The Rowett Institute

Health and nutrition benefits of Scottish salmon

A report for Salmon Scotland

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Glossary

CRP:	Pro-inflammation marker C-reactive protein
DHA:	Docosahexaenoic acid (a main omega-3 fatty acid)
EAT Lancet:	A global scientific study that defines a sustainable, healthy diet that can feed 10 billion people by 2050
EFSA:	European Food Safety Authority
EPA:	Eicosapentaenoic acid (a main omega-3 fatty acid)
Factor VII:	Vitamin K-dependent protein produced in the liver that initiates the blood clotting
FAO:	Food and Agriculture Organisation
GHG emissions:	Greenhouse Gas emissions
HDL cholesterol:	High density lipoprotein cholesterol ('good cholesterol')
IL-6	Pro-inflammation marker Interleukin-6
LDL cholesterol:	Low density lipoprotein cholesterol ('bad cholesterol')
NDNS:	National Diet and Nutrition Survey
PAI-1:	Plasminogen activator inhibitor-1 (PAI-1), the primary inhibitor of the process that breaks down blood clots
PCBs:	Polychlorinated biphenyls
SACN:	Scientific Advisory Committee on Nutrition
TNF-α:	Pro-inflammation marker Tumour Necrosis Factor alpha
VCAM-1:	Vascular Cell Adhesion Molecule-1, a pro-inflammation marker in the blood vessel lining
VKM:	Norwegian Scientific Committee for Food and Environment
WHO:	World Health Organisation

Executive summary

Scottish salmon is a major contributor to Scotland's economy and a central component of UK seafood consumption. Despite strong production and export performance, UK consumers continue to eat far less fish than recommended for optimal health, limiting the potential public-health benefits associated with the consumption of nutrient-rich seafood such as salmon. This report provides an academic evaluation of the health and nutrition benefits of fish consumption generally, and of Scottish salmon specifically, drawing on authoritative reviews, observational epidemiology, and randomised controlled trials.

Health benefits of fish consumption. A substantial body of evidence—including authoritative reviews by the Scientific Advisory Committee on Nutrition (SACN), the European Food Safety Authority (EFSA), the Food and Agriculture Organisation (FAO), and the World Health Organisation (WHO), as well as meta-analyses combining the findings from multiple research studies to reach a stronger and more accurate conclusion—shows that regular fish intake, particularly oily fish, provides clear and measurable health benefits:

- **Strong evidence for a reduced all-cause and cardiovascular mortality**, with meta-analyses showing 21% lower coronary heart disease mortality, and 9% lower stroke risk, at 2–4 servings of fish per week.
- **Moderate evidence for improved neurodevelopment in children**, supported by observational studies and randomised controlled trials, showing benefits of fish consumption for cognitive, language, and behavioural outcomes.
- **Moderate evidence for a reduced risk of preterm birth**, with fish oil supplementation trials demonstrating a ~40% reduction in early preterm delivery.
- **Strong evidence for improved nutrient status**, particularly for the main fish omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

While contaminants such as methylmercury and dioxins remain important considerations, current evidence indicates that, for most population groups, the benefits of fish consumption outweigh the risks when adhering to species-specific guidance.

Health and nutrition benefits of salmon consumption. Although few studies explicitly examine "Scottish salmon," the broader evidence on salmon consumption is extensive. Across diverse populations and settings, salmon intake consistently improves health by improving nutritional status and key markers for cardiovascular disease.

- **Omega-3 status**: Randomised controlled trials across Europe, North America, and Asia, show that salmon reliably increases levels of the main fish omega-3 fatty acids EPA and DHA in healthy adults, pregnant women, overweight individuals, and in populations with abnormal blood lipid levels. These effects are comparable to, and sometimes exceed, those achieved with fish oil supplements when expressed per unit of EPA/DHA provided.
- **Vitamin D**: Salmon contributes meaningfully to dietary vitamin D intake, and can attenuate seasonal declines in plasma vitamin D levels, particularly in winter at higher latitudes. However, even high salmon intakes cannot fully prevent wintertime reductions in vitamin D, indicating that salmon supports—but cannot replace—other vitamin D sources like supplements.
- **Markers of cardiovascular disease:** Salmon consumption consistently reduces levels of plasma triglycerides (with high triglyceride levels being a risk factor for cardiovascular disease), increases levels of high-density lipoprotein (HDL) cholesterol ('good cholesterol'),

improves the profile of lipoproteins that transport cholesterol and triglycerides in our blood, and lowers blood pressure in some populations. These changes correspond to meaningful reductions in the risk of cardiovascular disease, with larger effects seen in individuals with abnormal blood lipid levels, or in those who are at higher risk of cardiovascular disease.

- **Inflammation and regulation of glucose and insulin**: Evidence suggests that eating salmon can reduce inflammation, and improve levels of blood clotting markers, particularly in those who are at higher risk for cardiovascular disease. The effects on glucose and insulin regulation are modest and context-dependent.
- **Cognition and mental health.** There is limited but promising evidence that salmon consumption could support cognitive development in children, and reduce anxiety in vulnerable adult populations, though the number of studies on this research topic is small.
- **Gut health**. Emerging evidence shows modest shifts in gut microbiota composition following salmon consumption, though its clinical significance is not yet established.

Nutrient composition of farmed Scottish salmon. The nutrient profile of farmed salmon has evolved due to changes in aquaculture feed formulations. While EPA and DHA levels have decreased over the past two decades, modern farmed salmon remains a valuable source of omega-3 fatty acids, high-quality protein, and key micronutrients. Recent analyses of Scottish farmed salmon show:

- Comparable total fat, saturated fat and total protein profiles to those reported in earlier datasets, despite feed changes.
- Higher vitamin D content in recently analysed Scottish samples compared with those reported in older UK and Norwegian datasets.
- Substantial variability in, and lower content of, EPA and DHA, across producers, reflecting differences in feed composition compared with one to two decades ago.

Human studies confirm, however, that consumption of salmon raised on rapeseed oil–enriched feed also improves omega-3 status and markers of cardiovascular health, such as plasma triglycerides, indicating preserved health benefits despite the lower absolute content of EPA and DHA in modern salmon.

Contaminant exposure. A recent expert review from the FAO/WHO confirms that:

- Farmed Atlantic salmon is a low-mercury species, contributing only a small fraction of methylmercury exposure, even with regular consumption.
- Dioxin and polychlorinated biphenyls (PCBs) levels have declined over time due to changes in feed composition and are typically below regulatory limits.

Overall, contaminant risks associated with farmed salmon are low relative to its nutritional benefits.

In conclusion, across multiple lines of evidence, salmon consumption provides clear and consistent health benefits, particularly for cardiovascular health and omega-3 and vitamin D status. Scottish farmed salmon is a nutrient-dense food that contributes meaningfully to public health, even if production practices have evolved, with salmon containing less EPA and DHA compared with one or two decades ago. Increasing consumption of salmon and other seafood represents a significant opportunity to improve population health while supporting sustainable food systems and Scotland's rural economy.

Introduction

Scottish salmon is one of Scotland's most economically significant food exports – it has been ranked as the UK's largest food export by value, and in recent years, it has also maintained a leading position in volume. The sector contributes £953 million gross value added (GVA) to the national economy, supports 10,850 jobs across the country, and plays a vital role to the prosperity and sustainability of the rural and coastal communities where producers and farmers are based (1). The importance of Scotland's salmon sector to the UK economy is underscored by salmon production rising by 27% to 192,000 tonnes in 2024. This expansion, combined with strong international demand—particularly from the US and Asia—has cemented salmon as the UK's leading seafood export. Yet this success also exposes a structural imbalance in the UK's salmon supply, as the UK continues to rely on imports to meet domestic demand. Salmon remains the third most-imported species by live weight, with import supplies rising 4.6% to 125,500 tonnes in the year to June 2025. Norway alone accounts for 61% of these imports, increasing shipments by more than 15% as falling prices and high production volumes made Norwegian salmon more competitive. This dynamic—strong export performance alongside substantial import dependence—illustrates the tension between Scotland's role as a major global producer and the UK's need to secure sufficient supply for its own consumers, who continue to drive salmon's position as the top-selling seafood in UK retail (2).

Despite the strength of the salmon and seafood supply chains (2), overall demand for salmon and seafood in the UK remains low. UK consumers eat only half the recommended amounts of fish needed for optimal health, despite fish providing important nutrients such as omega-3 fatty acids, and micronutrients including vitamins B_{12} and D, zinc, selenium, iodine and iron. Salmon and seafood consumption is associated with significant health benefits, and clear dietary guidelines for fish consumption have been in place for more than 20 years. Moreover, most seafoods, including salmon, have lower carbon emissions than land-based protein sources. As a result, seafood consumption can make an important contribution to healthy and sustainable food systems, by improving public health while also supporting progress toward net zero carbon emissions. It is therefore likely that seafood will feature more frequently and prominently in global diets as countries transition to net zero.

This report has been prepared for Salmon Scotland, at their request, to provide a high-level overview of the reported health and nutrition benefits of consuming fish generally, and of Scottish salmon specifically, and to contextualise these findings within broader concepts such as planetary health, fish production systems, and consumer demand. The report does not provide a detailed review of individual human studies assessing the effects of fish or salmon consumption on specific health outcomes, as this has been comprehensively assessed elsewhere (3).

This report will comment on the strength of evidence for the health and nutrition benefits of fish and salmon consumption. In nutrition research, the most reliable evidence comes from systematic reviews and meta-analyses of intervention studies - these combine results from many high-quality studies to show the overall effect of an intervention (with fish or salmon), and reduce the influence of chance findings or bias. Next in strength are individual randomised controlled trials, which can demonstrate cause and effect, but studies may be limited by sample size, short duration, or methodological variation. Long-term observational studies are helpful for spotting real-world patterns and potential links between diet and health, though they can't fully prove what causes what. Short-term or less controlled studies sit lower on the evidence ladder and are mainly useful for generating ideas rather than confirming efficacy. This hierarchy helps to understand how confident we can be in a nutrition claim.

Health and nutrition benefits of fish consumption

Fish is a nutrient-dense food providing long-chain omega-3 polyunsaturated fatty acids, high-quality protein, and a range of micronutrients including vitamins B12, D and A, iodine, selenium, zinc, iron, and calcium. Over several decades, a substantial body of observational epidemiological studies, randomised controlled trials, and studies investigating the molecular or cellular actions of omega-3 fatty acids, have examined the health implications of fish consumption across the life course. While the evidence base is heterogeneous, a broad consensus has emerged that regular fish intake—particularly that of oily fish—confers measurable benefits for cardiovascular and neurodevelopmental outcomes, with risks from contaminants generally low at typical consumption levels. Despite this, UK population intake remains below recommended levels, limiting potential public health impact.

A series of authoritative reviews has shaped current understanding of the health effects of fish consumption. These include assessments by the UK Scientific Advisory Committee on Nutrition (SACN) (4), by Mozaffarian & Rimm (5), the European Food Safety Authority (EFSA) (6), the joint Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO) expert consultation (7), and the VKM (Norwegian Scientific Committee for Food and Environment) (8). Although these evaluations differ in scope and methodological approaches, all converge on a consistent conclusion: fish consumption provides several well-supported health benefits. Across these reviews, the evidence ranges from moderate to strong for key outcomes, including a reduction in all-cause mortality (moderate evidence), a lower risk of cardiovascular disease in adults (strong evidence), improved neurodevelopment in children (moderate evidence), a lower risk of preterm birth and some other adverse pregnancy outcomes (moderate evidence), and clear improvements in nutrient status (strong evidence).

The cardiovascular benefits of fish consumption are among the most extensively studied. Mozaffarian & Rimm (5) synthesised decades of evidence from epidemiological and clinical studies, concluding that modest fish intake (1–2 servings/week), particularly of oily species, is associated with a substantial (36%) reduction in coronary heart disease mortality, and a 17% reduction in all-cause mortality. These findings are derived largely from prospective cohort studies, which, while robust in scale and consistency, remain susceptible to confounding from lifestyle and dietary patterns. For example, it may be that those consuming more fish could also have a generally healthier lifestyle and/or diet.

The SACN report (4) provided one of the earliest comprehensive UK-specific risk–benefit analyses. Drawing on evidence available at the time, SACN recommended that the population should consume at least two portions of fish per week, including one portion of oily fish (with a portion being 140 grams). This intake—equivalent to approximately 0.45 g per day of the fish omega-3 fatty acids eicosapentaenoic acid (EPA) + docosahexaenoic acid (DHA) averaged across the week—was judged sufficient to confer cardiovascular and developmental benefits without appreciable risk from contaminants for most individuals. SACN also introduced differentiated guidance for women of reproductive age, advising limits on oily fish consumption to mitigate long-term dioxin accumulation, and reinforced advice to avoid high-mercury species such as shark, marlin, and swordfish.

The EFSA report, published in 2012 (6), suggested that approximately 250 mg/day of the omega-3 fatty acids EPA+DHA is adequate for the primary prevention of cardiovascular disease. This recommendation is supported by evidence from molecular and cellular studies demonstrating that omega-3 fatty acids have anti-arrhythmic (e.g. preventing an irregular or accelerated heartbeat), anti-inflammatory (e.g. lowering inflammation markers), and triglyceride-lowering effects. Of note is that in the UK we only have dietary recommendations for fish intake, and not for the amount of EPA and DHA we should consume.

In 2012, two separate systematic reviews and meta-analyses, analysing the collective outcomes of multiple cohort studies assessing the health effects of whole-fish consumption were published, concluding that moderate fish intake (2–4 servings/week) is associated with a 21% reduction in mortality from coronary heart disease (9), and a 9% reduction in the risk of stroke (10), providing some of the most robust evidence we have for the cardioprotective benefits of eating fish. In contrast, however, evidence from randomised controlled trials of omega-3 supplementation has been less compelling (11). Large trials conducted in populations with increasingly higher use of statins and other cardioprotective therapies have shown minimal or no clinically meaningful reductions in cardiovascular events in those taking omega-3 supplements. This attenuation of effect may reflect the changing therapeutic landscape of cardiovascular disease management, as well as the isolated nature of supplements, lacking the broader nutrient matrix of whole fish (11). Indeed, the benefits from fish consumption may arise not only from the omega-3 fatty acids EPA and DHA, but also from other nutrients in fish such as micronutrients, and the displacement of less healthy foods (e.g., processed meats).

In addition to the cardiovascular benefits of eating fish, a substantial body of evidence links maternal fish consumption during pregnancy with improved neurodevelopmental outcomes in their offspring. Studies systematically reviewed by Snetselaar (12) report a positive association between higher maternal seafood intake and better cognitive, language, and behavioural outcomes in early childhood. Benefits typically appear at modest intakes (1–3 servings of fish/week), with limited evidence of additional gains at higher levels of fish intake. Importantly, the positive associations between maternal fish intake and cognitive and behavioural outcomes in early childhood persist even in populations with a relatively high methylmercury exposure, provided that intake of high-mercury species is restricted. Evidence for the beneficial effects of fish consumption on neurodevelopment and cognition in children and adolescents is more limited and varied (13). While some studies suggest associations between higher seafood intake and improved academic or cognitive performance, confounding by socioeconomic status and overall diet remains a significant challenge in such studies.

The evidence linking fish consumption with cognitive ageing is less robust than that for early neurodevelopment. Reviews of mostly observational studies report that higher fish intake was associated with a ~20% lower risk of dementia or Alzheimer's disease, and slower cognitive decline (14,15). Consuming fish was also associated with better cognitive performance, and slower declines in processing speed, memory and cognition (16), with results from a Spanish cohort confirming that greater intakes of EPA+DHA were associated with less age-related functional and cognitive impairments. This suggests that oily fish and omega-3 fatty acids may be key contributors to the health effects of fish during ageing (17). However, such findings could be confounded by the fact that fish consumers may have healthier overall dietary patterns and lifestyle factors. Randomised controlled trials testing the effects of omega-3 supplements on cognitive decline have largely been negative or inconclusive, particularly when initiated late in life, or in individuals with established impairment (3). This divergence suggests that fish consumption may contribute to cognitive health as part of a broader dietary pattern rather than as a stand-alone intervention.

Two systematic reviews have been influential in establishing the relationship between maternal fish consumption and preterm birth. The first review combined evidence from observational studies and randomised controlled trials and demonstrated that higher intake of fish or omega-3 fatty acids during pregnancy was associated with a significant reduction in early preterm birth, with supplementation trials showing a ~40% decrease in births before 34 weeks (18). The second review found that moderate habitual fish consumption (around 1–3 servings per week) was associated with a significantly lower risk of preterm birth, with maximal benefit being shown at moderate intake levels (19). Together, these analyses provide consistent and complementary evidence that regular moderate fish consumption during pregnancy reduces the risk of preterm birth, supporting current dietary recommendations that encourage fish as part of a healthy prenatal diet.

Thus, across multiple lines of evidence—observational studies, randomised controlled trials, studies investigating the molecular or cellular actions of omega-3 fatty acids, and risk–benefit analyses—there is consistent support for the inclusion of fish, particularly oily fish, within a healthy dietary pattern, and a healthy prenatal diet. The strongest evidence relates to cardiovascular and early neurodevelopmental benefits, with more modest and uncertain effects observed for cognitive ageing. While contaminants remain a concern for some groups such as pregnant women, current evidence indicates that, for most population groups, the benefits of regular fish consumption outweigh the risks when adhering to species-specific guidance (7).

Health and nutrition benefits of Scottish salmon consumption

There are very few studies that explicitly brand their intervention as "Scottish salmon". For only one study we are certain that the health benefits of Scottish farmed Atlantic salmon were tested (20), as the study was done by ourselves at the University of Aberdeen. Our findings are entirely consistent with the broader oily fish and salmon literature. Therefore, the next section will focus, more generally, on the health benefits of salmon consumption.

A substantial number of randomised controlled trials and mechanistic studies has examined the effects of salmon on nutritional markers and cardiovascular health. Although the strength of evidence varies across outcomes and populations, the collective findings indicate that salmon consumption improves omega-3 status and plasma lipids, with more modest and context-dependent effects on vitamin D status, inflammation, and the regulation of glucose and insulin. There is, thus far, limited evidence that salmon consumption can support cognitive and mental-health, or gut health, based on a restricted number of studies in these areas.

Nutritional status

Across a diverse set of randomised controlled trials conducted in Europe, North America, and Asia, salmon consumption consistently improves omega-3 fatty acid status. This effect is observed irrespective of baseline health status, with trials in healthy adults, overweight individuals, pregnant women, and in populations with abnormal blood lipid levels, all demonstrating significant increases in circulating levels of the omega-3 fatty acids EPA and DHA following salmon intake. For example, controlled feeding studies in Norway showed that both smoked and cooked salmon increased levels of serum EPA and DHA to a degree comparable to, or in some cases exceeding, fish-oil capsules, when expressed per unit of EPA/DHA provided (21). Similar findings were reported in the USA, where dose-response trials demonstrated proportional increases in plasma omega-3 fatty acids with higher salmon intake (22). Evidence from pregnancy trials further confirms that salmon consumption effectively increases the concentration of omega-3 fatty acids in breast milk in early lactation, thus improving the supply of these fatty acids to the breast-fed newborn (23), while studies in Chinese men with abnormal blood lipid levels showed that oily fish, including salmon, substantially increased dietary and plasma levels of EPA and DHA (24). Taken together, these findings provide strong and coherent evidence that salmon consumption reliably improves omega-3 status across populations and settings.

The evidence for salmon intake enhancing vitamin D status is more modest and context-dependent. Oily fish is a meaningful dietary source of vitamin D, and randomised controlled trials consistently show that regular consumption attenuates seasonal declines in plasma vitamin D levels over winter (25). However, high intakes of salmon are insufficient to prevent wintertime reductions in vitamin D status at high latitudes. In Norway, for example, five salmon dinners per week slowed—but did not prevent—the autumn decline in plasma vitamin D levels among adults living at 60°N (26). Similar findings were observed in Poland, where young women consuming salmon products experienced a smaller seasonal decline in plasma vitamin D levels; the young women who benefitted most from eating salmon were those with low baseline levels of plasma vitamin D (27). Evidence from a meta-analysis confirms that oily fish consumption increased plasma vitamin D by approximately 4–7 nmol/L, with larger increases observed in longer trials, but the review concluded that recommended fish intakes alone cannot optimise vitamin D status (28). Overall, the evidence indicates that salmon contributes meaningfully to vitamin D intake and can modestly improve or stabilise status, but it cannot substitute for sunlight exposure or vitamin D supplementation.

Plasma lipids

The most robust and consistent evidence for the health benefits of salmon consumption relates to improvements in plasma lipids, which are associated with cardiovascular health. Across numerous randomised controlled trials in healthy, overweight, and in populations with abnormal blood lipid levels, salmon intake reliably reduced fasting triglycerides and frequently increased HDL cholesterol (“good” cholesterol). These effects were observed across a range of intakes and geographical settings. For example, daily salmon consumption in healthy Scottish adults reduced plasma triglycerides by 15%, lowered LDL cholesterol (“bad” cholesterol) by 7%, increased HDL cholesterol by 5%, and reduced blood pressure—changes corresponding to an estimated 25% reduction in coronary heart disease risk (29). Trials in Norway similarly showed that high salmon intake reduced plasma triglycerides and increased HDL cholesterol, whereas lean fish or chicken did not (30). In Chinese adults with abnormal blood lipid levels, salmon and other oily fish produced substantial reductions in plasma triglycerides and markers of inflammation (24,31). Additional evidence from the USA indicates that salmon consumption improves the profile of lipoproteins that transport cholesterol and triglycerides in blood in overweight adults (32), while earlier work in men with healthy blood lipids also demonstrated favourable shifts in lipoprotein profiles upon salmon consumption (33). Collectively, these findings provide strong causal evidence that salmon consumption improves plasma lipids in a manner consistent with a reduced cardiovascular risk, with larger effects in individuals with abnormal blood lipid levels, or with an elevated risk of cardiovascular disease.

Inflammation

Evidence for effects of salmon on systemic inflammation and blood vessel function is more mixed but still suggestive of benefit. Several randomised controlled trials in higher-risk populations report reductions in inflammatory markers (such as IL-6 and TNF-α) following salmon consumption, particularly in adults with abnormal blood lipid levels (24,31). Trials in healthy adults show smaller or inconsistent effects, which is expected given lower levels of baseline inflammation. Some studies also report improvements in blood clotting markers (including reductions in factor VII and PAI-1) (29), and favourable changes in markers for a "stressed" state of the inner lining of blood vessels (such as VCAM-1) (34). Increased fish intake has also been associated with reductions in plasma CRP, an important marker of general inflammation, although effects on local gut inflammation markers appear minimal (35). Overall, the evidence suggests that salmon consumption can reduce inflammation, particularly in individuals with elevated baseline inflammation, but effects are less researched than those observed for plasma lipid biomarkers.

Regulation of glucose and insulin

There are only a few studies that have assessed the effects of salmon on the regulation of glucose and insulin. A study in healthy overweight adults who consumed Atlantic salmon twice weekly at different doses for 4 weeks (22), and another study in in healthy, normal-weight adults who consumed 750 g of salmon per week for 4 weeks (30), found no evidence for effects of salmon consumption on glucose or insulin metabolism. Overall, there is no strong evidence that salmon improves the regulation of glucose and insulin levels, and this aligns with the results from systematic reviews and meta-analyses that there is no association between fish consumption and risk of type 2 diabetes (3).

Cognition

Across the available evidence, salmon consumption appears to confer modest, context-dependent benefits for cognitive and mental-health outcomes, with the strongest effects observed in populations where cognitive development is ongoing (e.g., preschool children), baseline omega-3 status is suboptimal, or mental-health vulnerability is high (e.g., forensic psychiatric inpatients). The strongest direct evidence for cognitive benefits of salmon consumption comes from a well-designed randomised controlled trial in healthy preschool children in Norway (36), with salmon-based meals increasing EPA and DHA status, and modest but measurable improvements in cognitive function, most notably in attention and aspects of executive function. A randomised controlled trial in forensic inpatients (37) suggests that salmon consumption reduces anxiety, accompanied by improvements in heart-rate variability. Taken together, the evidence indicates that salmon consumption can support cognitive and mental-health functioning, but effects are not large, and the number of studies conducted in this area is very limited.

Gut health

Research examining the effects of salmon consumption on gut health is still emerging. Across two well-conducted randomised controlled trials in overweight adults, and adults with impaired glucose and insulin metabolism (38,39), salmon consumption produced modest changes in the composition of gut microbiota, without altering overall microbial diversity. However, the clinical significance of these microbiota shifts is not yet established, and effects may not be unique to salmon—similar changes could occur after consumption of other fish such as cod.

Factors affecting the health and nutrition benefits of farmed salmon

The health and nutritional value of farmed salmon is shaped by multiple interacting factors. From a production perspective, this includes feed composition and subsequent nutrition profiles in farmed fish, but also contaminant exposure. From a consumer perspective, a main factor includes demand for fish, and for salmon specifically.

Nutrient composition of farmed Atlantic salmon

The nutrient composition of farmed salmon has changed substantially over the past decades, largely due to shifts in aquaculture feed formulations by partly replacing the traditional finite marine ingredients, fishmeal and fish oil, in farmed salmon diets with sustainable alternatives of terrestrial origin, that are not containing EPA and DHA. Comparison of the fatty acid composition of over 3,000 Scottish Atlantic salmon farmed between 2006 and 2015 showed a significant increase in terrestrial fatty acids, alongside a decrease in EPA and DHA levels (40). From a nutritional perspective, one could argue that consumers would need to eat more fish to satisfy (European) recommendations for EPA and DHA (6), in order to benefit from its health properties. However, the evidence shows that while fish feed regimes have changed, farmed salmon remains a valuable source of key nutrients, including EPA and DHA (40).

A comprehensive UK retail survey by Sprague et al. (41) analysed 20 pre-packaged salmon fillets from major retailers, covering value, standard, premium, and organic ranges sourced from Scotland and Norway. Protein content was relatively stable (17.5–20.2% wet weight), but lipid content varied markedly (11.2–16.3%). Tail cuts delivered significantly less omega-3 fatty acids EPA and DHA than all other cuts, whilst both protein and mineral levels demonstrated minor changes across fillet cuts (42). The most striking variation was in fatty acid composition, reflecting differences in feed formulations across producers. EPA+DHA content ranged from 0.88 to 2.36 g per 130 g portion, equivalent to 26–67% of the recommended weekly intake for optimal cardiovascular health. This wide range was driven by differing levels of marine oil inclusion in feeds, with higher vegetable-oil feeds producing lower EPA+DHA levels. Selenium content also varied substantially, providing 14–55% of the daily requirement for men and 17–69% for women per portion (41). These findings highlight that modern farmed salmon is not nutritionally uniform, and nutrient delivery to consumers depends heavily on production practices and retailer sourcing.

Even when salmon are fed identical diets, substantial individual variation in EPA and DHA deposition can occur. A controlled study by Horn et al. (43) demonstrated that salmon fed the same diet throughout life showed large inter-individual differences in EPA and DHA content in skeletal muscle, driven by differences in gene expression related to lipid and glucose metabolism, and insulin signalling.

Non-dietary factors such as age, body weight, and lipid deposition patterns can also influence the omega-3 content. A study by Olsen & Skjervold (44) examined salmon from nine Norwegian farms, all fed the same diet, and found that lipid content increased with fish age, leading to higher absolute EPA and DHA content despite declining percentage values. Furthermore, DHA (as % of total fatty acids) decreased with increasing fish size, while EPA levels remained relatively stable. Seawater temperatures and latitude had minimal effects, except for a slight decline in DHA at higher temperatures. Wild salmon had a higher % of EPA and DHA, but farmed salmon had higher absolute amounts of these fatty acids, due to greater total lipid content.

As part of this report, we performed a comparison of nutrient analysis for farmed salmon (flesh, raw), obtained from:

i) the UK CoFID/McCance & Widdowson database, with samples being analysed in 2003
ii) the Norwegian Food database, with samples being analysed between 2006-2019
iii) salmon sampled across 4 fish farms in Scotland, with samples being analysed in 2024 and 2025

From this we can observe the following trends:

- Outcomes for total fat, total saturated fat, and total protein, are comparable between salmon analysed across datasets in the past twenty years.
- Vitamin D_3 values are notably higher in salmon samples from Scottish farms, being recently analysed, compared with those reported for salmon samples analysed for the Norwegian database between 2006 and 2019, and especially compared with those reported for salmon samples analysed for the CoFID/McCance & Widdoson database, in 2003.
- Compared with salmon samples analysed in 2003 (CoFID/McCance & Widdowson database), salmon samples analysed more recently (Norwegian Food Database, and samples from Scottish farms) contain notably more monounsaturated fatty acids, more polyunsaturated fatty acids, and more omega-6 fatty acids, but less of the omega-3 fatty acids EPA and DHA, which is likely reflective of changing feeding regimes.

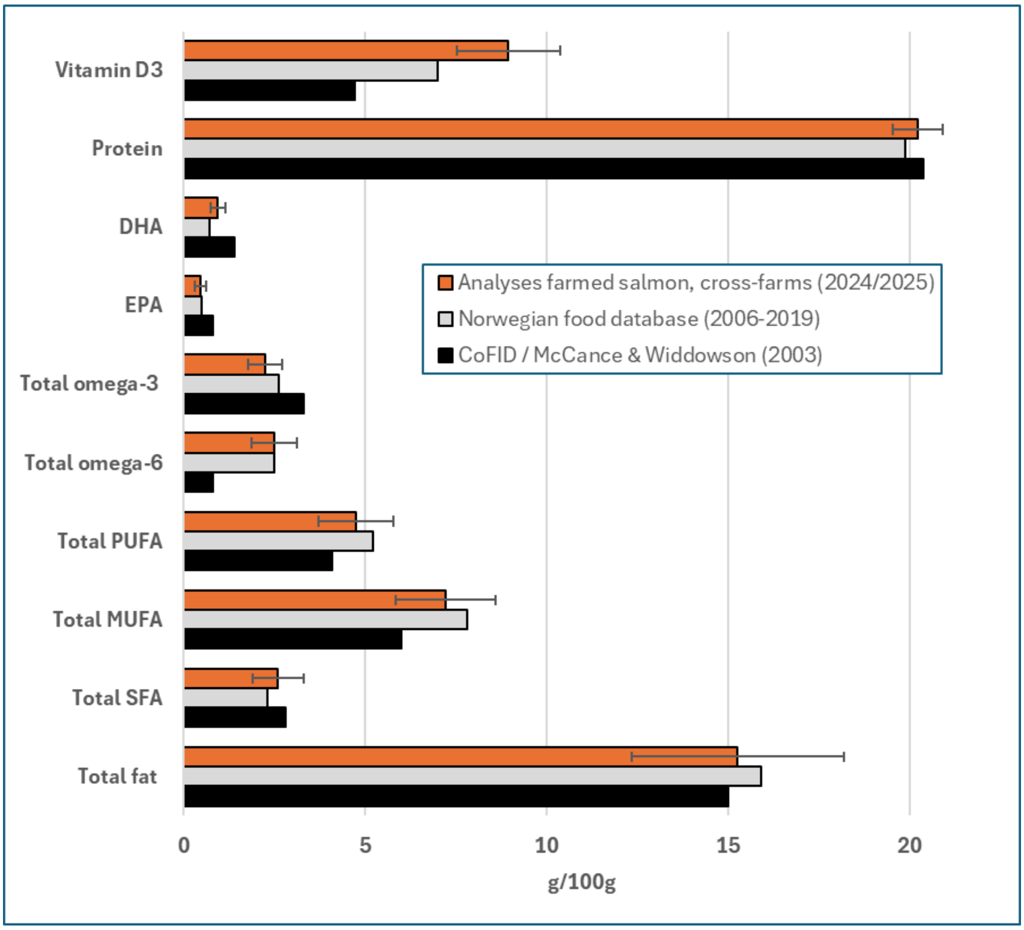

Figure 1. Nutrient analysis of farmed salmon. Data were obtained from UK and Norwegian food composition tables, and average results from recent nutrient analysis in salmon samples from four Scottish fish farms.

Concerns about the declining content of the fish fatty acids EPA and DHA in modern farmed salmon, due to an increased use of vegetable oils in feed, have prompted several human trials. However, these studies consistently show that salmon raised on rapeseed-oil–enriched feed still improve omega-3 status and plasma lipids, and almost to a similar extent as traditionally fish oil and fish meal-fed salmon.

For example, randomised controlled trials in Norway and Scotland demonstrated that the benefits of salmon consumption on health outcomes such as plasma triglycerides and omega-3 status were preserved despite lower marine-oil content in feed (20,34). Sissener (45) emphasises that while the content of EPA+DHA has decreased, farmed salmon remains a major source of long-chain n-3 PUFA, and as indicated, human randomised controlled trials confirm preserved health benefits. Thus, the verdict on feed is that current evidence suggests that modern farmed salmon, even with higher vegetable oil content, still produce meaningful health benefits, albeit that absolute EPA+DHA delivered per portion is lower than in earlier decades.

Contaminant exposure

The recent Joint FAO/WHO Expert consultation on risks and benefits of fish consumption (7,46) systematically reviewed new evidence on the health benefits of fish versus the toxic effects of dioxins and dioxin-like polychlorinated biphenyls (PCBs) and methylmercury, the role of selenium in methylmercury toxicity, as well as the occurrence of methylmercury, dioxins and dioxin-like PCBs in fishery and aquaculture products. The review included both wild and farmed fish, with salmon being considered as one of the key aquaculture species.

The review shows that salmon (including farmed Atlantic salmon) is a low methylmercury species compared with large predatory fish. Typical concentrations are in the lower range of values reported for fish in general, and below Codex maximum levels. At the methylmercury levels reported for salmon, even regular consumption (e.g. 1–2 portions per week) contributes only a small fraction of the methylmercury exposure that would approach FAO/WHO health-based guidance values, including for pregnant people. This makes methylmercury a relatively minor risk driver for farmed salmon in the FAO/WHO framework.

Dioxins and dioxin-like PCBs are lipophilic and persistent, so fatty fish and aquaculture products are contributors to dietary exposure. However, concentrations in farmed salmon have generally decreased over time, largely due to changes in feed composition, with less use of potentially contaminated marine oils. Fish feed manufacturers increasingly take a dynamic approach to controlling the matrix of nutrient and contaminant outcomes in feed. Through a combination of sourcing, oil cleaning and blending with vegetable oils, and by using feed formulation software, it is possible to optimise outcomes for fatty acid profile whilst simultaneously controlling contaminant levels. In terms of sourcing, this means buying fish oils with different omega-3 and contaminant contents (variable according to origin) which may have been cleaned according to their analysed contaminant burden. Oil cleaning methods including treatment with activated carbon and distillation are chosen according to the targeted contaminant outcomes required. Blending the various fish oil types with vegetable oils further decreases farmed fish's dietary exposure to marine-specific organic pollutants (personal communication, Paul Morris, Mowi Feed). Current levels of dioxins and dioxin-like PCBs in salmon are typically below regulatory maximum levels. For typical consumers, farmed salmon is one contributor to overall dioxin/dioxin-like PCB exposure, but not usually the dominant one, and at current levels 1–2 portions per week do not generally push total intake above FAO/WHO health-based guidance values. High-consumption groups (very frequent fish eaters) could get closer to those values, but still within the range where FAO/WHO judge that benefits and risks must be weighed, not that salmon should be avoided outright (46).

The review concludes that, for the general adult population, cardiovascular and other health benefits of eating fish (including farmed species) are substantial, especially from oily fish rich in omega-3 fatty acids. For typical consumption (around 1–2 portions per week), the resulting exposures to methyl mercury and dioxins/dioxin-like PCBs remain within FAO/WHO health-based guidance values for both contaminants, and farmed salmon is not classified as a high-risk species. For sensitive groups, including pregnant people, women of childbearing age and young children, the report reiterates that methylmercury is the key contaminant of concern for neurodevelopment, but that low-methylmercury species (like salmon) can be consumed within recommended fish-intake ranges without exceeding guidance values. However, dioxins/dioxin-like PCBs remain a long-term background risk, but again, salmon is only one of several dietary sources (46).

Demand for fish, and salmon, in UK consumers

Food consumption, nutrient intakes and nutritional status in the UK population are monitored through the National Diet and Nutrition Survey (NDNS) rolling programme—a continuous cross-sectional survey of UK residents aged >18 months and living in private households. Household food purchases are captured through the Family Food module of the Living Costs and Food Survey, which records expenditure on, and quantities of, food and drink purchased for consumption both inside and outside the home. Together, NDNS intake data and UK Family Food statistics consistently show that average fish consumption remains below recommended levels. Oily-fish intake is particularly low: many adults and most children consume oily fish less than once per week. Consumption is dominated by white fish—often battered or fried—while shellfish intake is minimal. As a result, current UK consumption patterns fall short of SACN (4) and EFSA (6) recommendations, limiting the potential population-level health benefits associated with regular fish intake.

Our analysis of NDNS data over the past decade confirms that UK dietary recommendations for fish consumption are not being met. Average intake is less than half of the advised amount. Using NDNS household-income tertiles (lowest, middle and highest), we found that mean weekly seafood intake was below the recommended two portions per week (equivalent to ~280 g) across all income groups: approximately 180 g/week in the highest-income households, ~150 g/week in middle-income households, and ~100 g/week in the lowest-income households. The highest-income group consumed similar amounts of oily and lean fish and the most shellfish, whereas middle- and lower-income groups consumed more lean fish than oily fish and very small quantities of shellfish.

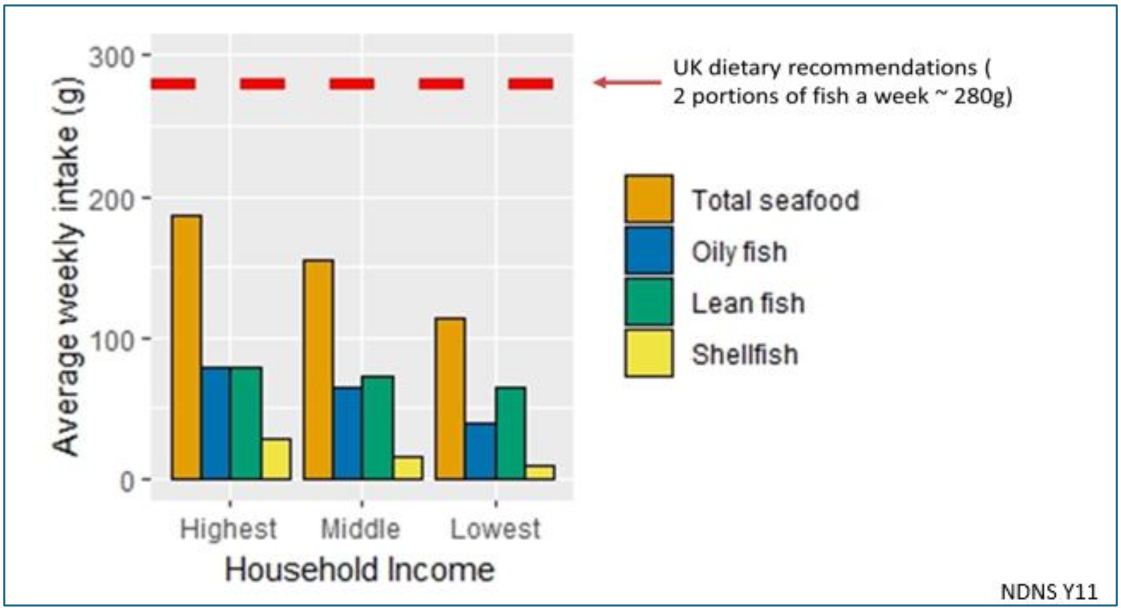

Figure 2. Average weekly intake of total seafood, oily fish, lean fish and shellfish, in individuals living in high, middle and low-income households, based on NDNS data.

Seafish's 2024 update on Seafood Consumption, drawing on Family Food statistics, reported that total UK seafood purchases in 2022 averaged ~145 g per person per week—equivalent to just over one 140 g portion (47). Salmon remains the most purchased seafood species in UK retail, and is the most commonly consumed oily fish. Seafish market data typically show that salmon accounts for 25–30% of all seafood volume sold, making it the dominant oily-fish choice.

Despite low domestic consumption, much of the UK's oily-fish production—including salmon, herring and mackerel—is exported. This indicates that consumer preferences and demand, rather than supply constraints, shape current patterns of fish production, trade and consumption (48). UK consumers tend to favour a narrow range of species—the so-called "big five": salmon, cod, haddock, tuna and prawns—many of which are not predominantly caught or farmed in the UK. **Increasing consumption of species such as salmon, mackerel and herring would improve population intakes of key nutrients abundant in oily fish, including omega-3 fatty acids, vitamin B_{12} and vitamin D (48).**

Innovation in the development of healthy seafood products could help encourage dietary shifts. However, such products must remain cost-sensitive, as cost, taste and food safety continue to be the three primary drivers of European consumers' food choices (49). Processed seafood may offer a promising route. Although "ultra-processed" foods often carry negative connotations, the issue lies not in processing itself but in the typical nutritional profile of such products. Processed foods can be healthy. Reimagining processed seafood to be nutritious, appealing and convenient could help revitalise national interest in fish.

Our research reveals that demand for fish is not primarily driven by price. Instead, it's shaped by household income and personal taste preferences (50). This suggests that in lower-income communities where fish is not already a dietary norm, reducing prices alone is unlikely to increase consumption. Introducing fish to children early—such as through school meal programmes at no additional cost to families—may be a more effective strategy. Evidence indicates that increasing fish in school meals can support improved academic performance (51,52) and enhance vitamin D status (52) during winter months. Such initiatives may also help foster long-term familiarity with, and acceptance of, seafood.

Salmon as a sustainable food choice

Food is one of the most powerful levers for improving both human health and environmental sustainability. Today, our diets and the global food system account for roughly one third of global greenhouse gas (GHG) emissions (53). Transforming dietary patterns is therefore essential for building a sustainable food system and achieving net zero emissions by 2050. Seafood has a significant role to play in this transition. Many seafoods products deliver higher nutrient density than terrestrial animal protein alternatives, at lower emissions (54). Modelling of optimal sustainable diets – those designed to reduce GHG emissions – consistently identifies fish as the most frequently added food to improve both health and environmental outcomes (55). As a result, seafood consumption is likely to increase globally as countries move toward net zero targets.

EAT-Lancet, a global scientific study which set out to define a sustainable, healthy diet that can feed 10 billion people by 2050, proposes a predominantly plant-based diet that incorporates modest amounts of animal-source foods, including fish. It recommends an average intake of 28 g (range 0–100 g) of fish or shellfish per day, equivalent to one or two servings per week, as part of a healthy low-emission diet (56). For many populations this means an increase from current consumption levels. Global (57) and Swedish (58) analysis highlight small pelagic species, salmonids and bivalves as offering the greatest nutritional benefits with the lowest environmental footprints.

Recent work provided standardised estimates of greenhouse gas emissions, freshwater use, land use, and nitrogen and phosphorus emissions, for a range of blue foods, reported per tonne of edible product (59). Among farmed finfish and crustaceans, silver and bighead carps exhibit the lowest greenhouse gas, nitrogen and phosphorus emissions, though they require relatively high-water use. Farmed salmon and trout, by contrast, have the lowest land and water requirements. Scenario modelling shows that improving feed conversion ratios can reduce stressors across all fed groups, while increasing fish yield can cut land and water use by up to half. These findings demonstrate the ability of high-performing blue foods to improve environmental performance and inform sustainable diet design.

These insights do not imply that blue food production can expand indefinitely or without environmental trade-offs. However, aquaculture remains one of the fastest growing food sectors, and the current moment presents a unique opportunity to steer expansion towards sustainability (60).

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