

A shortage of healthful omega-3 fatty acid from fish looms as the global climate heats up. Here is a plant-based biotechnology solution

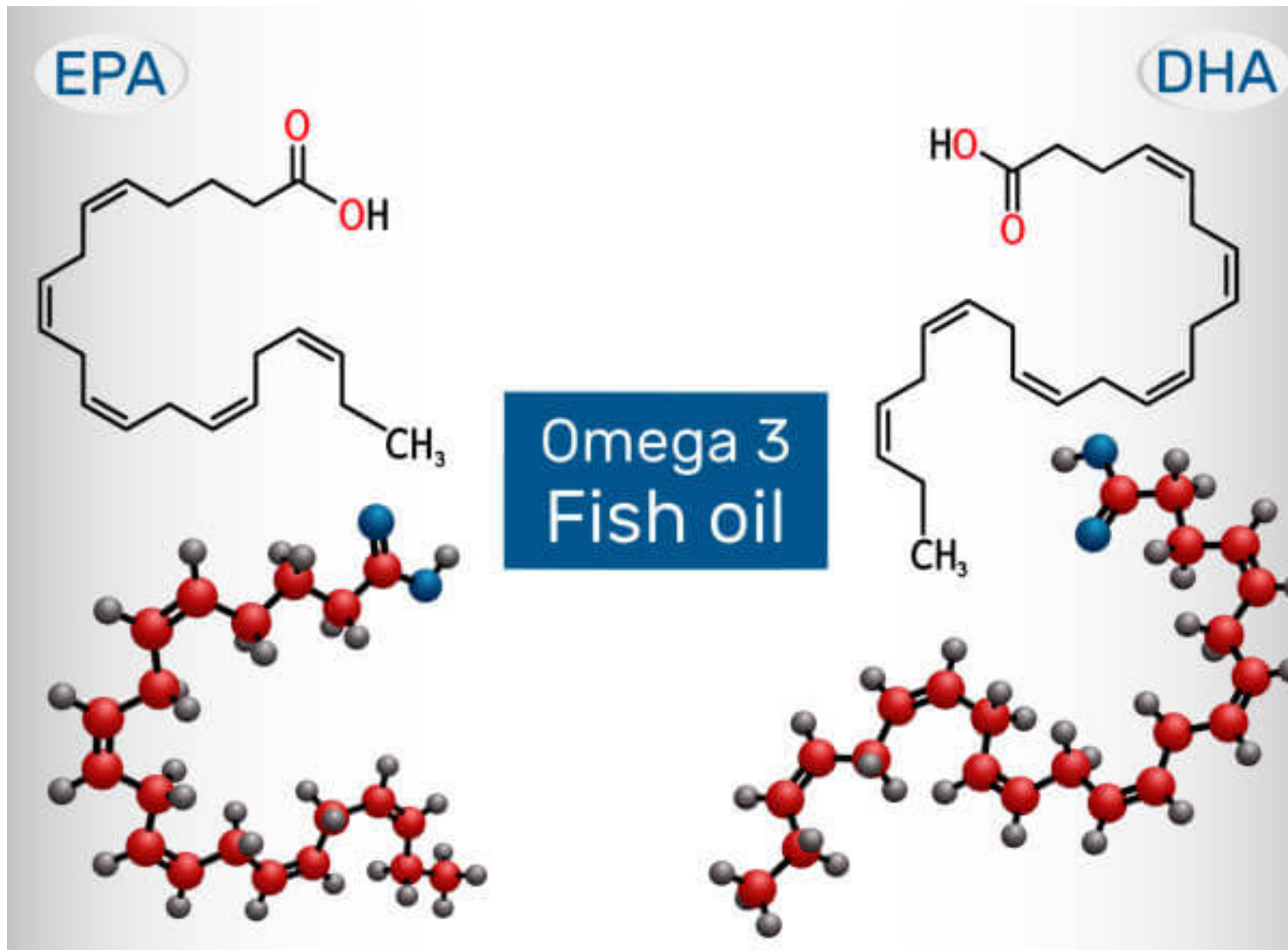
Consumption of fish and other seafood has played a pivotal role in human history as a nourishing protein. This warrants a reminder: global demand for healthy protein such as omega-3 oil reflects one of the many challenges around ensuring global food security. Research suggests that because of global warming, by 2100, 96 percent of the global population may not have sufficient access to a DHA, the naturally occurring essential [brain-building](#) omega-3 fatty acid. The researchers estimate a global loss of ~10-58 percent of the world's DHA in the next 80 years.

Innovation is needed to support natural fisheries while also encouraging sustainable production of farmed fish.

Overfishing has emerged as a major dilemma in Earth's vast oceans. According to the [United Nations Food and Agriculture Organization](#), more than 90 percent of the world's fisheries are fully exploited, overexploited or depleted. In addition, changing weather patterns and ocean temperatures are affecting ocean life. This includes the sardine shortage along the South Africa coast, as a November 2020 study from [South African Journal of Science](#) shows that changing weather patterns caused by the climate crisis may threaten the sardine run. If sardines are migrating later in the year, this could cause food shortages for sharks and other species that feed on them.

Omega-3 oil, including the fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential to the human diet and have been shown to reduce inflammation and certain risks of chronic disease. DHA is a key component of cell membranes and is critical for brain function. It helps regulate cell survival, inflammation, and neuroprotection, and makes up 10 percent of the mammalian brain's fatty acids. DHA is also thought to help develop the central nervous system and retina. [New research](#) says DHA and other types of omega-3s may help people suffering from depression, if taken alongside antidepressants. DHA is especially helpful for fetuses, babies, and young children for developing healthy brain and eyes.

But humans can't produce enough DHA on their own. To reach the [recommended dose](#) — 1.1 g for adult women and 1.6 g for adult males daily — they either have to eat DHA-rich foods like fish and seafood once or twice a week, or take dietary supplements. Omega-3 oils are present only in certain cold-water fatty fish species including sardines, mackerel, and salmon.



Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) molecule. Credit: iStock

Ethical and environmental concerns have arisen over the sustainable sourcing of omega-3 oils from naturally harvested fish for use in commercial fish meal used in farmed fish, including salmon. A recent [survey](#), detailing the collective opinion of 30 global seafood procurement executives from Spheric Research on behalf of Global Seafood Alliance, found that retail demand for the most popular seafood species such as salmon and shrimp surged by double digits and will continue to rise this year.

Also, according to a recent [Nielsen](#) study, seafood consumption escalated by more than 30 percent in retail channels in North America in 2020, greater than any other type of animal protein including beef and chicken. In this study, retail procurement executives who participated found that salmon and shrimp demand rose as much by 30 percent in North America and 20 percent in Europe.

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Innovation is needed to support natural fisheries while also encouraging the sustainable production of farmed fish. Plant-based alternatives for fish oil, including an alternative for omega-3 fish oil, are in high demand, especially as the public becomes more educated about the food they consume, and the impact it may have on their health. Therefore, technology is being developed using [Camelina plants](#) as a platform to produce oils that closely mimic omega-3 fish oil containing EPA and DHA, without the fish.

The team at Yield10 Biosciences is participating in a global research effort to utilize the oil seed plant *Camelina sativa* as a platform to produce omega-3 oil representing a sustainable, land-based solution to supplying this heart healthy oil for use in commercial fish feed, especially for farmed salmon. Last year Yield10 formed a collaboration with Rothamsted Research to develop biotechnology for producing omega-3 in *Camelina* as a potential fish oil alternative. As part of the agreement, Yield10 has an exclusive two-year option to sign a global license agreement to develop and commercialize this plant-based omega-3 technology.



Camelina sativa. Credit: Nexles

Rothamsted's Flagship leader, Johnathan A. Napier, is the head author of a [paper published this year in Nature](#) describing how AgTech innovation could help aquaculture become greener. The paper explains how aquaculture can deliver fish protein to a growing world population while staying within “planetary boundaries” of environmental sustainability. It also features research on how due to overfishing and the decline of marine diversity, only aquaculture has the potential to meet the needs of 10 billion people in 2050, while remaining within said planetary boundaries. Therefore, using omega-3 oil produced in *Camelina* represents an exciting alternative to combat the overfishing associated with the harvest of natural fish to produce omega-3 oil, and by supplying sufficient omega-3 as a nutrient for farmed fish as a healthy protein for human nutrition.

Over the last decade, the Rothamsted team led by Napier has successfully produced DHA/EPA omega-3 fish oils in *Camelina* seed. The [Rothamsted team](#) has used recombinant genetic engineering techniques to reproduce the omega-3 biosynthesis pathway from algae to *Camelina*. This approach worked very well in achieving high levels of both EPA and DHA in the seed oil of

Camelina. The Rothamsted team has demonstrated that the omega-3 oil produced in *Camelina* already matches (or exceeds) the DHA/EPA levels found in northern hemisphere fish oil (such as mackerel or cod liver) and is working on technology to raise the omega-3 levels to match southern hemisphere fish oil. The Rothamsted team also carried out multi-year field trials and multiple feeding studies showing the equivalence of the DHA and EPA *Camelina* oil to natural omega-3 fish oil in feeding studies of salmon, trout and sea bass.

Because it is readily genetically engineered, has a fast growth cycle, and demonstrates robust agronomics, *Camelina* is an ideal crop to produce this fish oil substitute. There are also benefits to avoiding production in commodity crops such as canola and soy, since *Camelina* seeds are easier to segregate from the major seed export crops during production, harvesting and processing.

We recognized fairly early that the work done at Rothamsted had not only been successful scientifically but was demonstrated from a nutritional point of view to essentially be a substitute for fish oil, both in aquafeed diets for salmon farming and bream but also for use directly in the human diet.

We are planning on submitting our engineered *Camelina* for approval in South American countries, followed by North America. We believe that attitudes toward biotech crops and products produced may be changing as consumers see sustainability and product benefits in the new crops coming forward in development. Producing omega-3 oil on land, in *Camelina*, presents clear benefits in nutrition and sustainability versus extracting oil from wild-caught fish.

Dr. Oliver Peoples is the CEO at [Yield10 Bioscience](#), an [agricultural bioscience company](#) focusing on the development of disruptive technologies to produce step-change improvements in crop yield for food and feed crops to enhance [global food security](#). Prior to founding Metabolix, Dr. Peoples was a research scientist with the Department of Biology at the Massachusetts Institute of Technology. Find him on Twitter [@Yield10Bio](#)