha et al., 2020).

**Subsidies** - Fishing has become increasingly subsidised to remain profitable because of the travel distances and resources required to fish efficiently. As alternatives become more widely available, this system will become politically unpopular as it has no economic viability (GFI, 2019).

## Role of the EU

The EU plays a crucial role in global aquatic food dynamics. While the EU has a relatively high demand for aquatic food, with annual per capita consumption of around 24 kg, its self-sufficiency is only around 45% and it is far from able to meet its fish requirements from its own seas. To be able to meet the demand, the EU pays around €160 million to non-EU countries annually for fishing agreements that allow the EU fleet to access their 200-mile zones. The EU also imports high amounts of fish, and was the largest fish importer in the world in 2018, followed by the US and Japan (FAO, 2020; Mirazo, 2022). With its high aquatic food consumption, the EU not only exacerbates the degradation of marine environments and IUU fishing, it also contributes to unequal distribution of aquatic food. The recently published report by the World Wide Fund for Nature (WWF) referred to this imbalance as "Europe eats the world". While millions of people outside the EU depend on aquatic food for their livelihoods and as a main source of protein, the EU consumes more than recommended by the WHO (FAO. 2020; Mirazo, 2022).

# 3. Methodology

This discussion paper presents an overview of both the current aquatic food system and the rapidly developing AAF sector. It focuses on the potential and the risks of AAF through an analysis of algae and cell-cultured options. The report is based on a literature review, as well as a webinar series with invited experts.


## Literature review

The review elements of the study were developed through a search of recently published reports. Key sources included publications from the GFI, EFA, IPES Food, WorldFish and the FAO.

## Webinar series with members and invited experts

A series of webinars was conducted with invited experts in order to:

- Identify the potential and risks of AAF;
- Identify knowledge gaps;
- Identify key perspectives on the developments in the AAF sector;
- Share thoughts and ideas;
- Add a marine and European perspective to discussions of alternative proteins.

Webinar 1 focused on the environmental impacts of AAF, while webinar 2 discussed aspects of health and political-economy aspects around the rapidly developing sector.

An additional internal brainstorming took place with Seas At Risk staff, as well as a kick-off meeting with the wider Seas At Risk membership. These initial discussions were followed by meetings with a  specially convened core group of Seas At Risk members.

# 4. Alternative Aquatic Food (AAF)

## 4.1 Major reasons underpinning the increasing interest in AAF

Aquatic food has become more accessible, popular and industrialised in European countries, leading to severe impacts on animals, people and the planet (see Chapter 2). These impacts become visible far beyond European borders. Rising GHG emissions, severe loss of marine biodiversity and other devastating consequences of our overexploitation of marine ecosystems, unsafe working conditions including forced labour and human trafficking in marine fisheries, and the spread of human infectious diseases and antimicrobial-resistant pathogens through aquaculture farming represent some of the major global impacts of the increasing demand for aquatic food (IPES Food, 2022).

Sustainability challenges we are facing cannot be overcome by the current high-impact aquatic food production system, which heavily relies on industrialised, destructive wild capture fishing fleets and unsustainable aquaculture farms. The urgent need for new approaches to complement existing efforts has seen increased interest in alternative proteins in recent years, both for terrestrial as well as for marine animal and plant proteins. The main reasons behind growing public interest in aquatic alternatives are summarised below.

## Environmental health

Ocean degradation and marine ecosystem disruption may become drivers of change towards AAF. As oceans get warmer, coral bleaches and sea levels rise, it is increasingly evident that aquatic species are among the most vulnerable to climate change, while also being crucial to meet current sustainability challenges. Advocates for alternatives point to the fact that they avoid conventional fishing and farming methods (including their negative consequences) and could therefore decrease some of the pressures imposed by our current aquatic food system (GFI, 2021a).

## Animal welfare

Whether or not fish and other aquatic animals feel pain has been debated for years. The balance of evidence shows that they feel fear, stress and pain. These findings not only have significant impacts for animal welfare legislation but have slowly started to reshape discussions of common slaughter methods used in capture fishing and aquaculture. Animal cruelty-free alternative proteins are seen as potentially reducing the consequences of the large-scale slaughter that characterises the current aquatic food system (Rucinque et al., 2017).

## Human health

Consumer awareness of public health issues, coupled with industrialised livestock farming, have gained attention in recent years. The health claims of aquatic food are slowly coming to be questioned, in light of contaminants, zoonotic diseases and antimicrobial resistance (AMR) connected with increased aquatic animal extraction and farming. Alternatives are seen as particularly promising for consumer groups who do not want to give up eating aquatic animals and plants, or who want the positive health impacts of aquatic food in their diet (Koehn et al., 2022)

## Investment opportunities

There are substantial opportunities for investment in modern foods and materials. As a new way to increase the supply of aquatic food, AAF is seeing growing interest among investors. The last year has seen €175 million of financing flow into the alternative food sector, almost doubling the amount invested in 2020. Although industry investors are seeing the opportunities in AAF, the the industry remains in its infancy compared to the $401 billion global aquatic food industry (GFI, 2021a).

# 4.2 Landscape of AAF

**Food and protein security, an increasing world population with a rising need for food**, and the nutritional contribution of aquatic food, supposedly necessary for modern healthy diets, are some of the **predominant claims** influencing the public debate around AAF (GFI, 2020; IPES Food, 2022). This leads to different perspectives on the topic of alternatives (see discussion in Chapter 5), with most approaches are mainly driven by the question of **how to meet the increasing demand for aquatic food in a sustainable and just way.** The following sections provide an overview of the landscape of AAF, diving deeper into some of the most promising and the most risky aspects of alternatives and mapping key perspectives on the growing sector.

AAF – also referred to as alternative seafood – is used as an umbrella term for plant-based, cell-cultured and fermentation-based aquatic food. The sector is young, with only 87 companies globally that are solely focused on AAF. Most of these companies work on plant-based alternatives, with the majority in the US and the EU, and an increasing share in Asia. Investment and development has gathered pace in the last two years (GFI, 2020). Significant private interest is mobilising research, and start-ups are partnering with larger companies, but there are also examples of EU funding exploring AAF (i.e. the EU Commission launched a €2 million Horizon Europe grant "Building alternative protein-friendly sustainable and healthy food environments").

These rapid developments are in stark contrast to the current industrial livestock farming and extraction model, the latter having reached its limit in terms of scale, reach and efficiency. Modern alternatives are estimated to be more efficient in their use of energy, land and water, and to produce an order of magnitude less waste, potentially complementing a new system of food production (Tubb and Seba, 2019).

Nevertheless, there are important emerging questions: Which sections of the current aquatic food offer do these alternatives replace? Who owns the technologies? What is the most appropriate mix of private/public investment and policy support? What does they mean for the traditional fishing industry? How can we scale up quickly, while creating a diverse and dynamic ecosystem of start-ups rather than a big corporate concentration? From a policy perspective, what do these developments mean in relation to the Farm to Fork strategy and other EU policies, such as the highly relevant Sustainable Food System Law?

**These questions clearly demonstrate the need to look at the development of AAF now, before the industry moves forward and develops in ways that should be avoided**. This paper focuses on the emerging and underexplored potential and threats of cell-cultured aquatic alternatives and algae. It does not take a position, but rather seeks to understand the different approaches and implications of the emerging AAF sector.

# 4.3 Spotlight on cell-cultured fish

Cell-cultured fish – also referred to as cell-based fish, in-vitro fish, or cultivated fish – consists of animal cells grown outside of an animal in a bioreactor. The aim of cell-cultured fish is to replicate the taste and health benefits of conventional fish by growing it directly from cells instead of catching, farming and slaughtering fish. As it consists of the same cell types as conventional fish, it is genetically identical to conventional fish (Tubb and Seba 2019). Figure 4 illustrates the process of cell-culturing in more detail.


Figure 4. Technical process of cell-cultured fish (based on GFI, 2020)

Cell culturing of fish works analogous to cultivated meat and other cell-cultured animal proteins. It begins with the extraction of a small sample of cells from the animal, which are then transferred into what is known as a bioreactor/cultivator. The latter works in a similar way to a brewery, where cells are bathed in a cell-culture medium (i.e. a soup of nutrients containing amino acids, sugars and other substances cells need to grow) under controlled temperatures for them to multiply. The cells multiply and differentiate into different types of cells like fat, muscle or fibroblast cells. A structure for the final product is then created for the cells to develop on. Some companies use stem cells, while others take repeated biopsies (GFI, 2020).

The technology used for production is adapted from other industries, such as biotechnology and brewing. Therefore, the majority of open questions relate to whether it is feasible to optimize and scale-up production, including the development of cell-lines and scaffolds and the best media formulations and cell culture densities, as well as efficient use of energy and water (Marwaha et al., 2020).

As yet, **cell-cultured animal products have not entered the market**, except in Singapore, where they have been sold since 2020. In the EU, they fall under the EU Novel Foods Regulation and are subject to pre-market authorisation and risk assessment by the European Food Safety Authority (EFSA). Prototypes have been produced and tasted but cost-competitive (compared with conventional aquatic food) products are not expected to be on the market in the next few years. Globally, market entrances is expected in the US within the next year. The cell-cultured animal industry continues to be dominated by start-ups, albeit with increasing investment levels and partnerships between start-ups and big companies (GFI, 2020).

One advantage of cell-cultured food is the fact that it is not limited to geographical regions or the production of specific species. Production facilities can be located outside sensitive coastal areas and connected with efficient logistical access for materials and distribution. In addition, cell-cultured fish could provide contaminant-free, animal cruelty-free and (potentially) healthy aquatic food, while reducing pressures on marine ecosystems.
Nevertheless, there are high risks of shifting the impacts to other aspects of the production process, especially when scaled-up (see Chapter 5 for a discussion of these and other potential impacts).

# 4.4 Spotlight on algae

According to the EU Blue Bioeconomy report, algae is one of the most notable marine resources sectors of the EU Blue Bioeconomy, as “it is evolving and growing, offering new opportunities, sustainable products and creating jobs while contributing to ocean regeneration. In this regard, the new approach [...] emphasises a major opportunity for developing new algae-based food and feed products in the EU market to alleviate environmental pressures exerted by agriculture, aquaculture, and fisheries” (European Commission, 2022, p.127).

Algae – which can be differentiated into macro algae, micro algae, and spirulina – are becoming increasingly popular due to their wide range of commercial applications as food, feed or biofuels, in addition to being rich in nutrients and proteins (GFI, 2021b).

Globally, the algae industry has grown exponentially, with most activities located in Asia. Although there is increasing interest and potential for algae production in Europe, major technological, regulatory and market-related limitations persist (Araújo et al., 2021).

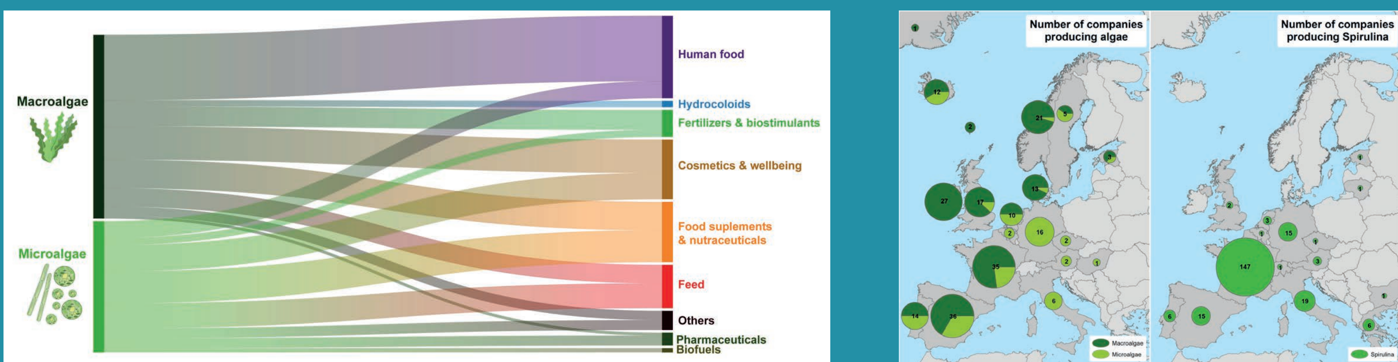



Figure 5. Share of commercial biomass applications by macroalgae and microalgae production company (left) ; Number and relative distribution between macro- and microalgae (A) and Spirulina (B) production companies by country (right) (Araújo et al., 2021)

Current studies estimate that the **European algae landscape consists of 447 algae and Spirulina production units** in 23 countries. Around half of these companies produce microalgae and/or Spirulina, while the other half focus on macroalgae production.

Two-thirds of the European **macroalgae production** depends on harvesting from wild stocks, but macroalgae aquaculture is present in 13 countries and developing in several others. Three-quarters of the production units are located at sea and one-quarter on land. Nevertheless, macroalgae aquaculture is in its infancy in Europe in terms of production volumes and number of production units. European macroalgae aquaculture currently contributes less than 1% to total European seaweed biomass production, despite accounting for one-third of the mapped **macroalgae** production units (European Commission, 2022). Photobioreactors are the predominant system for microalgae production, followed by ponds and fermenters. Ponds are typically used for **Spirulina production,** with a small fraction using photobioreactors (Araújoet et al., 2021).

The primary application of algae biomass is for food (36%), food-related products such as supplements and nutraceuticals (15%) and feed (10%). Algae are also used in cosmetics, fertilisers, and bio stimulants (European Commission, 2022).

The use of algae for food products is rising, fueled by the opportunity to get the same nutrients as from fish consumption, but directly from plants, thereby avoiding animal suffering. Algae are becoming attractive as a major ingredient of plant-based seafood due to their nutritional value, flavour and pigmentation. They can also play a role in cell-culturing when used as scaffolds or part of the nutrient-rich medium for cell growth (GFI, 2020).

In the European Green Deal, the Farm to Fork Strategy and Bioeconomy Strategy, the EU recognises the potential of algae to meet current sustainability challenges of aquatic food production. By the e**nd of 2022, the European Commission intends to adopt a cross-cutting EU Algae Initiative** (European Commission, 2022).

Nevertheless, there is considerable uncertainty, particularly in respect of the impacts of a scaled algae sector (see Chapter 5).

# 5. Potential impacts of Alternative Aquatic Food (AAF)

This chapter gives an overview of some of the potential impacts of AAF. Rather than an exhaustive examination, it spotlights the major concerns that arose in discussions with Seas At Risk staff and members.

## 5.1 Environmental impacts

The main overall positive environmental impacts of AAF stem from the fact that they avoid conventional fishing methods with all their negative consequences (see Chapter 2).

### Cell-cultured fish

Given the lack of coherent research, especially life cycle analysis (LCA), on cell-cultured fish, there are high levels of uncertainty about its environmental impacts (GFI, 2020). Nevertheless, the methods of culturing fish cells appear broadly similar to meat cell-culturing. Drawing on insights from cultivated meat LCA can thus illustrate the overall tendencies of these developments.

#### Energy consumption

As the culturing of in-vitro fish cells happens in bioreactors, the energy consumption of the cell-culturing process is a significant concern. Although meat and fish cell culturing are similar processes, cell-cultured fish exhibits potential benefits compared to its terrestrial counterparts. Fish naturally live in a colder environment than terrestrial animals, meaning that fish cell-culturing can be conducted at substantially lower temperatures than meat, reducing energy requirements (GFI, 2020).

Many species of fish are subject to muscle hyperplasia in early years, leading to a rapid increase in muscle cell count and biomass. Fish cells also differentiate into muscle and fat more easily than meat cells do, meaning more efficient production processes and lower energy requirements (GFI, 2020).

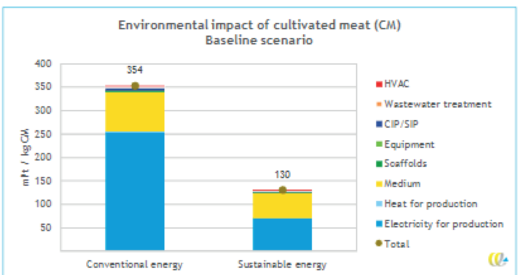



Figure 6. Energy consumption of cultivated meat (CE Delft, 2021)

One major question is whether scaling-up production requires active cooling, which accounts for 75% of the carbon footprint. It remains unclear if cooling will be needed in upscaled scenarios. Some facilities use less energy-intensive passive cooling, which could significantly decrease the energy consumption and thus the carbon footprint. Figure 6 illustrates the differences between conventional and sustainable energy use. The latter leads to a substantial decrease in the carbon footprint (CE Delft, 2021).

This inevitably raises questions of energy transition and moving away from the use of fossil fuels, particularly if the sector wants to live up to its sustainability claims. As cell-cultured meat and fish production uses electricity as a primary energy source, the creation of that energy is crucial.

### GHG emissions

Current studies estimate the GHG emissions from cultivated meat production to be between 3.8 kg and 29 kg of CO2-equivalent per kg of meat, including supply to restaurants and grocery stores, cooling, and accounting for food waste. These calculations depend on the energy used and on the materials needed to feed and care for the growing cells. Depending on these factors, the GHG emissions of cultivated meat are potentially still below those associated with farmed fish or shrimp and prawns. Due to the particularities of fish cell-culturing, the latter could be even lower than the estimates for cultivated meat (Mattick et al., 2015).

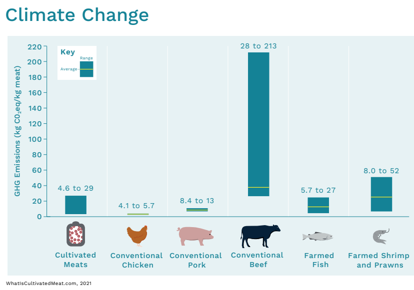



Figure 7. Carbon footprint of cultivated meat compared to other animal proteins (Whatiscultivatedmeat, 2021)

### Water use

The water use for cultivated meat is estimated at between 42 litres and 920 litres per kg of meat, including retail. The use of water for the cell culturing depends on whether the crops that feed the cells are irrigated and the technologies at the cultivated meat facility. In contrast, the amounts of water used to farm fish and shrimps are significantly higher. Globally, estimates of water use for farmed fish vary between 1,100 and 10,000 litres per kg (Tuomisto et al., 2014).

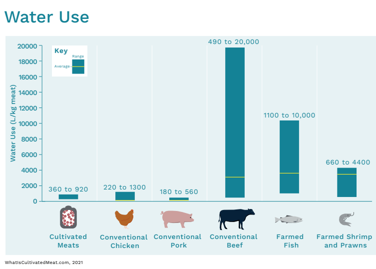



Figure 8. Water use for cultivated meat compared to other animal proteins (Whatiscultivatedmeat, 2021)

## Pollution

Only a single study has looked at the nutrient pollution footprint of cultivated meat production. Depending on the method used, aquaculture has high associated risk of polluting the environment and potentially leading to eutrophication and dead zones in the ocean. Cell-cultured fish could have substantial benefits compared to aquaculture in respect of the pollution footprint. The study estimated a footprint of 6 g to 17 g PO4 eq per kg of cultivated meat, including supply chains and waste (Tuomisto et al., 2014).

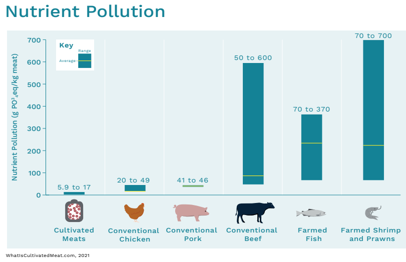



Figure 9. Nutrient pollution of cultivated meat compared to other animal proteins (Whatiscultivatedmeat, 2021)

## Animal welfare

One of the major concerns for animal welfare and culturing of cells is the use of foetal bovine serum (FBS). The FBS is taken from bovine foetuses of pregnant animals during slaughter, typically without anesthesia. Traditionally, FBS was used in the biomedical field as a growth media ingredient where alternatives were not available. Cultivated meat producers are now focusing on developing animal-free and serum-free growth media for the cell-culturing, which can be obtained from plant and fungus or through fermentation. Some serum-free media are already in use for certain biomedical applications, but they remain quite expensive (Kolkmann et al., 2019, What is cultivated meat, 2021).

# Algae

The cultivation of algae requires energy, water, and land, and can generate Nitrogen Oxide (N2O) emissions. The environmental impacts of algae production depend heavily on whether macro or microalgae are produced, as well as on the respective facility and location.

Microalgae are mostly produced in photobioreactors and the process is quite similar to cell-culturing methods when it comes to the environmental impacts of energy consumption, land and water use, feed, and pollution. These factors will therefore not be discussed in further detail in this section. By contrast, macroalgae generally require sufficient natural production areas with light, nutrients and a good temperature for growth. Accordingly, they have higher interactions and greater impacts on their surrounding environment (Campbell et al., 2019).

## Eutrophication

Algal blooms have generated concern about the upscaling of algae, as they can lead to eutrophication. According to current studies, microalgae have been shown to produce high amounts of N2O. Therefore, scaled-up microalgae production is also referred to as “controlled eutrophication”. This process needs to be well managed, particularly the risk of accidental water release from the facility into the wider environment. This risk becomes even greater if the facility is located near a body of water (Bechet et al., 2017). On the other hand, farmed macroalgae could help to mitigate the effects of ocean acidification by naturally sequestering carbon. Large-scale aquaculture of macroalgae could, if managed correctly, remove large amounts of carbon from the oceans (Usher et al., 2014).

### Non-native species

As in aquaculture, the release of non-native algae species can lead to severe problems. This is particularly relevant where non-native species can crowd out native species and severely interrupt local ecosystems (Usher et al., 2014).

### Land use

The farming of macroalgae creates questions of space and land use competition, as the coastlines in Europe are already intensively used for other purposes. It might, for example, be beneficial to situate algae in areas of offshore windfarms in order to create multi-use spaces, for example. However, this could lead to increased distances for maintenance traffic and higher carbon footprints of algae farming (Bechet et al., 2017). For both macroalgae and microalgae, production should not negatively affect or displace the communities that depend on those spaces.

### Marine habitats

As well as contributing to ocean restoration by sequestering carbon, macroalgae could support marine ecosystems by providing shelter to fish and fostering marine biodiversity. Macroalgae could potentially become a crucial component of integrated multi-trophic aquaculture, together with other marine animals and plants, which might allow for increased production with decreased environmental impacts. However, depending on the method of harvesting, it can also destroy ecosystems, for example when dredges are used (Campbell et al., 2019).

### Monoculture

Monoculture is a significant issue for algae farming. This is a problem often seen in China, where much farming focuses on only one type of seaweed. Although this makes sense from an industry point of view (a lot of biomass from a single provider), it is accompanied by substantial biofouling and the risk of viruses. These have similar negative effects as aquaculture, where diseases and pests affecting aquaculture production are a major global concern (Campbell et al., 2019).

**Potential environmental impacts of cell-cultured fish and algae**

Overall, the potential benefits of AAF compared to wild capture fishery or aquaculture **are that production does not require destructive fishing gear,** nor does it (in the case of cell-culturing and microalgae) need to operate in sensitive marine ecosystems. If serum-free media are used for cell-culturing, the production of AAF **does not kill animals or lead to animal cruelty.**

However, there is a **lack of coherent scientific data** and LCA on cell-cultured fish and upscaling of algae, which raises significant questions about the real environmental impact of an **upscaled sector.** Nevertheless, as the cultivation of animal cells and microalgae **require a lot of energy and growth medium**, these are the main factors that could unlock the environmental potential of cell-cultured fish and microalgae. Fish cells, due to their growth at lower temperature, their particular structure and cell replication behaviour, could decrease overall environmental impacts at a greater rate compared to their meat counterparts.

As many of the dangers relate to upscaling the respective industries, there is a **risk of repeating some of the problems of aquaculture, which are strongly connected to intensive industrial farming** (e.g. monoculture, pollution, non-native species).

# 5.2 Social impacts of AAFs

### Health

The development of AAF such as cell-cultured fish and algae has the potential to provide an alternative to industrial livestock farming, which adversely affects both human and animal health. Recent crises have again exemplified the interlinkages between animal welfare and human health. Intensive industrial animal farming (on land and at sea) is often connected to overuse of antibiotics, which can lead to AMR. Frequent underlying reasons for AMR are poor animal welfare in densely stocked farms (e.g. in many aquaculture farms), leading to stress in the animals and a higher susceptibility to diseases that require reactive administration of antibiotics (Van Boeckel, 2017).

In contrast, improving animal welfare can reduce the use of antibiotics, potentially reducing AMR. In addition, algae provide completely animal-free omega-3 fatty acids, as well as other important nutrients for human health (Van Boeckel, 2017).

### Feed

Another potential benefit of AAF is that they could positively change the system of animal feed-crops in the longer term. Many crops are currently produced for animal feed, but producing products directly for human consumption is a lot more efficient and uses fewer resources (Björkbom, 2022).

### Food security

In response to the claims of the need for increased food production to feed the growing world population, the question arises as to whether cell-cultured products have the potential to feed people on a large scale, given the volume of resources required. In fact, studies estimate that these products are likely to be available in wealthier countries first. This means that low-income and middle-income countries will experience limited food security benefits through the developments of cell-cultured fish and meat (Marwaha et al., 2020).
However, the development of AAF could lead to general indirect impacts on food security in low and middle-income countries. This could happen if AAFs replace part of the (high) imports of aquatic food, which is increasingly caught and farmed in low and middle-income countries (FAO, 2020).

### Funding

To date, investment in AAF has come primarily from the private sector. The GFI states that research investments by governments are important to make technology – particularly cell-culturing, but also innovative algae farming – accessible for small-scale fishers as well (GFI, 2020).

**Potential social impacts of cell-cultured fish and algae**

Overall, the most significant social potential of AAF relates to the health benefits, which could lead to **healthier aquatic food and decreasing AMR** by decreasing reliance on industrial livestock farming.

Nevertheless, it is highly uncertain which foods these AAFs (specifically cell-cultured fish) would replace. There is fear that the emerging AAF sector could further increase seafood consumption, which is already at a very high level. This was demonstrably the case for aquaculture, whose development led to increased aquatic food consumption rather than a reduction of wild catch.

Another under-studied factor is the **cultural dimension of food.** There are fears that "techno-fixes" such as cell-cultured fish could further disconnect humans from nature. Interestingly, current studies indicate that contrary scenarios could also be the case, as people's initial perception of cell-cultured meat being unnatural generated discussions about the unnatural conditions in which animals in industrial meat production are raised (van der Weele and Driessen, 2019).

## 5.3 Economic impacts of AAFs

### Corporate concentration

One of the major concerns about the emerging AAF sector is corporate concentration and capture, i.e. that large corporations use these developments to further increase their power in the food system.

IPES Food has expressed concerns that alternatives could potentially meet the same fate as conventional fish and meat regarding the political economy of food. The animal farming sector is increasingly showing signs of corporate power concentration, with some of the biggest livestock processors expanding their product lines with new alternative animal and plant proteins. Some of these companies have already invested in start-ups with a view to commercialising their products (IPES Food, 2022). Nevertheless, there is hope for a more diversified and decentralised system in the emerging alternative protein sector, with local access to region-specific products (e.g. similar to the beer industry). Those approaches envision a localised cell-culturing and algae production system, with local production and distribution of food (Björkbom, 2022).

Considerable uncertainties and limitations are evident in the latter approach. In order to achieve a decentralised and diversified system, cell-cultured fish must first become economically viable, coupled with an increase in the price of conventional animal products (Björkbom, 2022).

### Consumer behaviour

As the sector of plant-based alternatives has expanded considerably in recent years, questions have emerged about the need for cell-cultured options. Do we really need any kind of animal protein when plant-based alternatives are becoming more widely available?

A predominant argument is that plant-based alternatives exclude those to whom such alternatives do not appeal or who do not want to give up eating meat (Björkbom, 2022). On the other hand, bringing animal cruelty-free and environmentally friendly animal proteins to market could lead to rebound effects among some vegetarians and vegans, who stopped eating meat for ethical and environmental reasons. There is high uncertainty about the shares of these groups and whether that argument might outweigh other benefits of cell-cultured fish.

### Jobs

In a scenario where AAF production replaces parts of the conventional system, this could lead to new employment opportunities (Marwaha et al., 2020). The shift towards high-value AAF is likely to affect small-scale fishers and farmers, who typically react to system disruption by diversification. Appropriate incentives (management and policy) would therefore need to be developed (Marwaha et al., 2020).

**Potential economic impacts of cell-cultured fish and algae**

The economic impact of AAF depend on how the **risk of corporate concentration is addressed** and how a scaled-up scenario could unfold. The main open questions are whether a decentralised and diversified system for alternative proteins is possible, and the incentives necessary to accelerate such a system change.

The target groups for these new products remain unclear, as does the potential **rebound effects** of vegetarians and vegans. In addition, the larger and longer-term impacts on industrial and small-scale **fishers remain to be seen.**

# 5.4 Overview of key perspectives

This section presents some of the key perspectives, as identified through discussions with Seas At Risk staff and members.

## Environmental perspective

“Alternatives are a chance to reduce the negative environmental impacts of our current system, which are caused mainly by destructive fisheries and aquaculture. They reduce the environmental impacts of our food system, slow biodiversity loss, reduce air and water pollution, and preserve our oceans.”

## Anti-techno-fixes perspective

“Techno-fixes will not save us as they are part of the problem and do not increase awareness of the negative impacts of our consumption of animals. By using techno-fixes, even more consumption might be added to the existing amount instead of replacing other destructive practices and decreasing overall consumption. This will make people believe that techno-fixes will save us and will further disconnect humans from nature.”

## Animal welfare perspective

“Alternatives can help to reduce animal slaughtering and increase animal welfare, in addition to decreasing the risk of zoonotic disease and AMR caused by industrialised animal farming.”

## Political economy perspective

“Alternatives present yet another way of changing the product and not the system, which comes at the benefit of the biggest companies, thus intensifying existing corporate concentrations.”

## Food security perspective

“We need alternatives to feed our growing world population. Food security needs to be ensured as the world population rises. Alternatives could help to feed more people with fewer resources.”

## Human health perspective

“As our current marine proteins are unhealthy due to contamination with heavy metals and microplastics, alternatives offer new ways of accessing healthy aquatic food.”

# 6. Food for thought

## 6.1 Conclusions

Our current aquatic food system faces severe problems and imposes significant environmental, social and economic impacts. This paper took a closer look at two emerging alternatives in the aquatic food sector, cell-cultured fish and algae. A series of webinars discussed some of the major concerns on the environmental, social and economic impacts of these alternatives (see Chapter 5). As AAF is a young sector, it is difficult to predict what upscaled production would look like. Nevertheless, some important conclusions and follow-up questions remain:

1. We need to start asking our questions differently, and move away from asking “how can we produce more?” towards “How much is really needed and how big is the gap to what can be extracted in a just and sustainable way?”. Many of the approaches presented reflected the underlying question of “how to produce more aquatic food for a growing world population.”

2. We need to shift the debate from food and protein security to that of just and equitable nutrition security.

3. The underlying roots of the increasing per capita consumption need to be addressed by questioning some of the claims about fish consumption (e.g. fish as an indispensable protein source for a balanced diet). Awareness must be raised about the many negative impacts of our current aquatic food system, beyond the usual GHG analysis.

4. Does the scaling-up of AAF automatically result in corporate concentration? What (political) incentives are needed to prevent this?

The overall question is whether AAFs fit with the change needed to our overall food systems. More specifically, if AAFs can complement existing strategies for sustainable fishing and replace or reduce harmful fishing and aquaculture practices, or if they will simply increase consumption. Could they guide the way to nutritious, low-impact aquatic foods, serving as complementary products to bridge the gap between what can be fished and farmed with low impact and sustainably, and what we truly need for a healthy and just diet?

# 6.2 Implications for Seas At Risk and its members

What do these results imply for the future work of Seas At Risk and its members?

This discussion paper showcased the unsustainability of our current aquatic food system and the crucial role the EU and Member States can play in changing the current system. It highlighted the very real danger of repeating the mistakes of terrestrial industrialised livestock and crop farming at sea, which is already somewhat evident in aquaculture production. Accordingly, further guiding open questions for Seas At Risk and its members could be:

-> Can we create a **common vision of what a sustainable and just aquatic food system** looks like, in line with the Seas At Risk system change approach?

- Can we move away from an unsustainable, ecologically and socially harmful, and inequitable aquatic food sector that is fueled by the mechanisms of economic growth?
- Can we accelerate the shift to a more diversified, decentralised, and localised food production system that is more stable and resilient? What incentives are necessary to accelerate such a shift?

-> Can we use the **Sustainable Food Systems Law as momentum for change** towards our systemic change vision of aquatic food systems?

- That includes aquatic food as an integral part of the overall food system;
- That uses a holistic approach beyond GHG emissions alone;
- That targets a diversified, decentralised and just system;
- That debunks myths around the health of aquatic food, as well as the need to produce more food due to a growing world population.

-> We should take a **closer look at other alternatives**, such as integrated multitrophic aquaculture[1] .

The question is not whether these processes will happen, but rather how they will unfold and what role Seas At Risk and its members could play in ensuring that these changes are as sustainable as possible.

1. Combined aquaculture of various organisms at different trophic levels within the same production unit (Alfred Wegener Institut (AWI), 2020)

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