Overfishing has depleted numbers of wild fish, and fish farms meet much of the growing demand. Could we one day be eating "fish" grown from cells in a factory, as a number of start-ups are planning?

"Caviar is no longer a luxury good," says David Shenson who owns four fish farms in Sacramento, California, raising sturgeon for their eggs, better known as caviar.

Business is booming says Mr Shenson and he's not just being self-promotional: The global caviar market reached £670m ($854m) in 2018 and is expected to expand by close to 10% by 2025, according to market research firm Androit Market.
But the caviar market might have to rely more and more on farmed fish, the number of wild sturgeon in major river basins has declined by 70% over the last century, according to figures from the World Wildlife Fund.

Overfishing and global warming have long wreaked havoc on fish stocks, and a third of marine fish stocks are still being fished at biologically unsustainable levels, according to the UN.

"Simply put, we are running out of fish," says Daniel Pauly, a professor of fisheries at the Institute of Oceans and Fisheries at the University of British Columbia. "And the situation, the trend line, is getting worse every year."

"Maybe centuries ago we could live off hunting for our food but we can't live off hunting today and fishing is hunting. The notion of hunting in the 21st century to feed 10 billion people is absurd."
A handful of start-up firms think they might have the answer. They are experimenting with growing fish "meat" in the lab.

Mainly based in Silicon Valley with a couple in Europe and Asia, they have developed techniques to extract fish stem cells and grow them into commercial quantities of edible flesh.

Stem cells are a type of cell, found in embryos or adult creatures - which can grow into a number of different specialised cells. They can grow into the muscle cells which make up most the parts of fish people like to eat.

"Picture it like 3D printing, but we're 3D printing fish," explains Michael Selden, chief executive and co-founder of lab-grown fish start-up Finless Foods.
His company's faux fish will come out as ground fish as opposed to whole fillets because developing, from scratch, skin and bone and blood isn't yet feasible.

Finless Foods and similar start-ups haven't yet commercialised their products and they still require approval from regulators, so their fish might not be on the market for two or three years.

Wild Type, based in San Francisco, has similar ambitions, but it is focused on Pacific salmon. Making fish in a lab sounds like it could be pricey for both producer and consumer, but chief executive Justin Kolbeck hopes to make the fish affordable at some point.

"Our goal is to eventually drive down the price of our salmon to have its price run lower than conventionally-harvested salmon."
Shiok Meats in Singapore has trained its eyes on lab-grown crustaceans such as shrimp.

It creates lab-grown fish by taking a small sample of stem cells from a real shrimp and growing them in large quantities in a large bioreactor chamber, similar to the huge stainless steel tanks brewers use to manufacture beer.

The tanks maintain a constant pressure and temperature and bathe the cells in gases and a nutrient-rich liquid. After a couple weeks the meat is ready.

"[It's] the same meat that would have come from a slaughtered animal but with no animal slaughter in this case," say Sandhya Sriram, chief executive and co-founder of Shiok Meats.

The company plans to launch its minced shrimp product in 2021, distributing it first in Singapore and then across East Asia. She is excited about dubbing his firm's product "clean meat" due to the lack of antibiotics and lower levels of greenhouse gas emissions, compared to traditional farming.
A third of fish stocks are being fished at levels that are not sustainable.

However, the environmental claims have yet to be fully verified. While cell-based meats have a smaller carbon footprint than traditional protein sources, they will still require "a lot" of electricity, says Simon Somogyi, a professor at the University of Guelph in Ontario, Canada.

"Where is that energy coming from? Are they using carbonized or renewable energy?" he asks.

Still, Mr Somogyi thinks lab-grown fish is perhaps an even more promising market than lab-grown beef.

"Fish has a better business case going forward than red meat because much of the volume of finned fish is turned into minced fish, and put into food such as fish fingers and fish burgers. Cell-based fish fits perfectly into that category."
Wild Type's Mr Kolbeck envisions a future where fish lovers will have similar options to meat (and meat-alternative) eaters.

"From real meat to plant-based substitutes to cell-based meat... one company won't be the winner, but rather the winner will be increased choice and transparency in our food systems."