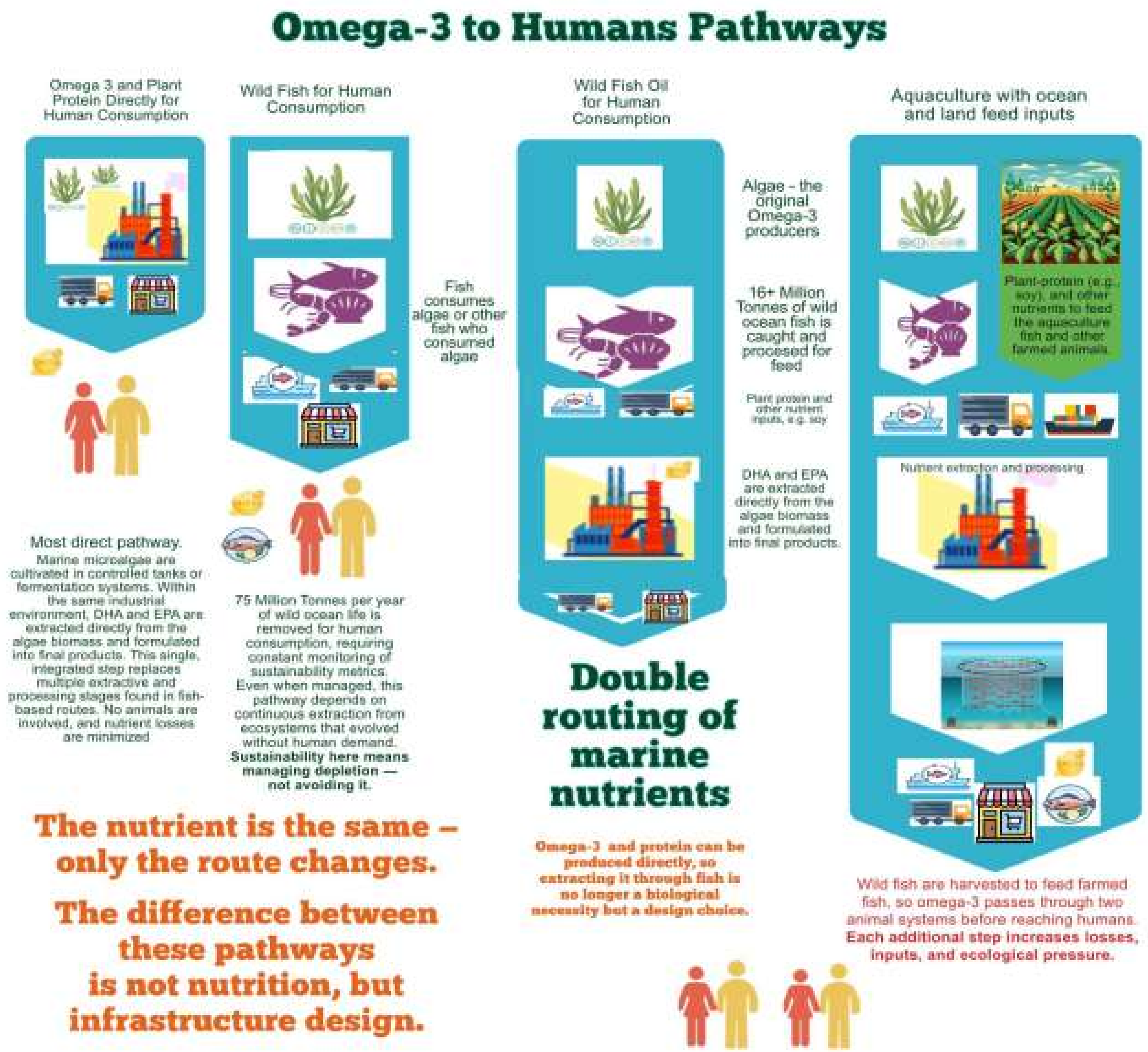
Action Plan for Scaling Algae-Based EPA/DHA and Reducing Dependence on Wild-Caught Marine Ingredients

Blue Bioeconomy 2.0 / Sustainable Omega-3 Nutrient Routing — Concept Draft

Discussion document prepared by Joanna Słodownik / Green Reset Foundation initiative
For review and feedback by companies, experts, policymakers and organisations working on omega-3, aquaculture, feed innovation, marine ingredients and sustainable food systems.

At a glance:

Core idea: shorten omega-3 nutrient routes



From current industrial detour: *Marine microalgae → wild fish → fishmeal/fish oil → aquaculture feed / supplements → consumers*
To a shorter route: *Marine microalgae → algae-based EPA/DHA oil → feed / human nutrition*

Main pressure point: wild fish reduced into fishmeal and fish oil.
Main opportunity: algae-based EPA/DHA and lower-pressure feed ingredients.
Strategic frame: functional replacement, not one-for-one biomass replacement.
Transition model: gradual diversification with existing industries, not abrupt disruption.
Ask: expert feedback on a realistic 2030/2035/2040 roadmap.

1. Executive Summary

Omega-3 supply is still often routed through a long biological and industrial detour. EPA and DHA originate in marine microalgae, but a major industrial pathway still depends on wild-caught small pelagic fish that are reduced into fishmeal and fish oil, then used in aquaculture feed, supplements, pet food and other markets.

This creates pressure on marine ecosystems and exposes companies and countries to supply volatility, climate variability, price shocks and reputational risk. The issue is not only overfishing or certification. It is a nutrient-routing problem: a valuable nutrient is being delivered through a long and fragile pathway when shorter routes are increasingly available.

The objective is not to replace wild fish, fishmeal or fish oil overnight. A realistic transition should focus on gradual diversification and functional replacement. The key question is not how to replace millions of tonnes of fish biomass one-for-one, but how to replace specific functions — especially EPA/DHA delivery — through lower-pressure pathways such as algae-based omega-3 oil and complementary non-fish feed ingredients.

This distinction makes the transition more practical. Millions of tonnes of wild fish are reduced into much smaller volumes of fishmeal and fish oil, and only part of that fish oil represents the EPA/DHA function. Concentrated algal oil can deliver EPA and DHA more directly, closer to the original biological source.

The opportunity is industrial as well as ecological. Fish processors, marine ingredient companies, feed producers, aquaculture firms, algae and fermentation companies, retailers, policymakers and finance institutions can all help build the next generation of marine-safe nutrient infrastructure. Existing producers should not be treated only as obstacles; many already have the logistics, quality systems, market knowledge and customer relationships needed to participate in the transition.

This discussion draft proposes a phased action plan: map the current omega-3 route, separate the functions of fishmeal and fish oil, quantify the functional replacement challenge, build global production capacity, create demand signals, support transition finance, and reframe omega-3 communication so that algae-based EPA/DHA becomes visible, trusted and normal.

The goal is to gather practical input from businesses, academics, and government officials regarding a feasible route for transitioning to omega-3s by the years 2030, 2035, and 2040.

2. The Problem: Routing of Omega-3 Through a Long Biological Detour

The prevailing public story is that fish provide omega-3. Scientifically, this is incomplete. EPA and DHA originate in marine microalgae. Fish accumulate these fatty acids through the food chain.

This distinction matters because it changes the core question.
The question is not simply: *how can we manage fish stocks better?*
The deeper question is: ***why are we still using wild fish as an intermediary for nutrients that can now be produced more directly?***

The main industrial reduction pathway discussed in this document can be simplified as follows:

> ***Marine microalgae → small pelagic fish → fishmeal and fish oil → aquaculture feed / other uses → farmed fish or products → consumers***

This is not the only omega-3 route. Wild fish can also be consumed directly by humans, which is a shorter pathway than reducing fish into fishmeal and fish oil and then routing those nutrients through feed systems. The focus here is specifically on high-volume industrial reduction and marine ingredients in aquaculture, supplements, pet food, and other markets.

This route is long, biologically inefficient and geographically fragile. It depends on wild fish populations, ocean conditions, reduction fisheries, export markets, feed formulation, aquaculture demand and global trade flows. It also places pressure on coastal ecosystems and communities that may be far removed from the final consumers of farmed salmon, supplements or other omega-3-containing products.

A shorter route already exists:

> ***Marine microalgae → algae-based EPA/DHA oil → feed or human nutrition***

This "shortcut" won't immediately eliminate all marine ingredients. But it leads to a practical question: ***which functions fish oil / fishmeal functions can be replaced safely and cost-effectively with direct or lower-pressure alternatives?***

This framing avoids two common mistakes. First, it avoids pretending that better certification alone can solve the structural problem. Certification, quotas and stock management are necessary, but they do not change the underlying nutrient pathway. Second, it avoids framing the transition as an attack on existing industries. The goal is not to erase marine ingredient companies. The goal is to help them diversify as ecological, regulatory, and market pressures intensify.

3. Why the Replacement Challenge Is Smaller Than It Looks

At first glance, replacing wild fish inputs may appear impossible. Global reduction fisheries use millions of tonnes of wild fish annually to produce fishmeal and fish oil. Recent estimates and projections place the wild fish reduced into fishmeal and fish oil roughly around 15–17 million tonnes in some years, with global fishmeal production around several million tonnes and fish oil around one million tonnes annually.

But this is exactly why nutrient routing matters.

The transition does not require replacing every tonne of wild fish biomass with one tonne of algae or another ingredient. The relevant question is: *what function are we replacing?*

This is where the scale of the opportunity becomes apparent. Wild fish reduced into fishmeal and fish oil go through several layers of concentration and loss. A large volume of whole fish is first reduced into a much smaller volume of marine ingredients. As an approximate conversion range, **15–17 million tonnes of wild fish may produce roughly 3.5–4 million tonnes of fishmeal and only about 0.8–1 million tonnes of fish oil**. In simpler terms, **1 tonne of wild fish may yield approximately 220–240 kg of fishmeal and only 50–70 kg of fish oil**, while the rest is mostly water, processing loss and residual biomass.

This matters because fish oil is the main carrier of EPA and DHA in this system, and fish oil itself contains only a fraction of these omega-3 fatty acids. This functional difference is illustrated clearly by Veramaris, a company producing algal EPA/DHA oil for aquaculture and other omega-3 markets: according to its impact communication, **1 tonne of algal oil can contain as much EPA and DHA as 60 tonnes of wild fish**, with an EPA/DHA concentration of about **65%**, significantly higher than conventional fish oils. This means the replacement challenge should not be imagined as "17 million tonnes of fish must be replaced by 17 million tonnes of algae." The relevant comparison is much smaller and more precise: how much concentrated algal EPA/DHA is needed to replace the omega-3 function currently extracted from wild fish after all the reduction, processing and conversion losses have already occurred?

Fishmeal and fish oil perform several functions. Fishmeal provides protein, amino acids, minerals and palatability. Fish oil provides EPA and DHA, energy and other lipid functions. These functions can be separated. The omega-3 function can increasingly be replaced by concentrated algal EPA/DHA oil. The protein function can be addressed through a wider portfolio of ingredients, including plant protein concentrates, microbial proteins, fermentation-derived ingredients, circular by-products and other emerging feed inputs.

This means the transition should be designed as functional replacement, not biomass replacement.

To put it simply, we are not trying to replace 17 million tonnes of fish one-for-one.
We are trying to replace the nutrient functions currently extracted through that biomass.

That distinction makes the strategy more realistic, more investable and more persuasive. It also helps policymakers and companies move away from the false choice between "continue as usual" and "ban fish oil." The practical pathway is gradual substitution of specific functions in specific markets, starting where alternatives are technically ready and where the sustainability benefit is highest.

For omega-3, this means scaling algae-based EPA/DHA. For feed protein, it means developing complementary ingredient streams. For aquaculture, it means reformulating feeds over time while maintaining fish health, product quality and consumer trust. For producers in fishmeal-producing countries, it means building new industrial capacity before existing extraction-based models become more constrained.

The Industry Is Already Changing — But the Pressure Remains

The marine ingredient industry is not standing still. Aquaculture feeds already use less fishmeal and fish oil than in the past, and more marine ingredients now come from fish-processing by-products and trimmings rather than whole wild fish. This progress matters. Recent industry figures suggest that roughly **one-third of global fishmeal** and **just over half of global fish oil** now come from by-products rather than direct reduction fisheries.

But this does not remove the structural issue. By-products are limited by the amount of fish already being processed, and aquaculture demand continues to grow. This means that efficiency gains can be absorbed by market expansion rather than translating into a clear absolute reduction in wild-fish extraction. The system can become more efficient per unit of feed while still keeping millions of tonnes of wild fish in the reduction pathway.

Fish oil is also the tighter bottleneck. Protein functions can be supplied by a broader portfolio of ingredients, including plant proteins, microbial proteins and other feed inputs. EPA and DHA are more specific. That is why by-products and feed reformulation are important, but not sufficient. A next-stage strategy still needs direct EPA/DHA sources such as algal oil, alongside a wider portfolio of lower-pressure feed ingredients.

4. The Opportunity: From Fish Processors to Nutrient Processors

The most constructive way to approach this transition is not to divide the world into “old industry” and “new technology.” A successful omega-3 transition will require existing industry knowledge.

Marine ingredient companies, fish processors, aquaculture feed producers and global traders already understand many of the systems that new entrants need to navigate: feed performance, commodity logistics, customer requirements, quality standards, price sensitivity, regulatory documentation and long-term supply relationships. These capabilities are highly valuable.

The opportunity is to shift capacity to future nutrient infrastructure.

Fishmeal and fish oil producers could gradually become broader feed ingredient and nutrient companies. Existing processing regions could become production or blending hubs for algal oil, microbial meals, plant protein concentrates and other complementary inputs. Aquaculture feed companies could use their formulation expertise to reduce dependence on wild-caught marine inputs while maintaining product performance. Retailers and seafood brands could create demand signals for fish fed with lower-pressure omega-3 sources.

This is especially important for countries such as Peru and Chile, which are major players in fishmeal and fish oil supply chains. A transition strategy that simply reduces demand for fish oil without creating new opportunities for current producing regions would be politically and economically weak. A better strategy would invite these regions into the next value chain.

For example, major fishmeal-producing countries could explore whether they can also become hubs for:

- algae-based omega-3 oil production or finishing;
- feed ingredient blending and formulation;
- plant protein processing;
- microbial or fermentation-derived feed ingredients;
- higher-value marine-safe nutrition inputs;
- research partnerships with aquaculture and biotech companies.

This would shift the conversation from extraction reduction to industrial upgrading. It would also make the transition more attractive to governments, companies and development finance institutions.

Let's be clear: this initiative extends beyond merely protecting fish. It is also about building the next generation of nutrient infrastructure.

5. Why This Transition Matters for Europe and Global Markets

Europe has strong reasons to take this transition seriously, but the opportunity is not Europe-only. The omega-3 and marine ingredient system is global. Fishmeal and fish oil are produced, traded and used across many regions, with important links between South America, Europe, Norway, Asia and other aquaculture markets. A realistic transition therefore needs both European leadership and global partnership.

For Europe, reducing dependence on wild-sourced fish oil and fishmeal is a resilience strategy. European food and feed systems are exposed to marine ingredient supply chains that depend on distant ecosystems, climate variability and global commodity markets. El Niño events, stock fluctuations, regulatory changes, shipping disruptions and price volatility can all affect supply. Europe also presents itself as a leader in biodiversity, sustainable finance, food safety, public health and responsible supply chains. Supporting direct omega-3 sources such as algae-based EPA/DHA would make that leadership more credible.

At the same time, Europe is not outside the current system. The EU produces a meaningful share of global fishmeal and fish oil, and Denmark is by far the largest EU producer. This matters because the transition is not only about imports from Peru, Chile or other regions. It is also about how European production, trade, aquaculture links and industrial know-how could be redirected over time toward lower-pressure nutrient infrastructure.

The global opportunity is equally important. Countries and companies currently involved in fishmeal and fish oil production should not be treated only as sources of ecological pressure or as sectors to be displaced. Many already have processing capacity, logistics, quality systems, export relationships and market knowledge. These capabilities could become part of the next value chain: algae-based omega-3 production, feed ingredient blending, microbial proteins, plant protein concentrates, circular ingredients and other lower-pressure nutrient systems.

Major fishmeal-producing countries, aquaculture regions and ingredient companies could all benefit from this transition if it is designed as industrial upgrading rather than simple demand reduction. Peru, Chile, Norway, Denmark, Morocco, Mauritania, Senegal, China and other aquaculture and marine-ingredient markets could all have different roles in a diversified omega-3 and feed ingredient system.

Europe can help accelerate this shift by using its market power, research capacity, regulation, sustainability standards and finance tools. But the goal should not be European self-sufficiency alone. **The more strategic goal is to help build a distributed global network of marine-safe nutrient production, where current producer regions have a pathway into higher-value, lower-pressure ingredient systems.**

The risk of inaction is not only environmental. Companies and regions that remain locked into legacy nutrient routes may face higher exposure to supply shocks, ecological constraints, price volatility, regulation and reputational risk. Those that move early can shape future standards, secure stronger supply chains and build competitive advantage in the next generation of food and feed infrastructure.

6. Demand Matters: Decoupling Omega-3 from Wild Fish

This document focuses on supply chains, production capacity and ingredient innovation. But demand matters too. Across Europe, omega-3 is still often discussed as if it simply means "eat more fish." That message is familiar and easy to understand, but it is incomplete. EPA and DHA originate in marine microalgae. Fish are one way of delivering them, not the original source.

This distinction matters because not everyone eats fish for taste or tradition. Some people eat fish because they believe it is necessary for health, especially for omega-3. If algae-based EPA/DHA becomes more visible, trusted and normal, part of that health-driven demand can be met without routing the nutrient through wild fish or fish oil.

The same applies to feed and aquaculture markets. If fish oil remains the default way to think about EPA/DHA, then direct algae-based sources will continue to look like niche alternatives. But if the function is named clearly — EPA/DHA delivery — then algae-based oil becomes a direct route, not a strange substitute.

This demand-side reframing helps explain why alternatives have remained marginal despite existing technology. A realistic omega-3 transition therefore needs both sides: more production capacity and better communication. The shorter route has to be available, affordable and technically reliable, but it also has to be understood. The goal is simple: make algae-based EPA/DHA visible as a normal, legitimate way to deliver omega-3 in food, feed and nutrition markets.

7. Proposed Action Plan

Step 1: Map the Current Omega-3 and Marine Ingredient Route

The starting point for a credible transition strategy is a clear blueprint of the present system. This should include wild fish inputs, reduction fisheries, fishmeal and fish oil production, export flows, aquaculture feed uses, supplement markets, pet food uses, livestock feed uses where relevant, and final consumer markets.

The mapping should also identify where ecological and social pressure is concentrated. Which species are being reduced? Which countries and coastal communities are most affected? Which markets are driving demand? Which companies and sectors are most exposed to supply shocks?

This mapping would turn the omega-3 conversation from a vague sustainability concern into a concrete supply-chain and infrastructure question.

Step 2: Separate the Functions of Fishmeal and Fish Oil

Fishmeal and fish oil should not be treated as one undifferentiated problem. Their functions differ. Fish oil is especially important for EPA and DHA. Fishmeal contributes protein and other nutritional properties. A serious strategy should identify which functions can be replaced now, which require more innovation, and which may need hybrid solutions for longer.

This functional approach makes the transition more practical. It allows companies to replace the easiest and highest-impact functions first, rather than treating marine ingredients as an all-or-nothing category.

Step 3: Quantify the Functional Replacement Challenge

The next step is to estimate how much algal EPA/DHA would be required to replace specific shares of fish oil use in aquaculture and other markets. This should be done in scenarios: for example, 5%, 10%, 25%, 50% and higher shares over time.

The same scenario approach can be used for fishmeal protein replacement, using a portfolio of ingredients rather than a single substitute. The result would be a more realistic transition model: not “replace all fishmeal and fish oil immediately,” but “replace specific nutrient functions in specific markets over defined time horizons.”

Step 4: Build a Distributed Global Production Network

Europe should invest in its own algae and fermentation capacity, but the transition cannot be Europe-only. The current marine ingredient system is global, so the alternative must be too. Production capacity should be explored in multiple regions: Europe, current fishmeal-producing countries, major aquaculture regions and countries with suitable industrial, energy, water, land, logistics or fermentation infrastructure. The goal should be to create a diversified network of production hubs rather than a single concentrated supply chain.

This is especially important for fairness and political feasibility. If countries that currently depend on fishmeal and fish oil exports are excluded from the new value chain, they may see the transition as a threat. If they are invited into production, processing, blending and technology partnerships, the transition becomes an opportunity.

Step 5: Create Demand Signals

New production capacity will not scale without credible demand. Companies and investors need confidence that there will be buyers for algae-based omega-3 and other non-fish feed ingredients.

Possible demand signals include:

- long-term offtake agreements from feed companies and aquaculture producers;
- retailer commitments to lower-pressure aquaculture feeds;
- certification schemes that recognise non-fish EPA/DHA inputs;
- voluntary industry roadmaps;
- public procurement criteria;
- sustainability-linked finance;
- gradual inclusion targets where technically feasible;
- public-private partnerships for strategic ingredients.

The key point is that cost reduction requires scale, and scale requires predictable demand.

Step 6: Use Transition Finance

Algae-based omega-3 and other alternative feed ingredients may cost more than conventional fish oil or fishmeal initially. This should not justify inaction. Many strategic industries were initially expensive before policy support, scale and learning curves reduced costs.

Possible financing tools include innovation funds, loan guarantees, blended finance, development finance, green industrial policy, public research programmes, tax incentives, pilot procurement and strategic investment platforms.

The rationale is simple: the current system's market prices don't reflect external costs like biodiversity loss, ecosystem strain, supply chain weakness, and geopolitical risks.

Step 7: Reframe Omega-3 Communication

Public health bodies, retailers, aquaculture standards and nutrition communicators should begin treating algae-based EPA/DHA as a normal and legitimate omega-3 source. The message should be simple: fish are one delivery route for EPA and DHA, but microalgae are the original source. Clarifying this would lessen the automatic link between omega-3 demand and wild fish extraction.

Step 8: Build a Multi-Stakeholder Roadmap

The transition should be developed with companies, researchers, feed formulators, aquaculture producers, marine ingredient companies, policymakers, NGOs, coastal regions and finance institutions. A practical roadmap should identify:

- what is technically possible today;
- what can scale by 2030;
- what might be realistic by 2035 and 2040;
- which markets should move first;
- what policy signals are most useful;
- what infrastructure is missing;
- how existing producers can diversify;
- where international partnerships are needed.

This roadmap needs to be concrete for investment guidance yet flexible for changes in costs, tech, and markets.

8. Questions for Companies & Expert Reviewers

Practical comments and suggestions on the following questions are welcome:

1. What share of fish oil use in aquaculture could technically be replaced by algal EPA/DHA in the short, medium and long term?
2. What is the main bottleneck today: cost, production capacity, customer demand, feed formulation, regulation, financing, long-term contracts or something else?
3. What policy signals from the EU or major aquaculture markets would make new algae-based omega-3 production capacity easier to finance?
4. What kind of infrastructure is needed to scale algae-based EPA/DHA and other lower-pressure feed ingredients — production hubs, fermentation capacity, processing facilities, blending plants, or regional scale-up centres?
5. What feasibility studies would be most useful at this stage: technical, commercial, regional, environmental, financial, or supply-chain studies?
6. What kind of long-term demand commitments would make new facilities bankable?
7. Could major fishmeal-producing countries, such as Peru or Chile, also become production hubs for algal omega-3 or other alternative feed ingredients?
8. Could existing marine ingredient companies diversify into algal oil, microbial protein, plant protein concentrates or other feed inputs?
9. What would a realistic 2030, 2035 and 2040 replacement pathway look like for fish oil in aquaculture feeds?
10. Which uses of fish oil should be prioritised for replacement first: aquaculture feed, supplements, pet food, livestock feed or other markets?
11. What data would be most useful for modelling the true replacement challenge: total fish biomass, fish oil volumes, EPA/DHA content, feed inclusion rates, production cost curves or regional demand?
12. How should this transition be communicated so that it is constructive for existing industries rather than perceived as an attack on them?

9. Possible First Milestones

Initially, focus on shared understanding, not binding targets. Possible first milestones include:

1. A short expert consultation with algae omega-3 companies, feed companies, aquaculture producers and marine ingredient firms;
2. A data brief comparing the fish-based omega-3 route with direct algal EPA/DHA routes;
3. Ascenario model estimating how much algal EPA/DHA would be needed to replace 5%, 10%, 25% and 50% of fish oil omega-3 function in selected markets;
4. Identification of 3–5 regions where new production capacity could realistically be built;
5. EU policy note on omega-3s, marine feed, and strategic autonomy.

6. A visual presentation showing the current detour and the shorter route;
7. A proposal for a voluntary industry roadmap to lessen dependence on wild-sourced fish oil.

These steps would test the concept and gauge interest in a broader coalition or working group.

10. Closing Argument

Every tonne of omega-3 function shifted from wild-caught marine detours to direct nutrient pathways can reduce pressure on marine ecosystems, lower exposure to volatile supply chains, create new industrial opportunities and strengthen the credibility of sustainable aquaculture.

The current system was built because it once made sense: fish accumulated omega-3, and fish oil became the available industrial source. But technology has changed. We can now produce EPA and DHA closer to their biological origin. The question is whether policy, finance and industry strategy will catch up.

Making a significant change won't happen overnight. It will require cost reduction, infrastructure, demand creation, feed reformulation, regulatory approval and cooperation with existing producers. But the direction is clear.

The future omega-3 system should not depend primarily on extracting nutrients through wild fish. It should be built around shorter, safer and more resilient nutrient pathways.

This document is just a starting point. Any comments, corrections, and practical insights are welcome, particularly from those in the fields of algae-based omega-3, aquaculture feeds, marine ingredients, biotechnology, sustainable finance, and food-system strategy.

11. Selected References and Data Sources

This draft uses the following sources as a factual starting point. Figures should be checked again, especially if the document is later converted into a policy brief, petition or presentation.

1. **OECD-FAO Agricultural Outlook 2025–2034 — Chapter: Fish and other aquatic products.**
   Used for projections that capture fisheries production reduced to fishmeal and fish oil is expected to fluctuate between approximately **15.2 million tonnes in El Niño years and 17.1 million tonnes in peak fishing years**, while remaining below the roughly **26 million tonnes** used in the 1990s. Also used for projected fishmeal and fish oil production by 2034. Relevant pages: **pp. 111–112** in the PDF edition.
   URL: https://www.oecd.org/en/publications/2025/07/oecd-fao-agricultural-outlook-2025-2034_3eb15914/full-report/fish-and-other-aquatic-products_ed13346f.html
2. **EUMOFA — Fishmeal and Fish Oil, 2025 Edition.**
   Used for global fishmeal and fish oil production figures, including average production of approximately **5.1 million tonnes of fishmeal** and **1.2 million tonnes of fish oil** over the previous decade; 2024 estimates of around **5.5 million tonnes of fishmeal** and **1.3 million tonnes of fish oil**; and the statement that around **15 million tonnes** of fish are channelled into fishmeal and fish oil production. Also used for EU production, trade flows, Denmark's role, import/export patterns, South American price influence and by-product use. Relevant pages: **pp. 2–9**, especially the summary and sections 2.1–2.4. URL:
   https://eumofa.eu/documents/20124/35725/Fishmeal%2Band%2Bfish%2Boil%2Bstudy_2025%2BEdition.pdf/cfae4d0a-4568-277c-cce0-33ebce2f3a00
3. **EUMOFA — Fishmeal and Fish Oil, 2025 Edition, conversion data.**
   Used for the simplified conversion estimate that **100 kg of raw material produces around 21 kg of fishmeal and between 2 and 6 kg of fish oil**. This supports the explanation that large volumes of wild fish are reduced into much smaller quantities of marine ingredients, and that fish oil is only a small part of the original biomass.
   Relevant page: **p. 3 of the report body / p. 5 of the PDF view**. URL:
   https://eumofa.eu/documents/20124/35725/Fishmeal%2Band%2Bfish%2Boil%2Bstudy_2025%2BEdition.pdf/cfae4d0a-4568-277c-cce0-33ebce2f3a00
4. **EUMOFA — Fishmeal and Fish Oil, 2025 Edition, EU production and Denmark.**
   Used for the statement that the EU produces approximately **370,000–520,000 tonnes of fishmeal** and **90,000–140,000 tonnes of fish oil**, representing **8–12% of global production**, and that **Denmark accounts for around 35–50% of total EU production**.
   Relevant page: **p. 2 of the report body / p. 4 of the PDF view**. URL:
   https://eumofa.eu/documents/20124/35725/Fishmeal%2Band%2Bfish%2Boil%2Bstudy_2025%2BEdition.pdf/cfae4d0a-4568-277c-cce0-33ebce2f3a00
5. **EUMOFA — Fishmeal and Fish Oil, 2025 Edition, by-products and trimmings.**
   Used for background on the growing role of fish-processing by-products and trimmings in fishmeal and fish oil production, including the estimate that in 2023 around **39% of fishmeal** and **54% of fish oil** were obtained from by-products.
   Relevant pages: **pp. 8–9 of the report body / pp. 10–11 of the PDF view**. URL:
   https://eumofa.eu/documents/20124/35725/Fishmeal%2Band%2Bfish%2Boil%2Bstudy_2025%2BEdition.pdf/cfae4d0a-4568-277c-cce0-33ebce2f3a00
6. **IFFO — Update on by-product marine ingredients.**
   Used as a complementary industry source on by-product use and the growing share of marine

ingredients produced from fish-processing by-products.
URL: https://www.iffo.com/by-product

7. **IFFO — Key takeaways from IFFO's 2025 Members Meeting, Day 2.**
Used as a complementary industry source for reported by-product shares in fishmeal and fish oil production. URL: https://www.iffo.com/key-takeaways-iffos-2025-members-meeting-day-2

8. **Veramaris — Algal Oil Features and Benefits.**
Used for the comparison that **one tonne of Veramaris algal oil delivers the same amount of EPA and DHA as up to 66 tonnes of wild forage fish**, and for positioning algal oil as a way to reduce the marine footprint of aquaculture.
URL: https://www.veramaris.com/algal-oil-features-and-benefits
https://www.veramaris.com/about-us

9. **Evonik — Veramaris feature article.**
Used as a supporting company source for the statement that one tonne of Veramaris algae oil can provide as much EPA and DHA as up to **66 tonnes of feed fish**, and for context on Veramaris as a joint venture between Evonik and dsm-firmenich.
URL: https://elements.evonik.com/en/articles/OnlineOnly/veramaris.html

10. **FAO — The State of World Fisheries and Aquaculture 2024 / Utilization and processing of fisheries and aquaculture production.**
Used for general context on global use of aquatic production for food and non-food purposes, and for distinguishing direct human consumption from non-food uses such as fishmeal and fish oil.
URL: https://www.fao.org/3/cd0683en/online/sofia/2024/utilization-processing-fisheries-production.html

11. **Majluf, P., Matthews, K., Pauly, D., Skerritt, D., and Palomares, M. L. D. — "A review of the global use of fishmeal and fish oil and the Fish In:Fish Out metric" (2024).**
Used as a background academic source on the continued role of fishmeal and fish oil in aquaculture, the Fish In:Fish Out debate, and concerns around small pelagic fish, ecosystems and coastal communities. URL: https://pmc.ncbi.nlm.nih.gov/articles/PMC11482318/

About the Author / Green Reset Foundation Initiative

Joanna Słodownik is an independent researcher and the founder of the Green Reset initiative. Working at the intersection of nutrition, natural systems, biotechnology, public policy and market transition, she focuses on identifying practical pathways for shifting food and feed systems toward shorter nutrient routes, lower ecological pressure and more resilient production infrastructure. She develops briefs, policy proposals and communication frameworks that translate complex food-system challenges into actionable transition pathways for public institutions, companies, NGOs and cross-sector partnerships.

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