The hidden role of market-making in the rise of farmed salmon

Abstract

Aquaculture is expected to play an important role in transitioning towards healthy and sustainable diets, requiring dietary changes towards products with lower environmental footprints, in ways that address dietary needs. Farmed Atlantic salmon accounts for 2% of global aquaculture, with productivity-growth factors, such as research investment, credited with creating a high-value, globalized food commodity. However, its contribution to sustainability and nutrition goals remains unclear, and factors underlying consumer demand, such as marketing work, have been overlooked. We inspect the rise of farmed salmon in the UK, using key stakeholder interviews to understand the role of various actors (e.g., industry, retailers) in 'making' farmed salmon markets. Interviewees identified retailer strategies, such as labelling, and consumer-facing promotion efforts, such as health benefits, as key demand-growth factors underlying farmed salmon sales. Using data on UK seafood markets, we assess interviewee views, finding that farmed salmon is the most consumed aquatic food, but is less popular than other animal-source foods and primarily consumed by affluent households. Our analyses discuss how market-making efforts by industry and retail actors have shaped consumer demand by promoting salmon as an accessible, nutritious, and sustainable product. Accreditation and labelling have helped to develop perceptions of healthy and sustainable, despite farmed salmon being comparable in nutrient profile to other aquatic foods and having long-standing environmental impacts. Market-making insights could be used to enhance demand for other aquatic foods, in ways that target dietary gaps by supplying affordable and sustainable products, such as mussels.

Introduction

Sustainable transitions towards affordable, healthy diets will require dietary shifts that disadopt unsustainable foods in favour of existing but more sustainable products (Cottrell et al., 2021), or emerging future foods (Parodi et al., 2018). Aquatic foods are often positioned as ways to enhance global food and nutrition security (Garlock et al., 2022; Golden et al., 2021) while reducing environmental footprints (Willett et al., 2019), with farmed aquatic foods expected to play a significant role in sustainable dietary transitions (Gephart et al., 2020). Global aquaculture produces over 100 million tons of marine algae, invertebrates, and finfish annually, accounting for ~50% of aquatic foods, and will soon exceed wild fisheries supply (FAO, 2022; Naylor et al., 2021). Much aquaculture supply is traded globally, with rising demand linked to rapid expansion in farming of few marine species, such as Atlantic salmon and whiteleg shrimp (Gephart et al., 2024). These species characterise an increasingly globalized aquatic food system, directed by a small number of corporate actors (Österblom et al., 2015), with unclear contributions to sustainable development goals (Barton et al., 2023) and food and nutrition security (Belton et al., 2020).

Farmed Atlantic salmon (*Salmo salar*) is the world's most valuable mariculture (i.e. farmed at sea) commodity (ISFA, 2018) and accounts for 2% of global aquaculture production (Naylor et al., 2021). Commercial salmon farming started in the 1960s (Ellis et al., 2016), expanding into a large-scale, intensive production system that now supplies over 2.7 million tons of fish globally (Pandey et al., 2023). Multiple factors have been credited with the rise of farmed

Deleted: Our analyses
Deleted: behaviours
Deleted:
Deleted: perceptions
Moved down [3]: reveal market-making efforts by industry and retail actors have co-created consumer demand by promoting perceptions of accessible, nutritious, and sustainable products.
Deleted: consumption
Deleted: challenge
Deleted: these
Deleted: perceptions
Moved (insertion) [3]
Deleted: reveal
Deleted: co-created
Deleted: making salmon into and
Deleted: perceptions of
Deleted: s
Deleted: Increasing farmed salmon consumption led to decreases in consumption of other species, while population-level aquatic food consumption remained below UK health guidelines. We discuss use of a
Deleted: in market making to
Deleted: to shape messaging consumer perceptions
Deleted: attach salmon to around health
Deleted: ility
Deleted: ,
Deleted: (e.g. feeds)
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed
Field Code Changed

salmon as a global commodity, particularly those relating to 'productivity growth' (Asche et al., 2011) such as the species' suitability for large-scale intensive farming (e.g. fast growth), investment in technology and innovation (Regan et al., 2021), and industry consolidation (Asche et al., 2013). Consumer demand is often cited as a key driver of farmed salmon production, but aspects underlying such 'demand growth' are less well understood (Asche et al., 2011), particularly in how market characteristics shape demand and consumption of products. Such 'market making' requires the felicitous and purposeful coalescing of multiple elements, including market actors (e.g., producers, retailers, consumers), devices (e.g., pricing mechanisms, packaging), practices (e.g., farming, transporting, categorising) that, combined, generate a market (infra)structure that facilitates and encourages consumption (Araujo, 2007; Katy Mason and Hagberg, 2015). These elements are characteristic of farmed salmon retail, which has undergone substantial product categorisation (Asche et al., 2021) and creation of new markets (Straume et al., 2024), with use of diverse labelling schemes to convey messages around food quality, dietary value, and sustainability (Global Salmon Initiative, 2019, Salmon Scotland, n.d.).

In market making for farmed salmon, producers and retailers thus develop widely-available, convenient products (e.g., salmon fillets, ready meals), and amplify characteristics that are desirable to consumers (e.g. sustainability, health properties) in order to create demand. While these actions can have positive outcomes, such as creating new markets for sustainable products, market making has also been criticized for perpetuating false narratives. Seafood labelling schemes, for example, can promote environmentally-damaging fisheries (Jacquet et al., 2010), while marketing and lobbying for ultra-processed foods is expected to significantly raise health risks for middle-income countries (Moodie et al., 2021). For farmed salmon, large-scale, intensive practices have long-standing sustainability issues around feeds, disease, and animal welfare (Kuempel et al., 2023), while the potential for high-value mariculture products to contribute to global food and nutrition security has been questioned (Belton et al., 2020). Even within the UK, a high-income salmon-producing country, seafood consumption remains below recommended levels (Lofstedt et al., 2021), suggesting farmed salmon production has not addressed dietary gaps. While the global trade (Gephart et al., 2024) and environmental pressures (Kuempel et al., 2023) of salmon industry are well-documented, effects of salmon market-making on aquatic food markets and consumer diets remain unclear.

Here, we examine perspectives of farmed salmon in the UK to develop insights into 'market-making' of aquatic foods. We interview eight expert actors involved with industry (n = 3), research (3), government (1), and policy advocacy (1) in Scotland to gather multi-sided views on farmed salmon, and examine productivity and demand factors underlying the rise of salmon industry. We conduct a qualitative, thematic analysis of interviews to identify demand-growth factors that relate to 'market making', and test these perspectives against data on industry supply and composition, retail and marketing, and food consumption. Finally, we discuss how aquatic food markets could be shaped to better prioritise public health and environmental sustainability, focusing on existing aquatic food markets in the UK.

Results

Through coding interviews, we identified ten key topics that were frequently raised by most or all of the expert actors, categorised into four themes (Industry, Retailers, Diets,

Deleted: co-drive

Field Code Changed

Deleted: research,

Deleted: policy

Deleted: use

Deleted:

Moved (insertion) [1]

Deleted: ¶
Stakeholder perspectives on salmon markets¶

Formatted: Space Before: 12 pt, After: 12 pt

Environment) (Table 1). We examined interviewee perspectives on these ten topics, and confronted their statements against secondary datasets on farmed salmon production and consumption, and published literature

Industry

All interviewees identified the significance of market consolidation and technological innovation (e.g. efficiency of feed, disease treatments) in supporting industry growth and the creation of a global commodity. While Norway and Chile dominate global Atlantic salmon mariculture, Scotland now accounts for 7.1% of total annual supply (205,000 t in 2021) (Fig. 1a). Supporting interviewee perspectives of a global commodity, farmed salmon production in Scotland has also increasingly oriented towards export markets. In 2022, 90,351 t of salmon was exported (£701 million, or 41% of total seafood export value), making farmed salmon the UK's most valuable and high-volume aquatic food export (Fig. 1b,c). Market consolidation was perceived to have enabled '*vertical integration*' of farmed salmon production, increasing production through economies of scale. Indeed, farmed salmon markets have consolidated over the last three decades, with the number of salmon producer companies in the UK decreasing from 132 in 1993 to 10 in 2022, when four companies accounted for 92% of UK production (Fig. 2a). Productivity-growth through industry has been associated with technological innovations in genetic selection (e.g. faster fish growth, shorter life cycles, disease resistance) and vaccines (less mortality), and regulatory changes that permit larger and higher numbers of cages and sites, and a higher stocking density (in freshwater systems/stages) (Ellis et al., 2016). These technological advances and regulatory changes supported an increase from initial experimental farms in the 1970s to 203 farm sites active between 2018-2021 (Fig. 2b).

Deleted: Our interviewees linked multiple productivity and demand factors with

Deleted: growth in global and UK

Deleted: (Table 1).

Formatted: Font: Italic

Moved (insertion) [2]

Deleted: Most

Formatted: Font: Italic

Deleted: Farm productivity has also steadily increased, owing to

Deleted: This intensive, large-scale model of salmon production has been referred to as 'precision aquaculture' (Føre et al., 2018) and presented as an example of 'sustainable intensification', where yields are increased without causing additional environmental impacts (e.g. land conversion) (Ellis et al., 2016).¶

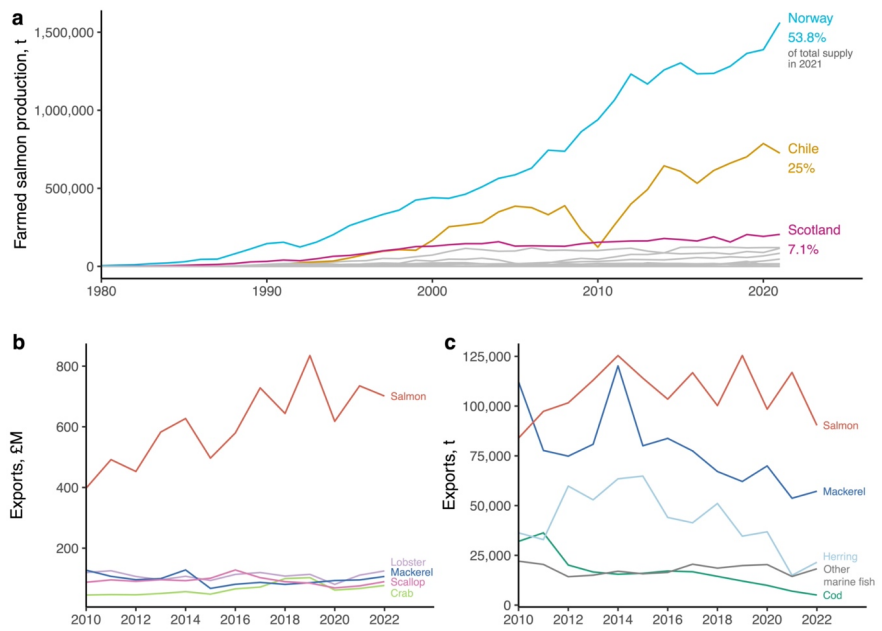

Figure 1 | Farmed salmon as a global commodity. a) Farmed salmon production from 1980-2022 in 22 countries (tonnes per year) (FAO Fisheries Division, Statistics and Information Branch, 2020). Top three producers are highlighted (Norway, Chile, Scotland), with labels showing relative contribution (%) to global supply in 2022. In Scotland, export statistics show farmed salmon dominated UK exports of aquatic foods by **b**) total value (million £ GBP) and **c**) total volume (tonnes) between 2010-2022 (Seafish, 2019). Lines show the top five exported aquatic food species.

Deleted: *Scottish salmon context*¶
Norway, Chile, and Scotland dominate global Atlantic salmon mariculture, with Scotland contributing 205,000 t (in 2021), accounting for 7.1% of total annual supply (Fig. 1a). From initial experimental farms in the 1970s, growth in production was achieved through registering more marine farm sites around Scotland's coastline, reaching 203 active sites between 2018-2021 (Fig. 2b), alongside increases in farm size, productivity, and fish growth and survival (Ellis et al., 2016). Farmed salmon production in Scotland has also increasingly oriented towards export markets. In 2022, 90,351 t of salmon was exported (£701 million, or 41% of total seafood export value), making farmed salmon the UK's most valuable and high-volume aquatic food export (Fig. 1b,c). Salmon is also popular in domestic retail markets, where salmon, cod, haddock, tuna, and prawns ('the big 5') account for most UK fish consumption (Harrison et al., 2023). ¶

Deleted: The global rise of f

Deleted: Global f

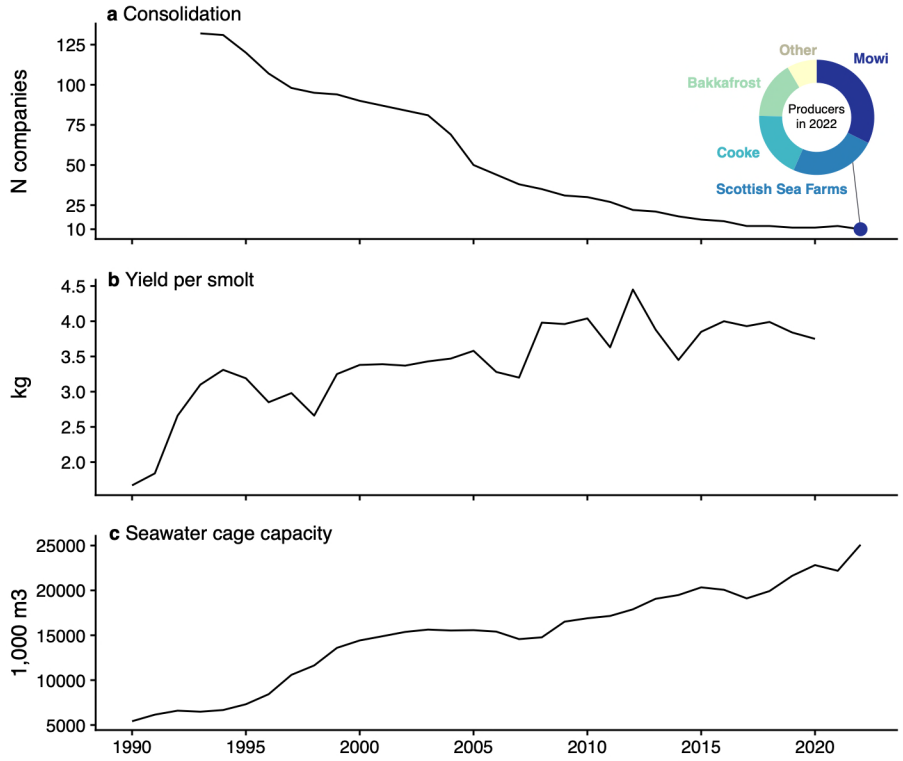

Figure 2 | Industry consolidation and intensification in Scotland from 1990 - 2022. a) Number of companies producing farmed salmon, inset with top producers in 2022, b) system productivity measured by yield per smolt age class, and c) total seawater cage capacity. Data from the Scottish Fish Farm Production Survey (Scotland, 2021).

Retailers

Most interviewees viewed retailers as key players in the farmed salmon industry, and noted 'demand-growth' factors such as labelling and certification. Retailers mentioned in interviews were primarily supermarkets, which were associated with the growing convenience of salmon products, and popularity of foods labelled with images associated with Scotland and healthy ecosystems (e.g. '*Scottish environment pristine, great animal health and welfare*', Table S1). Accreditation labels were also associated with efforts to promote supply of sustainable food, which are widely used by seafood producers. For example, many Scottish salmon products are associated with eco- or sustainability labels, such as the Aquatic Stewardship Council (ASC) which has certified 57 farm sites in Scotland (26% of farms) (Aquaculture Stewardship Council, 2024). Retail messaging was also raised by interviewees who see health benefits of farmed salmon as important for consumers (e.g. omega-3 fatty acids, '*salmon is a regular health message out there*'). However, consumer demand for farmed salmon was less clearly communicated by interviewees, with farmed salmon

Moved up [1]: *Stakeholder perspectives on salmon markets*¶
¶
Our interviewees linked multiple productivity and demand factors with growth in global and UK farmed salmon production (Table 1).

Moved up [2]: Most interviewees identified the significance of market consolidation and technological innovation (e.g. efficiency of feed, disease treatments) in supporting industry growth. Market consolidation was perceived to have enabled 'vertical integration' of farmed salmon production, increasing production through economies of scale. Indeed, farmed salmon markets have consolidated over the last three decades, with the number of salmon producer companies in the UK decreasing from 132 in 1993 to 10 in 2022, when four companies accounted for 92% of UK production (Fig. 2a). Farm productivity has also steadily increased, owing to technological innovations in genetic selection (e.g. faster fish growth, shorter life cycles, disease resistance) and vaccines (less mortality), and regulatory changes that permit larger and higher numbers of cages and sites, and a higher stocking density (in freshwater systems/stages) (Ellis et al., 2016). This intensive, large-scale model of salmon production has been referred to as 'precision aquaculture' (Føre et al., 2018) and presented as an example of 'sustainable intensification', where yields are increased without causing additional environmental impacts (e.g. land conversion) (Ellis et al., 2016).¶

Deleted: Our interviewees linked multiple productivity demand factors with growth in global and UK farmed salmon production (Table 1).

Deleted: ¶
However, most interviewees also associated intensive salmon production with environmental impacts, suggesting that farmed salmon is, at best, a disputed example of sustainable intensification. Negative perceptions included declines in wild salmon populations, feed supply chain issues, environmental run-off, and impacts to local community economies (Table S1). However, several interviewees also identified sustainability and environmental accreditation as positive attributes of farmed salmon, with "*farming in the sea…intrinsically…more sustainable than farming on land*" (Table S1). Such a disconnect in perspectives may arise because environmental impacts can be diffuse and lagged, making it difficult to robustly link farm practices with environmental declines. For example, life cycle analysis shows that over 90% of salmon's environmental impacts are generated from fish feeds for which, in the UK, over 75% are sourced from countries distant from salmon farms (Newton and Little, 2018). Positive environmental assessments may also reflect recent improvements in salmon practices (Naylor et al. 2021), such as decreasing dependence on m… [1]

Deleted: C

Deleted: 's

Deleted: farmed salmon industry

Formatted: Font: Italic

Deleted: All

Deleted: underlying salmon industry market-making

considered both more expensive than other animal-source foods ('*premium price*') and '*one of the most purchased fish products in supermarkets*' (Table S1). Retail power was reflected in the high degree of categorisation in products, with farmed salmon '*the biggest single product within the seafood category*', offering '*30 to 40 different products*' to consumers.

Theme	Interview topic	Stakeholder perspectives	Example
Industry	Global commodity	Farmed salmon is now a global seafood commodity, enabling efficiencies of scale and industry power.	*"dramatic improvements in productivity and efficiency of production"*
	Consolidation	Salmon industry has consolidated into fewer, large companies	*"there's only really three or four producers...in Scotland now"*
Retailers	**Labelling and certification**	Scottish brand has positive connotations for consumers	*"...clear premium to be associated with the Scottish one, because it's seen as better"*
	Retail power	Retailers have strong influence on industry success and consumer perceptions	*"salmon...is the biggest single product within the seafood category"*
Diets	**Health benefits**	Farmed salmon contributes to healthy diets	*"it's at the pinnacle of nutritional value"*
	Convenience	Categorisation of farmed salmon products has made it easier for consumers (e.g. ready-to-eat)	*"accessible format is key"*
	Consumer perceptions		*"I think it's one of the most purchased fish products in supermarkets"*
		Accessible and popular seafood available in supermarkets	*"we can only encourage consumers to eat [what they want] to eat"*
Environment	Fish welfare	Scotland's farm production is associated with good fish welfare, but also fish welfare issues in global salmon industry	*"...if you ask them would turn to issues like sea lice, or use of antibiotics or polluting local waters"*
	Sustainability	Farmed salmon have impacts on marine ecosystems, but farmed salmon are also sustainable food choices	*"a really positive story, the space of water use [...] lower carbon footprint, because I know it's got a sort of similar footprint to chicken, for example."*
	Future challenges	Barriers to further growth in Scottish farmed salmon, such as marine spatial planning and climate change	*"challenges that you have around disease, and particularly sea lice"*

Table 1. Stakeholder perceptions of Scottish farmed salmon. We show 10 key topics that were frequently raised by interviewees. Each theme was mentioned at least once by all eight interviewees, except for fish welfare (7/8), convenience (7/8), future challenges (6/8), and retail power (5/8). Codes in bold are associated with demand-growth or market-making factors.

Diets

Deleted: "
Deleted: "
Formatted: Font: Italic
Formatted: Font: Italic
Deleted: Topic
Deleted: code
Deleted: Themes
Deleted: identified
Deleted: coding
Deleted: s
Deleted:
Deleted: for repeated or important topics raised by interviews.
Deleted: *Testing stakeholder perspectives against data from UK aquatic food systems*¶

All interviewees described the importance of consumers perceiving farmed salmon to be a convenient and healthy food, which supported retail demand (Table 1). Farmed salmon was considered to be popular because it '*can be produced in a ways that the consumers find it easy to consume*' (Table S1). Indeed, diet surveys of UK adults show that 60% of adults consumed aquatic foods (average daily intake = 40 g) between 2008-2018, with the 'big five' of salmon, tuna, cod, prawns, and haddock accounting for approximately two-thirds of the average seafood diet. Steady increase in farmed salmon demand (16% to 21%) has now placed salmon as one of the top two consumed aquatic foods (for people who eat aquatic foods), displacing haddock (-4.8%) and 'other' species (-6%) (Fig. 3d). Yet farmed salmon remains below other animal-source proteins. Since 1990, chicken has been the most consumed animal protein in the UK (195 g per person per week), followed by aquatic foods (135 g) and beef (86 g) (Fig 3a). Total fish consumption has remained relatively stable since 1980, while salmon consumption steadily increased from ~2 g per week in the 1970s to 18 g by 2022. Households have increasingly consumed fish in ready meals (40% of weekly diet in 2022), and these products are substituting for long-term declines in white fish (fresh or frozen) and takeaway fish (16% of diet, combined) (Fig. 3b). While these surveys quantified consumption of fresh or frozen salmon separately from convenience forms (e.g. ready meals), our analysis shows that salmon has always been consumed less than other terrestrial meats.

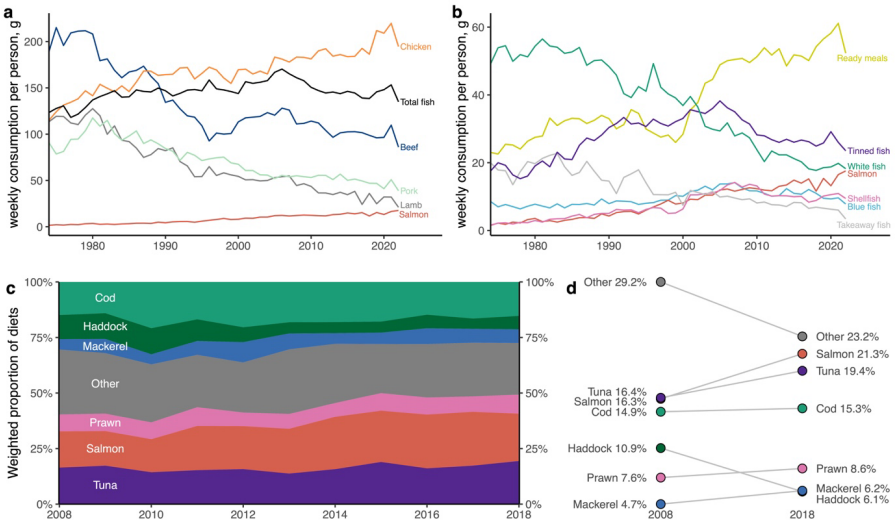

Figure 3 | Animal-source food consumption in the UK from 1974-2022. a) weekly household consumption of major animal-source foods and farmed salmon (dark blue), and **b**) major aquatic food products (Department for Environment, Food & Rural Affairs, 2012). Individual diet surveys from 2008-2018 show **c**) the average composition of diets for people eating aquatic foods, accounting for quantity and frequency of consumption (Office for Health Improvement and Disparities, 2016). **d**) Absolute change in diet composition from 2008 to 2018. Aquatic foods contributing < 5% of diet (by weight) were grouped as 'Other'. See Fig. S1 for household aquatic food consumption by wealth decile.

Deleted: We next used

Deleted: diet surveys, food composition tables, and market price data to test three key 'demand-growth' factors raised by consumers: that f

Deleted: is

Formatted: Font: Italic

Deleted: 1) a popular and accessible animal-source protein

Deleted: , 2)

Deleted: a nutritious food, with 3) accreditation and labelling used to highlight aspects of sustainability.

Deleted: First, we extracted household food consumption data to examine long-term trends in animal-meat consumption in the UK, examining consumer demand for farmed salmon.

Deleted: S

Deleted: -source

Deleted:

Deleted: We next examine the retail price of farmed salmon, using estimates for animal-source products tracked by the UK's Office of National Statistics (Office for National Statistics, 2023). Between 2018-24, farmed salmon was the most expensive animal-source food, and over three times more expensive than the cheapest products (canned tuna, pork sausages) (Fig. 4a). These price differences are reflected in household consumption data showing that white fish is more popular than salmon in all but the three highest wealth deciles (excluding ready meals, Fig. S1).¶

¶

We next examined farmed salmon consumption relative to other aquatic foods, using more highly-resolved diet surveys of UK adults (Office for Health Improvement and Disparities, 2016). Between 2008-2018, 60% of adults consumed aquatic foods (average daily intake = 40 g), with the 'big five' of salmon, tuna, cod, prawns, and haddock accounting for approximately two-thirds of the average seafood diet. Steady increase in farmed salmon demand (16% to 21%) has placed salmon as one of the top two consumed aquatic foods (for people who eat aquatic foods), displacing haddock (-4.8%) and 'other' species (-6%) (Fig. 3d). Together with household food consumption data (Fig. 3b), these trends suggest that increases in ready meal consumption is primarily of convenient forms of farmed salmon and tuna, consistent with evidence of growing categorisation and commodification of farmed salmon products (Asche et al., 2021).¶

All interviewees identified salmon health benefits as being important ("*the pinnacle of nutritional value*"), particularly noting its high omega-3 fatty acid content as a driver of consumer demand. Indeed, UK dietary guidelines recommend that adults eat two portions (2 x 140 g) of aquatic foods every week, with one of those being an oily fish, such as salmon (NHS, 2024). A 140 g portion of farmed salmon contains over 100% of an adult's recommended intake of omega-3 fatty acids, vitamins B12 and D, and thus can be a significant contributor to dietary nutrient intakes (Willer et al. 2023), though at the highest retail cost of any animal-source food (Fig. 4a). However, 'convenience' products such as smoked salmon or fishcakes, that were also considered important in consumer demand, have less EPA and DHA than fresh salmon, with levels below the recommended daily intake (Fig. 4b). Other oily fish such as herring, mackerel, and sardine also contained comparable or higher omega-3 fatty acid levels to farmed salmon (Fig. 4b).

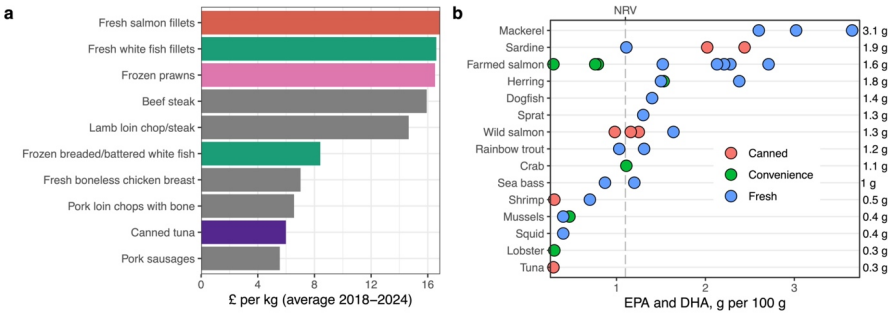

Figure 4 | Price and nutrient content of UK animal food products. a) Average price (£ GBP per kg) of animal-source foods in national food surveys that included salmon products (2018-24) (Office for National Statistics, 2023) and **b**) omega-3 fatty acid (EPA and DHA) content in UK aquatic food products (those >0.25 g per 100 g) (Widdowson, n.d.). Products were aggregated by common species name, and coloured by processing type (convenience products were pre-cooked, e.g. smoked fish or fish cakes). Terrestrial animal products contained negligible amounts of EPA and DHA (median = 0.03 g per 100 g). Dashed line shows the Nutrient Reference Value for adult women, indicating recommended daily intake of EPA and DHA (1.1 g) (FAO, 2010). Secondary y-axis shows the mean EPA and DHA concentration for each species.

Environment

Most interviewees associated intensive salmon production with environmental impacts. Diverse negative sustainability perceptions were raised by all interviewees, including declines in wild salmon populations, feed supply chain issues, environmental pollution, and impacts to local communities, with fish welfare identified as highly variable between Scotland and other producing countries (Table 1). However, several interviewees also identified sustainability and environmental accreditation as positive attributes of farmed salmon, with "*farming in the sea…intrinsically…more sustainable than farming on land*" (Table S1). Future environmental challenges, such as climate change, were also considered to be important factors for salmon industry. Environmental challenges were also diverse, ranging from "*demand for fish feed*" to sea lice and disease, and these will continue to be key concerns

Formatted: Font: Italic

Deleted: Second, we test interview claims about salmon consumption providing health benefits,

Deleted: through

Deleted: intakes

Deleted: .

Deleted: Food composition tables confirm that a

Deleted: .

Deleted: farmed salmon

Deleted: s

Deleted: such as smoked salmon or fishcakes,

Deleted: d

Deleted: that were

Deleted: for omega-3 fatty acids

Deleted: Such prepared products account for 39% of the UK farmed salmon market (Straume et al., 2024), suggesting contributions to omega-3 fatty acid intakes may be overstated. Indeed, focus on omega-3 fatty acid content also belies other health benefits of consuming a diverse set of aquatic foods (Beal et al., 2024). For example, seafood products available in the UK are sources of several nutrients, including iodine (e.g. cod), iron (e.g. farmed mussels), or zinc (e.g. shrimp / prawns), that have relatively lower concentrations in farmed salmon (Robinson et al., 2022).

("*the industry is very aware that sustainability debates are going to be increasingly important*") (Table S1).

Discussion

Favourable regulation, market consolidation, and technological innovation have supported farmed salmon producers in developing a model of intensive large-scale production (Asche et al., 2013; Ellis et al., 2016; Graziano et al., 2018), transforming salmon into one of the most valuable global food commodities. One of our interviewees said "*we can only encourage consumers to eat [what they want] to eat*" (E1, Table 1). However, our study suggests that the rise of farmed salmon demand in the UK was a process that included several purposeful actions from market actors, such as the processing and creation of convenience food products, wide availability, and health and sustainability labelling, leading to positive framing of the industry from almost all interviewees. Our analyses show that consumers responded to this increase in supply by changing aquatic food preferences towards farmed salmon, positioning salmon as the most popular aquatic food product in the UK.

Market-making by industry (e.g. farmers, processors, and retailers) has played a significant role in creating demand and popularity for farmed salmon. Interviewees suggested that salmon's market appeal is linked to its accessibility, nutrient value, and sustainability credentials, yet our analysis suggests these messages can be misleading. UK food consumption datasets showed that farmed salmon is less widely consumed than other animal-source proteins, while recent increases in salmon consumption (the most popular aquatic food in 2018) have displaced other aquatic foods from diets, primarily through popularity of convenience products. Together, long-term household consumption data and diet surveys (Fig. 3) suggest that increases in ready meal consumption is primarily of convenient forms of farmed salmon and tuna, consistent with evidence of growing categorisation and commodification of farmed salmon products (Asche et al., 2021). Our analysis thus suggests that retailers have steadily prioritised farmed salmon products over other aquatic foods, shaping seafood markets to favour more affluent consumers. With farmed salmon among the most expensive animal-source foods (Fig. 4a), consumed primarily by affluent households (Fig. S1), the availability of more affordable aquatic foods may have decreased in response to salmon market-making. Indeed, in the UK between 2006-18, salmon demand increased while total seafood consumption remained stable (Fig. 3a) and UK diets were below recommended levels of seafood intake (Harrison et al., 2023). The rise of farmed salmon has therefore not improved aquatic food consumption in the UK, while deficiencies of nutrients concentrated in aquatic foods, such as iron and selenium, remain prevalent (Derbyshire, 2018).

Food labelling can be a powerful market-making tool (Cochoy, 2020; Fuentes and Fuentes, 2017). Sustainability accreditation in farmed salmon products is prevalent, with all interviewees noting that retailer labelling was associated with positive perceptions of farmed salmon (e.g., '*local*', '*wild*', and '*organic*'). Multiple accreditation schemes and ecolabels have been introduced to promote sustainability standards for aquatic foods, introducing confusion for markets and consumers, with variable success in improving sustainability (Roheim et al., 2018). Labelling schemes used for farmed salmon have been considered indicators of

Formatted: Font: Italic

Formatted: Font: Not Italic

Deleted: Third, we examine the prevalence of sustainability accreditation in farmed salmon products, arising from interviewees who noted retailer labelling associated with positive perceptions of farmed salmon (e.g., '*local*', '*wild*', and '*organic*'). Multiple accreditation schemes and ecolabels have been introduced to promote sustainability standards for aquatic foods, introducing confusion for markets and consumers, with variable success in improving sustainability (Roheim et al., 2018). Labelling schemes used for farmed salmon have been considered indicators of environmental or social responsibility, rather than sustainability standards (Gulbrandsen et al., 2022). Indeed, accreditation movements may help larger companies to exert market influence by re-defining sustainability (Aarset et al., 2020), while environmental footprints remain large, due to longstanding impacts associated with aquafeeds (e.g. emissions and land use) (Kuempel et al., 2023; Newton and Little, 2018). ASC and other aquatic food ecolabels have been criticised for failing to capture these broader system impacts of salmon production (Gulbrandsen et al., 2022), having weak certification criteria, and even for misleading consumers (Jacquet et al., 2010). Labelling thus appears to serve as a powerful demand-growth factor. Industry influence in this area remains strong, with, for example, the UK government approving legislation in 2024 to market farmed products as 'Scottish Salmon', a labelling protection previously reserved for wild-caught products (Scotland, 2024).¶

Deleted: ¶

Deleted: thus

Deleted: While farmed salmon products can be a rich source of omega-3 fatty acids (EPA and DHA), they are also among the most expensive animal-source foods, and consumed primarily by affluent households.

Deleted: These trends

Deleted: thus

Deleted: .

Deleted: These dietary shifts occurred during a period when …

Deleted: remain

Deleted: and

Deleted: (Derbyshire, 2018)

Deleted: , remain

Deleted: .

environmental or social responsibility, rather than sustainability standards (Gulbrandsen et al., 2022). Indeed, the intensive large-scale model of salmon production has been referred to as 'precision aquaculture' (Føre et al., 2018) and presented as an example of 'sustainable intensification' (Ellis et al., 2016), yet all expert interviewees raised environmental and sustainability issues associated with mariculture. Such disconnect in sustainability credentials may be linked to accreditation movements that help larger companies to exert market influence by re-defining sustainability (Aarset et al., 2020) while environmental footprints remain large (e.g. emissions and land use in farmed salmon) (Kuempel et al., 2023; Newton and Little, 2018). Indeed, ASC and other aquatic food ecolabels have been criticised for failing to capture these broader system impacts of salmon production (Gulbrandsen et al., 2022). Labelling thus appears to serve as a powerful demand-growth factor. Industry influence in this area remains strong, with, for example, the UK government approving legislation in 2024 to market farmed products as 'Scottish Salmon', a labelling protection previously reserved for wild-caught products (Scotland, 2024).

Environmental impacts can also be diffuse and lagged, making it difficult to robustly link farm practices with environmental declines. For example, life cycle analysis shows that over 90% of salmon's environmental impacts are generated from fish feeds for which, in the UK, over 75% are sourced from countries distant from salmon farms (Newton and Little, 2018). Positive environmental assessments of farmed salmon may also reflect recent improvements in production practices (Naylor et al. 2021), such as decreasing dependence on marine ingredients (marine oil use in Norway declined from 31% to 10% from 2000-16, Aas et al. 2019), phasing out of antibiotics (Bondad-Reantaso et al., 2023), and (comparatively) low carbon footprints of net pen systems (Ziegler et al., 2013). Nevertheless, despite having lower carbon emissions than most livestock products (Bianchi et al., 2022; Robinson et al., 2022), environmental impacts of large-scale salmon farming (e.g. feed supply chains) remain substantial (Kuempel et al., 2023). Continued supply-growth in farmed salmon (Froehlich et al., 2021), and associated demand-growth through market-making, will therefore lead to mariculture accounting for an increasing share of the UK food system environmental footprint, irrespective of sustainability accreditation.

The role of retail commodification in market-making can also have strong influences on food system composition. For example, consumption of 'Other' aquatic foods was partly substituted by farmed salmon (and tuna), and over one third of salmon retail can be prepared convenience products (Straume et al., 2024), suggesting salmon contributions to omega-3 fatty acid intakes may be overstated. While such food substitutions are historically rare, aquatic food markets are highly diverse, encompassing many species, production methods, and sources (Ferraro et al., 2022). This sector may therefore be more suited to market making efforts to reshape consumer demand. Indeed, UK consumers have already transitioned from primarily consuming wild-caught species from UK waters (cod, haddock) in the 20th century, to retail dominated by imported and farmed products (Harrison et al., 2023). Characteristics of farmed salmon market-making could thus be used to encourage and enable the consumption of more sustainable and nutritious aquatic foods that reach people with greater dietary needs. For example, the UK also produces other farmed aquatic foods at smaller quantities (mussels, seaweed), and large quantities of wild-caught species such as herring and mackerel (Harrison et al., 2023; Robinson et al., 2022) destined for export markets (Graziano et al., 2018). Reorganising the market to help increase demand for such low-impact species would contribute to the reduction of environmental footprints from

Deleted: Finally

Deleted: creditation

Deleted: .

Deleted: with,

Deleted: f

Deleted: (Fig. 3d)

Deleted: .

Deleted: promote

Deleted: Creating

Deleted: help to

Deleted: reduce

aquatic foods (Jones et al., 2022), while addressing deficiencies in nutrients that are concentrated in aquatic foods (Vogliano et al., 2024; Willer et al., 2021). Such diversification (i.e. reducing farmed salmon dominance) would add resilience to food supply (e.g. from trade disruption) (Graziano et al., 2018) and reduce food system contributions to emissions targets (Stewart et al., 2023). Market-making efforts towards other products could engender new markets through, for example, product categorisation (Gawel et al., 2023). Upscaling production and demand for these markets will require further analysis on market dynamics between farmed salmon and other animal foods (terrestrial and aquatic), engagement with industry and retailers (Ruel et al., 2018), and investment and regulatory support (Vogliano et al., 2024).

Dominance of individual species within seafood sectors has been historically rare (Ferraro et al., 2022), while the intensive production, investments in infrastructure of processing and distribution, technology, labelling and categorisation, and other market-making practices of farmed salmon are similar to those in the poultry sector (i.e. '*aquatic chicken*') (Gephart et al., 2020). Our analysis suggests that farmed salmon demand is not simply 'naturally occurring' or 'intrinsic' but has been shaped through purposeful market-making by producers and retailers, underpinned by narratives of widespread appeal, nutrient value, and sustainability. We find that farmed salmon dominance of UK aquatic food consumption is primarily due to affluent households and, through categorisation, labelling, and differentiation, may have led to reduced demand for other aquatic foods. The knock-on impacts for other aquatic food sectors remain unclear, requiring further research on how producers and retailers act to influence consumer behaviour. Uncovering market-making in food systems can reveal ways of promoting consumption of new or alternative products, providing means to address consumer barriers for more affordable, nutritious and sustainable aquatic foods (Gawel et al., 2023).

Methods

Our 'marketography' of UK farmed salmon used "*interviews, observation, documentary work,* [and] *historical record*" to trace the market-making efforts of actors across space and time (Roscoe and Loza, 2019).

Interviews with expert stakeholders

Initial participants were recruited following the identification of main players in the market through publicly available data, and contacted via online channels. From this, a process of snowballing (Thorpe et al., 2008) allowed for further potential participants to be selected. Sampling through snowballing poses the risk of distorting bias (Hammersley and Atkinson, 2019) (e.g., only meeting colleagues), however, the multi-sided nature of our approach to recruitment ensured accounting for diverse perspectives. We contacted a variety of actors, recruiting a final count of eight people for interviews, including activists, aquaculture researchers, industry leaders, and policymakers who were identifiably involved with salmon farming (e.g., published research on salmon aquaculture). This number of interviews is appropriate for a qualitative data analysis, which prioritises depth over breadth of data, and adopts thematic saturation as a key determinant of sample size, the point at which no new themes are emerging (Easterby-Smith et al., 2015). One of the authors also attended one of

Field Code Changed

Deleted: and yet

Field Code Changed

Deleted: (re)

Deleted: co-created

Deleted:

the largest industry events in Scotland in 2023 to network and identify potential participants, which resulted in one of the expert interviews.

Interviews followed a semi-structured guide which allowed adaptation and exploration during conversations (Supplementary Methods). Thus, the authors made decisions about "which line of questioning […] to explore further" (Thorpe et al., 2008) depending on which points were raised by the interviewees. Interviews were conducted either in person in Scotland or online, and both authors were present at all but two interviews. In this case, the non-present co-author listened to the recording of the interview. All interviews, in person and online, were recorded and transcribed by an independent transcriber and subsequently cross-checked by the authors. Transcriptions formed the dataset of the thematic analysis to identify key topics raised by the participants. Analysis was performed through open, axial and selective coding in which every "pass-through" involved identifying and refining keywords, and grouping into topics (Neuman, 2012). Both authors conducted an independent analysis of the texts to identify key topics, which was followed by a process of contrasting, discussion and agreement.

Datasets on UK farmed salmon and aquatic foods

We extracted data on the global production of farmed salmon (tonnes) from the FAO Fishery and Aquaculture Statistics databases (FAO Fisheries Division, Statistics and Information Branch, 2020), and examined relative contributions of the top three producing countries (Norway, Chile, Scotland) from 1980 - 2021. We gathered additional data on Scotland's farmed salmon production, trade and industry. We extracted trade quantity and value of major aquatic foods over 2010-2022, using EUMOFA data provided by Seafish (Seafish, 2019). From the Scottish Fish Farm Production Survey (Scotland, 2021), we extracted data on industry composition (the number of companies from 1993-2022), and farm system productivity (the number of sites, smolt size, and cage capacity from 1990-2022).

We also used public food consumption databases to understand contributions of farmed salmon to UK diets relative to other terrestrial and aquatic animal-source foods. We assessed demand for animal-source foods using family food datasets collected by the UK government (Department for Environment, Food & Rural Affairs, 2012). These datasets estimate the average quantity of food products purchased per person per week, from 1974 to 2022, providing a standardised metric of long-term demand for major UK animal-source foods. We extracted all animal-source foods recorded in this dataset, and further categorised aquatic foods into groups of similar species (e.g. blue fish, white fish). We complemented these household consumption estimates with data from individual diet recall surveys, collected by the National Diet and Nutrition Survey (Office for Health Improvement and Disparities, 2016). These surveys allowed us to understand relative consumption of aquatic food products at greater resolution than the household consumption dataset, containing information on portion sizes and consumption frequency of 43 aquatic food products, from 2008-2018. We examined annual changes in aquatic food consumption by adults, aggregating products to common species names (e.g. salmon, cod, tuna) and estimating the relative proportion (i.e. frequency * portion size) of each product, for individuals who consumed aquatic foods. We visualized all species that had ≥5% of diets (cod, haddock, prawn, salmon, tuna, mackerel), and grouped the remaining species as 'Other'.

Deleted: themes

Deleted: themes

Deleted: themes

Formatted: Font: Italic

Deleted: ¶
UK farmed salmon production¶

Field Code Changed

Field Code Changed

Deleted: ¶
UK aquatic food consumption¶

Field Code Changed

Deleted: ¶
Market-making datasets¶

Finally, we examined aspects of market making in farmed salmon using data on the average price of animal-source foods, and omega-3 fatty acid content in aquatic foods. Price estimates were extracted from the Office for National Statistics dataset on inflation-corrected prices of commonly consumed foods by UK households (Office for National Statistics, 2023). This dataset tracks the monthly price of a food basket of popular items, corrected for inflation, including farmed salmon, four other aquatic foods, and five terrestrial animal-source foods. We estimated the average price per kg of these foods from 2018-2023. We next extracted omega-3 fatty acid estimates from (Widdowson, n.d.) and identified all foods with EPA and DHA concentrations above 250 mg per 100 g. The UK does not have specific health guidelines on EPA and DHA intakes, so we assessed these food values relative to guidelines for adult women (1.1 g per 100 g) (FAO, 2010).

Deleted: W

Field Code Changed

Field Code Changed

Deleted: ¶
¶
Acknowledgements¶
¶
We thank all interviewees for their time and insights on this project. This study was funded by a Lancaster University Management School Pump Prime grant. JPWR was funded by a Leverhulme Trust Early Career Fellowship and Royal Society University Research Fellowship (URF\R1\231087).

Formatted: Font: Not Bold

References

Aarset, B., Carson, S.G., Wiig, H., Måren, I.E., Marks, J., 2020. Lost in translation? Multiple discursive strategies and the interpretation of sustainability in the Norwegian salmon farming industry. Food Ethics 5. https://doi.org/10.1007/s41055-020-00068-3

Aquaculture Stewardship Council, 2024. Aquaculture Stewardship Council [WWW Document]. URL https://asc-aqua.org/our-impact/

Araujo, L., 2007. Markets, market-making and marketing. Mark. Theory 7, 211–226.

Asche, F., Dahl, R.E., Gordon, D.V., Trollvik, T., Aandahl, P., 2011. Demand Growth for Atlantic Salmon: The EU and French Markets. Mar. Resour. Econ. 26, 255–265.

Asche, F., Roll, K.H., Sandvold, H.N., Sørvig, A., Zhang, D., 2013. SALMON AQUACULTURE: LARGER COMPANIES AND INCREASED PRODUCTION. Aquacult. Econ. Manage. 17, 322–339.

Asche, F., Sogn-Grundvåg, G., Zhang, D., Cojocaru, A.L., Young, J.A., 2021. Brands, Labels, and Product Longevity: The Case of Salmon in UK Grocery Retailing. Journal of International Food & Agribusiness Marketing 33, 53–68.

Barton, J.R., Baeza-González, S., Román, Á., 2023. Unravelling sustainable salmon aquaculture: an historical political ecology of a business responsibility discourse, 1970–2020. Marit. Stud. 22, 10.

Belton, B., Little, D.C., Zhang, W., Edwards, P., Skladany, M., Thilsted, S.H., 2020. Farming fish in the sea will not nourish the world. Nat. Commun. 11, 5804.

Bianchi, M., Hallström, E., Parker, R.W.R., Mifflin, K., Tydemers, P., Ziegler, F., 2022. Accounting for nutritional diversity in seafood climate impact assessment – A global perspective. Communications Earth and Environment.

Bondad-Reantaso, M.G., MacKinnon, B., Karunasagar, Iddya, Fridman, S., Alday-Sanz, V., Brun, E., Le Groumellec, M., Li, A., Surachetpong, W., Karunasagar, Indrani, Hao, B., Dall'Occo, A., Urbani, R., Caputo, A., 2023. Review of alternatives to antibiotic use in aquaculture. Rev. Aquac. https://doi.org/10.1111/raq.12786

Cochoy, F., 2020. Is the modern consumer a buridan's donkey? Product packaging and consumer choice, in: Elusive Consumption. Routledge, pp. 205–227.

Cottrell, R.S., Maier, J., Ferraro, D.M., Blasco, G.D., Geyer, R., Froehlich, H.E., Halpern, B.S., 2021. The overlooked importance of food disadoption for the environmental sustainability of new foods. Environ. Res. Lett. 16, 104022.

Department for Environment, Food & Rural Affairs, 2012. Family food datasets.

Derbyshire, E., 2018. Micronutrient Intakes of British Adults Across Mid-Life: A Secondary Analysis of the UK National Diet and Nutrition Survey. Front Nutr 5, 55.

Easterby-Smith, M., Thorpe, R., Jackson, P.R. (Eds.), 2015. Management and Business Research. SAGE.

Ellis, T., Turnbull, J.F., Knowles, T.G., Lines, J.A., Auchterlonie, N.A., 2016. Trends during development of Scottish salmon farming: An example of sustainable intensification? Aquaculture 458, 82–99.

FAO, 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en

FAO Fisheries Division, Statistics and Information Branch, 2020. FishStatJ: Universal software for fishery statistical time series.

Ferraro, D.M., Cottrell, R.S., Blasco, G.D., Froehlich, H.E., Halpern, B.S., 2022. Historical food consumption declines and the role of alternative foods. Environ. Res. Lett. 17, 014020.

Føre, M., Frank, K., Norton, T., Svendsen, E., Alfredsen, J.A., Dempster, T., Eguiraun, H., Watson, W., Stahl, A., Sunde, L.M., Schellewald, C., Skøien, K.R., Alver, M.O., Berckmans, D., 2018. Precision fish farming: A new framework to improve production in aquaculture. Biosystems Eng. 173, 176–193.

Froehlich, H.E., Couture, J., Falconer, L., 2021. Mind the gap between ICES nations' future seafood consumption and aquaculture production. ICES J. Mar. Sci.

Fuentes, C., Fuentes, M., 2017. Making a market for alternatives: marketing devices and the

Field Code Changed

qualification of a vegan milk substitute. Journal of Marketing Management 33, 529–555.
Garlock, T., Asche, F., Anderson, J., Ceballos-Concha, A., Love, D.C., Osmundsen, T.C., Pincinato, R.B.M., 2022. Aquaculture: The missing contributor in the food security agenda. Global Food Security 32, 100620.
Gawel, J.P.F., Aldridge, D.C., Willer, D.F., 2023. Barriers and drivers to increasing sustainable bivalve seafood consumption in a mass market economy. Food Front. 4, 1257–1269.
Gephart, J.A., Agrawal Bejarano, R., Gorospe, K., Godwin, A., Golden, C.D., Naylor, R.L., Nash, K.L., Pace, M.L., Troell, M., 2024. Globalization of wild capture and farmed aquatic foods. Nat. Commun. 15, 8026.
Gephart, J.A., Golden, C.D., Asche, F., Belton, B., Brugere, C., Froehlich, H.E., Fry, J.P., Halpern, B.S., Hicks, C.C., Jones, R.C., Klinger, D.H., Little, D.C., McCauley, D.J., Thilsted, S.H., Troell, M., Allison, E.H., 2020. Scenarios for Global Aquaculture and Its Role in Human Nutrition. Reviews in Fisheries Science & Aquaculture 1–17.
Golden, C.D., Koehn, J.Z., Shepon, A., Passarelli, S., Free, C.M., Viana, D.F., Matthey, H., Eurich, J.G., Gephart, J.A., Fluet-Chouinard, E., Nyboer, E.A., Lynch, A.J., Kjellevold, M., Bromage, S., Charlebois, P., Barange, M., Vannuccini, S., Cao, L., Kleisner, K.M., Rimm, E.B., Danaei, G., DeSisto, C., Kelahan, H., Fiorella, K.J., Little, D.C., Allison, E.H., Fanzo, J., Thilsted, S.H., 2021. Aquatic foods to nourish nations. Nature 598, 315–320.
Graziano, M., Fox, C.J., Alexander, K., Pita, C., Heymans, J.J., Crumlish, M., Hughes, A., Ghanawi, J., Cannella, L., 2018. Environmental and socio-political shocks to the seafood sector: What does this mean for resilience? Lessons from two UK case studies, 1945–2016. Mar. Policy 87, 301–313.
Gulbrandsen, L.H., Vormedal, I., Larsen, M.L., 2022. No logo? The failure of ASC salmon labeling in Norway and the UK. Mar. Policy 138, 104987.
Hammersley, M., Atkinson, P., 2019. *Ethnography: Principles in practice*. Routledge, London.
Harrison, L.O.J., Engelhard, G.H., Thurstan, R.H., Sturrock, A.M., 2023. Widening mismatch between UK seafood production and consumer demand: a 120-year perspective. Rev. Fish Biol. Fish. https://doi.org/10.1007/s11160-023-09776-5
Jacquet, J., Pauly, D., Ainley, D., Holt, S., Dayton, P., Jackson, J., 2010. Seafood stewardship in crisis. Nature 467, 28–29.
Jones, A.R., Alleway, H.K., McAfee, D., Reis-Santos, P., Theuerkauf, S.J., Jones, R.C., 2022. Climate-friendly seafood: The potential for emissions reduction and carbon capture in marine aquaculture. Bioscience 72, 123–143.
Katy Mason, H.K., Hagberg, J., 2015. Exploring the performativity of marketing: theories, practices and devices. Journal of Marketing Management 31, 1–15.
Kuempel, C.D., Frazier, M., Verstaen, J., Rayner, P.-E., Blanchard, J.L., Cottrell, R.S., Froehlich, H.E., Gephart, J.A., Jacobsen, N.S., McIntyre, P.B., Metian, M., Moran, D., Nash, K.L., Többen, J., Williams, D.R., Halpern, B.S., 2023. Environmental footprints of farmed chicken and salmon bridge the land and sea. Curr. Biol. https://doi.org/10.1016/j.cub.2023.01.037
Lofstedt, A., de Roos, B., Fernandes, P.G., 2021. Less than half of the European dietary recommendations for fish consumption are satisfied by national seafood supplies. Eur. J. Nutr. 60, 4219–4228.
Moodie, R., Bennett, E., Kwong, E.J.L., Santos, T.M., Pratiwi, L., Williams, J., Baker, P., 2021. Ultra-processed profits: The political economy of countering the global spread of Ultra-processed foods - A synthesis review on the market and political practices of transnational food corporations and strategic public health responses. Int. J. Health Policy Manag. 10, 968–982.
Naylor, R.L., Hardy, R.W., Buschmann, A.H., Bush, S.R., Cao, L., Klinger, D.H., Little, D.C., Lubchenco, J., Shumway, S.E., Troell, M., 2021. A 20-year retrospective review of global aquaculture. Nature 591, 551–563.

Formatted: Font: Italic

Neuman, W.L., 2012. *Basics of social research*. Pearson, New Jersey.
Newton, R.W., Little, D.C., 2018. Mapping the impacts of farmed Scottish salmon from a life cycle perspective. Int. J. Life Cycle Assess. 23, 1018–1029.
NHS, 2024. The Eatwell Guide [WWW Document]. URL https://www.nhs.uk/live-well/eat-well/food-guidelines-and-food-labels/the-eatwell-guide/
Office for Health Improvement and Disparities, 2016. National Diet and Nutrition Survey.
Office for National Statistics, 2023. Shopping Prices Comparison Tool.
Österblom, H., Jouffray, J.-B., Folke, C., Crona, B., Troell, M., Merrie, A., Rockström, J., 2015. Transnational corporations as "keystone actors" in marine ecosystems. PLoS One 10, e0127533.
Pandey, R., Asche, F., Misund, B., Nygaard, R., Adewumi, O.M., Straume, H.-M., Zhang, D., 2023. Production growth, company size, and concentration: The case of salmon. Aquaculture 577, 739972.
Parodi, A., Leip, A., De Boer, I.J.M., Slegers, P.M., Ziegler, F., Temme, E.H.M., Herrero, M., Tuomisto, H., Valin, H., Van Middelaar, C.E., Van Loon, J.J.A., Van Zanten, H.H.E., 2018. The potential of future foods for sustainable and healthy diets. Nat Sustain 1, 782–789.
Regan, T., Bean, T.P., Ellis, T., Davie, A., Carboni, S., Migaud, H., Houston, R.D., 2021. Genetic improvement technologies to support the sustainable growth of UK aquaculture. Rev. Aquac. 13, 1958–1985.
Robinson, J.P.W., Garrett, A., Esclapez, J.C.P., Maire, E., Parker, R., Graham, N.A., 2022. Navigating sustainability and health trade-offs in global seafood systems. Environ. Res. Lett. 17. https://doi.org/10.1088/1748-9326/aca490
Roheim, C.A., Bush, S.R., Asche, F., Sanchirico, J.N., Uchida, H., 2018. Evolution and future of the sustainable seafood market. Nature Sustainability 1, 392–398.
Roscoe, P., Loza, O., 2019. The –ography of markets (or, the responsibilities of market studies). J. Cult. Econ. 12, 215–227.
Ruel, M.T., Quisumbing, A.R., Balagamwala, M., 2018. Nutrition-sensitive agriculture: What have we learned so far? Global Food Security 17, 128–153.
Scotland, M., 2021. Scottish Fish Farm Production Survey Data. https://doi.org/10.7489/1918-1
Scotland, S., 2024. Salmon Scotland secures protected status update [WWW Document]. URL https://www.salmonscotland.co.uk/news/scottish-salmon-secures-new-legal-protection
Seafish, 2019. UK Seafood Trade and Tariff Tool.
Stewart, K., Balmford, A., Scheelbeek, P., Doherty, A., Garnett, E.E., 2023. Changes in greenhouse gas emissions from food supply in the United Kingdom. J. Clean. Prod. 410, 137273.
Straume, H.-M., Asche, F., Landazuri-Tveteraas, U., Misund, B., Pettersen, I.K., Zhang, D., 2024. Product forms and price transmission in major European salmon markets. Aquaculture 582, 740508.
Thorpe, R., Jackson, P.R., Easterby-Smith, M., Lowe, A., 2008. Management Research, 3rd ed, Sage Series in Management Research. SAGE Publications, London, England.
Vogliano, C., Kennedy, G., Thilsted, S., Mbuya, M.N.N., Battista, W., Sadoff, C., White, G., Kim, J.K., Pucher, J., Koome, K., D'Cruz, G., Geagan, K., Chang, K., Sumaila, U.R., Palmer, S., Alleway, H., 2024. Regenerative aquatic foods can be a win-win for human and planetary health. Nat. Food 5, 718–719.
WHO, FAO, 2010. Fats and fatty acids in human nutrition. Proceedings of the Joint FAO/WHO Expert Consultation (No. 55).
Widdowson, M.A., n.d. Composition of foods integrated dataset (CoFID).
Willer, D.F., Nicholls, R.J., Aldridge, D.C., 2021. Opportunities and challenges for upscaled global bivalve seafood production. Nat. Food 2, 935–943.
Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L.J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J.A., De Vries, W., Majele Sibanda, L., Afshin, A.,

Formatted: Font: Italic

Chaudhary, A., Herrero, M., Agustina, R., Branca, F., Lartey, A., Fan, S., Crona, B., Fox, E., Bignet, V., Troell, M., Lindahl, T., Singh, S., Cornell, S.E., Srinath Reddy, K., Narain, S., Nishtar, S., Murray, C.J.L., 2019. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. Lancet 393, 447–492.

Ziegler, F., Winther, U., Hognes, E.S., Emanuelsson, A., Sund, V., Ellingsen, H., 2013. The carbon footprint of Norwegian seafood products on the global seafood market: Carbon footprint of Norwegian seafood on global market. J. Ind. Ecol. 17, 103–116.

Deleted: Aarset, B., Carson, S.G., Wiig, H., Måren, I.E., Marks, J., 2020. Lost in translation? Multiple discursive strategies and the interpretation of sustainability in the Norwegian salmon farming industry. Food Ethics 5. https://doi.org/10.1007/s41055-020-00068-3¶

Aquaculture Stewardship Council, 2024. Aquaculture Stewardship Council [WWW Document]. URL https://asc-aqua.org/our-impact/¶

Araujo, L., 2007. Markets, market-making and marketing. Mark. Theory 7, 211–226.¶

Asche, F., Dahl, R.E., Gordon, D.V., Trollvik, T., Aandahl, P., 2011. Demand Growth for Atlantic Salmon: The EU and French Markets. Mar. Resour. Econ. 26, 255–265.¶

Asche, F., Roll, K.H., Sandvold, H.N., Sørvig, A., Zhang, D., 2013. SALMON AQUACULTURE: LARGER COMPANIES AND INCREASED PRODUCTION. Aquacult. Econ. Manage. 17, 322–339.¶

Asche, F., Sogn-Grundvåg, G., Zhang, D., Cojocaru, A.L., Young, J.A., 2021. Brands, Labels, and Product Longevity: The Case of Salmon in UK Grocery Retailing. Journal of International Food & Agribusiness Marketing 33, 53–68.¶

Barton, J.R., Baeza-González, S., Román, Á., 2023. Unravelling sustainable salmon aquaculture: an historical political ecology of a business responsibility discourse, 1970–2020. Marit. Stud. 22, 10.¶

Beal, T., Manohar, S., Miachon, L., Fanzo, J., 2024. Nutrient-dense foods and diverse diets are important for ensuring adequate nutrition across the life course. Proc. Natl. Acad. Sci. U. S. A. 121, e2319007121.¶

Belton, B., Little, D.C., Zhang, W., Edwards, P., Skladany, M., Thilsted, S.H., 2020. Farming fish in the sea will not nourish the world. Nat. Commun. 11, 5804.¶

Bianchi, M., Hallström, E., Parker, R.W.R., Mifflin, K., Tydemers, P., Ziegler, F., 2022. Accounting for nutritional diversity in seafood climate impact assessment – A global perspective. Communications Earth and Environment.¶

Bondad-Reantaso, M.G., MacKinnon, B., Karunasagar, Iddya, Fridman, S., Alday-Sanz, V., Brun, E., Le Groumellec, M., Li, A., Surachetpong, W., Karunasagar, Indrani, Hao, B., Dall'Occo, A., Urbani, R., Caputo, A., 2023. Review of alternatives to antibiotic use in aquaculture. Rev. Aquac. https://doi.org/10.1111/raq.12786¶

Cottrell, R.S., Maier, J., Ferraro, D.M., Blasco, G.D., Geyer, R., Froehlich, H.E., Halpern, B.S., 2021. The overlooked importance of food disadoption for the environmental sustainability of new foods. Environ. Res. Lett. 16, 104022.¶

Department for Environment, Food & Rural Affairs, 2012. Family food datasets.¶

Derbyshire, E., 2018. Micronutrient Intakes of British Adults Across Mid-Life: A Secondary Analysis of the UK National Diet and Nutrition Survey. Front Nutr 5, 55.¶

Ellis, T., Turnbull, J.F., Knowles, T.G., Lines, J.A., Auchterlonie, N.A., 2016. Trends during development of Scottish salmon farming: An example of sustainable intensification? Aquaculture 458, 82–99.¶

FAO, 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en¶ ... [2]

Page 5: [1] Deleted	**Robinson, James (robins64)**	**02/05/2025 10:40:00**

Page 17: [2] Deleted	**Robinson, James (robins64)**	**30/04/2025 14:58:00**