GE Salmon
Will Not Feed the World

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> "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life."
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> – The State of Food Insecurity in the World 2001, The Food and Agriculture Organization of the United Nations

Expanding ways to feed the world's growing population is a persistent topic of discussion. One company, AquaBounty Technologies, is claiming to have a new method to help feed the world — a genetically engineered (GE) salmon that grows faster than a non-altered fish. While an increase in fish production could provide more protein to an expanding world in need of more food, a closer look at this GE salmon reveals that the costs likely far outweigh any benefits. The claim is a nice talking point for the company and a booster for the product, but analysis shows that alleviating hunger is not the primary intent of the GE salmon. Furthermore, the costs associated with bringing it to market, including the need for more feed to support rapid growth, its inferior nutritional profile as compared to wild salmon, and potential threats to wild salmon populations from escapes, make the likelihood that it will help feed the world a highly dubious proposition. Like other GE foods before it, GE salmon will not likely contribute to food security. And, while certain forms of fish farming may help alleviate food insecurity in some places, farmed fish do not need to be genetically engineered.

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The Claims

AquaBounty has genetically engineered an Atlantic salmon egg, in which genes from an ocean pout (an eel-like fish) have been inserted into the genes of Chinook salmon and then inserted into an Atlantic salmon.[1] The company claims that the egg produces a fish that grows about twice as fast as a non-altered Atlantic salmon. The eggs are intended for sale to aquaculture companies, to grow them into market-sized fish and sell them for human consumption. The Food and Drug Administration (FDA) is currently considering approval of the GE salmon through its process for new animal drugs, rather than developing an appropriate evaluation method for GE animals that will end up as human food.[2]

Proponents of allowing GE salmon in our food supply have claimed that it "will very effectively help to meet the demand for food from the growing world populations."[3] AquaBounty also states that this supposedly faster-growing fish "can help reduce pressure on wild fish stocks."[4]

However, AquaBounty admits it "markets and develops biotechnology products to enhance profitability of shrimp and fish farming."[5] In 2006, AquaBounty Technologies was listed in the London Stock Exchange's Alternative Investment Market, raising $28 million in an initial public offering of stock.[6] AquaBounty Technologies (ABTX) stock traded for $24.50 a share *after* the announcement of the FDA approval hearings. Six months prior, AquaBounty Technologies stock was trading for just $4.50.

How Much Faster Does GE Salmon Grow?

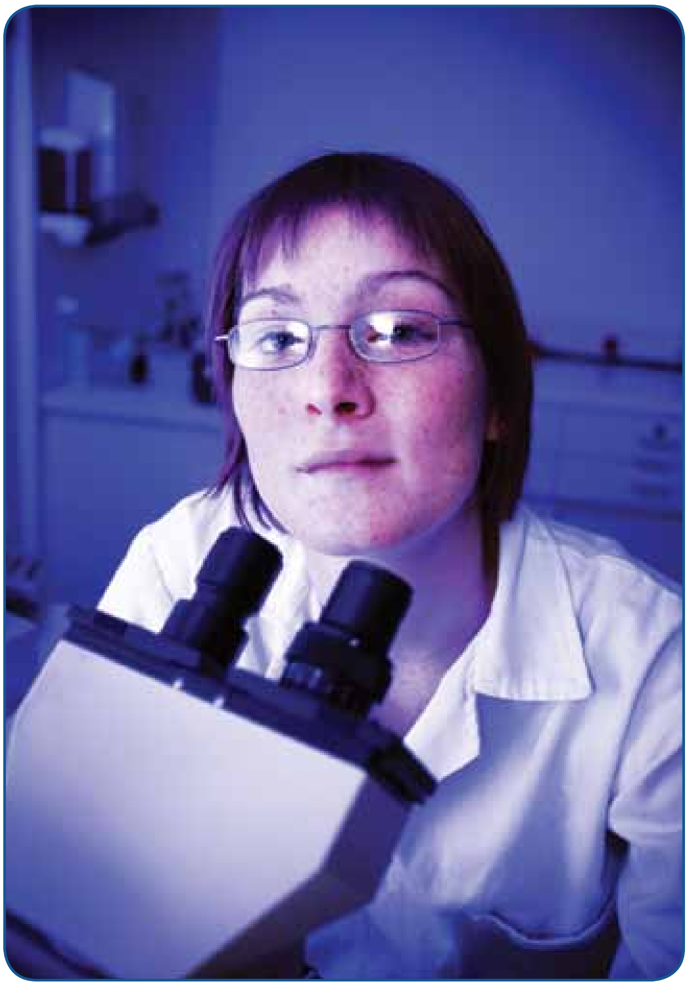
Most producers typically harvest fish at 8.8 pounds (four kilograms) or greater.[7] To reach this weight, according to AquaBounty's own figures, GE salmon need around 600 days, while non-GE salmon need about 800 days.[8] This demonstrates that GE salmon grow only about 33 percent faster. Interestingly, AquaBounty, in its submissions to the FDA, has acknowledged that normal (non-GE) domestic salmon farming could take as few as 20 months (600 days) to reach harvest weight — around the same amount of time as the company's own GE salmon.[9]

Quantity over Quality?

Research indicates that there are differences in both potentially dangerous chemicals and the nutritional profile of farmed salmon as compared with wild salmon. Salmon contain omega-3 fatty acids, which are important for human health but not produced by the body.[10] U.S. Department of Agriculture (USDA) testing data show that the fat of farmed non-GE salmon contains an average of 35 percent fewer omega-3 fatty acids than wild salmon.[11] While farmed non-GE salmon can contain more total fat than wild salmon, this is not necessarily a good thing, as farmed salmon fat can also be very contaminated. Polychlorinated biphenyls (PCBs), highly toxic industrial compounds that accumulate over time in animal fat and can cause serious human health risks, are just one common contaminant. These and over 100 other pollutants and pesticides have been found in the fat of farmed salmon.[12] In fact, non-GE farmed salmon consistently contain higher levels of persistent contaminants than wild salmon,[13] including 10 times the PCBs.[14] This difference between non-GE farmed salmon and wild salmon is attributed largely to feed.[15] If GE salmon eat the same food as non-GE farmed salmon, they would likely also have levels of contamination higher than wild salmon.[16]

"The FDA's summary of AquaBounty's claims notes that GE salmon have a different chemical composition than non-GE farmed salmon. In the summary of AquaBounty's limited nutritional testing, GE salmon exhibited a greater than 10 percent difference in some vitamins (notably vitamin B6), minerals and the amino acid serine.[17] These differences indicate that GE salmon are likely not as nutritious as wild salmon, in addition to possibly having higher levels of contaminants."

Additionally, "the engineered salmon have slightly higher levels of insulin-like growth factor 1 (IGF-1)."[18] Recent research shows that when present in the human body at elevated levels, IGF-1 increases the risk of breast, colon, prostate and other cancers,[19] although scientists do not fully understand why.



More Inputs = Lower Efficiency, Higher Costs

AquaBounty broadcasts widely its unsubstantiated claims that GE salmon will "improve the economics of salmon aquaculture by reducing time-to-market,"[20] implying that their product comes at a lower cost to produce and may result in savings that can be passed on to consumers. However, information provided by AquaBounty on the specifics of actually raising GE salmon paints a different financial picture. The model that AquaBounty is currently seeking approval for is *not* a locally grown, near-market, more sustainable model that could potentially reduce the carbon footprint and inputs for farmed fish production and therefore lower the cost of salmon for consumers. Rather, they plan to follow an entirely different production process.

When asked to explain the benefits of AquaBounty's GE salmon, AquaBounty CEO Dr. Ronald Stotish explained that producing the fish in captivity, in closed systems, would dramatically reduce transport costs and improve the whole supply chain, reducing the industry's carbon footprint.[21] But AquaBounty plans to develop its GE salmon eggs in Canada, then ship them to facilities in Panama where the fish would be raised and processed before shipping the end product to the United States for sale.[22] Shipping salmon eggs and processed fish to and from various parts of the world does not provide a reduced carbon footprint or help reduce costs over non-GE farmed salmon. The current proposal from AquaBounty does not include growing fish in local, near-market areas that could present such benefits from reduced transportation costs and energy use.

AquaBounty has very frequently publicized that GE salmon are more efficient eaters, growing to market weight with a 20 to 25 percent reduction in feed requirements.[23] In materials submitted to the FDA, Aqua Bounty qualifies its claim of enhanced growth by stating that GE salmon only reached these higher growth rates *when fed to "satiety*."[24] What does satiety mean? For GE salmon, it means eating as much as five times more food than control salmon. The "powerful stimulation of appetite in the presence of food and a larger capacity for food consumption given the opportunity" that the engineered trait engenders, according to AquaBounty, also means that GE salmon will grow fast only if they are fed more food.[25] According to the largest salmon-farming company in the world, Marine Harvest, feed costs represent their largest production cost — close to half of the entire production cost.[26] If feed costs quintuple, it would triple the total production costs of farmed salmon[27] and likely increase costs for consumers.

AquaBounty also acknowledged that GE fish designed for rapid growth have greater oxygen demands in order to sustain higher growth rates.[28] The likely increased demand for oxygen by GE salmon is also likely to create additional costs — for energy usage and purchasing or maintenance of more equipment to ensure adequate aeration of tanks — costs that can be passed on to the consumer.

AquaBounty performed "culling" of GE salmon prior to analyzing their health,[29] meaning they removed dead, ill and deformed salmon before looking at how healthy their fish are. Even so, in the data that was presented to the FDA, GE salmon still showed deformities and other morphological issues.[30] Deformed fish can result in lost profit to growers and add to production costs. This too can up the final cost for consumers.

In an interview, Eliot Entis, one of the founders of AquaBounty Technologies, estimated that AquaBounty's GE salmon could be produced "for somewhere between $1.65 and $1.80 a pound, head-on gutted."[31] It is unclear whether or not this is an estimate of production cost for the entire life cycle of the fish. Typical costs for non-GE farmed salmon in Norway and Scotland for the full lifecycle of a farmed salmon (from purchasing smolts — juvenile fish — through the entire growing period to market size) range between $1.65 and $1.79 per pound.[32] If Aquabounty's estimate is for the full lifecycle of the fish, it is, at best, the same cost to produce as a non-GE fish; If the cost estimate is for only a portion of the lifecycle, the production cost for AquaBounty's GE salmon could be considerably higher than a non GE salmon, and thus not even worth producing.

Finally, Dr. Ronald L. Stotish, CEO of AquaBounty, admitted that the eggs will cost more for salmon farmers than non-GE salmon eggs.[33]

In sum, raising GE fish may result in increased costs - for the eggs initially, then for oxygen levels, feed, and lost profit due to problems with deformities in the fish, throughout the production cycle. These projected costs, combined with the various potential human health and ecological concerns associated with GE fish, will not likely add up to a more financially advantageous product for growers or consumers.

GE Salmon Eat More Than Their Fair Share

Carnivorous farmed fish are fed pellets that contain wild fish, among other ingredients.[34] The small, wild fish used in feed are mostly converted to fishmeal and fish oil; this makes up approximately 40 percent of the pellets fed to farmed fish.[35] In 2006, the aquaculture sector alone consumed nearly 90 percent of small, prey fish captured worldwide.[36] These prey fish, like anchovies, herring and sardines, are at the base of the ocean food chain and are a critical food source for marine mammals, birds and larger fish. People in food insecure areas also depend on these fish as a primary protein source and as a means of employment — catching the fish contributes to their economic well-being.[37] Turning prey fish into aquaculture feed is a highly questionable and hotly debated use of important resources.

The increasing demand for fish feed by the aquaculture industry has already increased the market price of prey fish, driving prices up and out of reach for people in countries where these fish, until recently, were a critical and typical part of their diet. Increasingly, small fish are being diverted to feed carnivorous farmed fish, pigs, poultry and pets in higher-income countries.[38] Since the late 1970s, per-capita fish supply declined by 3 percent in Africa and 8 percent in South America while consumption of fish increased by 28 percent in North and Central America during the same decade.[39] GE salmon, requiring about five times the amount of feed as a non-altered salmon, will likely further exacerbate the decline of available fish in lower-income countries.

The nutritional profile of small prey fish is significant; they are a rich source of nutrients and a primary source of protein for many people worldwide. These fish contain essential vitamins and minerals, co-enzymes, and fatty acids, all beneficial for optimal health. Because these food fish are often eaten whole, people benefit from the calcium in the bones.[40] Prey fish contribute more than 25 percent of the total animal protein supply for approximately one billion people (one sixth of the world's population) in 58 countries.[41] Given the importance of these fish in people's diets, as well as for wildlife like larger fish, marine mammals and birds, the global aquaculture industry's increasing use of this resource is very troubling.

The use of small fish by developed countries and the aquaculture industry also changes the economies of fishing communities around the world. Exporting food often means the local population suffers from food insecurity due to a competitive market rather than an actual food shortage. Nine of the top 40 fish-exporting nations qualified as low-income food deficit countries (known as LIFDCs).[42] LIFDCs are encouraged to export food in exchange for money to buy cheaper, often imported, food. These countries are frequently left vulnerable to fluctuations in the

global market, which can result in people being unable to afford nutritious food with the money earned from their goods. Statistics from the Food and Agriculture Organization of the United Nations show that fish exports from LIFDCs only cover half of the cost of food imports.[43] This export model takes an accessible, nutrient-rich food source — small fish — from people that need it most, and instead feeds it to fish and other animals for sale and consumption in developed countries, exacerbating malnutrition in some of the very areas where the fish are plentiful and most important.

GE salmon that grow year-round to try to hit market weight in half the time of non-GE salmon will require even more prey fish inputs. This model will only decrease the availability of small fish as a dietary staple to people around the world, increasing global food insecurity and reducing a critical source of food for marine mammals, birds and larger fish. This is not a product that will help feed the world.

Lessons from Other GE Crops

It is not new for a biotechnology company to claim that its GE product will feed the world. Producers of GE crops have used this rhetoric for more than a decade. The reality is that while genetic engineering has been used to sell more herbicides (like Round-Up, produced by Monsanto Company) and has resulted in less choice for consumers and farmers, it hasn't made a dent in world hunger.

In 1996, biotech crops in the form of seeds became available to farmers.[44] GE seeds can be four times as expensive as non-GE seeds.[45] In 2009, one report indicated that non-GE soybean seed cost half as much as Round-Up Ready (GE) seed — $17 a bag versus $35.[46] As GE products take over the market, these costs can be passed to consumers. As food prices rise, more people become unable to afford it. Meanwhile, profits to companies producing GE seeds increase. Monsanto's net income doubled from $993 million in 2007 to $2 billion in 2008.[47]

Farmers pay a licensing fee to use patented GE seeds and sign a contract with the company that gives the farmer limited permission to plant the patented seeds for a single crop season.[48] Then, biotech companies zealously pursue anyone that may be violating the license agreement or infringing on their patents, even unintentionally. By October 2007, Monsanto had filed 112 lawsuits against farmers for alleged patent infringement, recovering between $85.7 and $160.6 million from farmers in out-of-court settlements alone.[49] It is well-documented that a farmer's field could be inadvertently contaminated with GE material through cross-pollination and seed dispersal from other various natural causes (like wind). At least one farmer contends he was sued when his fields were inadvertently contaminated with GE crops from neighboring farms.[50]

Additionally, the yields for GE crops have not lived up to industry promises about increased yields, especially for corn, soybeans and canola.[51] AquaBounty's GE salmon could experience similar problems, especially given the lack of testing and questionable information on health of the produced fish.

Like Monsanto and others, AquaBounty will likely own the intellectual property rights to GE salmon,[52] so a decline in wild stocks (from escaped farmed fish, pollution from salmon farms, natural occurrences, etc.) could boost its market share, spurring the company to increase production to make up for lost wild fish. For consumers, this would mean fewer choices and more GE salmon. However, the success of GE salmon production is questionable, so this may also mean less salmon is available as the market shifts toward GE products.

Other markets where GE products were introduced have experienced enormous concentration of power. In 2009, 93 percent of soybeans and 80 percent of corn cultivated in the United States were grown from seeds containing traits covered by Monsanto patents.[53] This transformation occurred within 15 years from the time of introduction. The consolidation of the market limits consumer choice and puts pricing power in the hands of a few large companies hoping to make significant profits from its products. This does not drive the development of more affordable food.

Based on the track record of GE crops, we should be aware that GE salmon will likely follow a similar path, with the consumer bearing higher costs and fewer choices, and perhaps even having less access to salmon than is currently available.

GE Salmon = Less Food?

AquaBounty intends to sell its GE salmon eggs to commercial farms, claiming that these operators will raise fish in contained facilities that limit the possibility of escape.[54] Potential harms from escaped GE salmon could be severe, with researchers suggesting a small number of GE fish escaping into the wild could cause extinction of the fish's populations in as little as 40 generations.[55] Because of their advantage as big, voracious fish, GE salmon could outcompete other wild fish for food, habitat and mates, but then fail to successfully reproduce, effectively leading to a total extinction of salmon in open waters.[56] AquaBounty's promises to prevent escapes seem especially weak given the widespread problem of regular farmed fish, including salmon, escaping from existing farms. In 2007, nearly 100,000 farmed Atlantic salmon escaped into the wild over a six-month period in Scotland.[57] In Norway alone, the government recorded 510,000 escaped farmed fish in 2009, including salmon, trout, cod and halibut.[58] Globally, these numbers are much higher, with an estimated 2 million farmed salmon escaping into North Atlantic waters every year[59] while millions more escape into the Pacific.[60]

A biotechnology corporation conducting experimental GE breeding in New Zealand is suspected of accidentally releasing GE salmon eggs into the wild,[61] demonstrating the logistical difficulties of preventing escapes, even in tightly controlled, experimental settings. AquaBounty acknowledges that "no single containment measure can be assured of 100% effectiveness" in the environmental assessment it submitted to the FDA.[62]

It appears inevitable that some of AquaBounty's GE salmon will end up outside farms and could interact with wild populations, threatening the survival of wild salmon. A disconcerting irony of GE salmon is that the worst-case scenario for the environment and consumers — wild stocks going extinct because of an accidental release of GE stock — could be the best-case scenario for AquaBounty. A decline in wild stocks would boost AquaBounty's market share, spurring an increase production and allowing them to control the price of salmon around the world, leaving consumers with little choice but to buy and eat GE salmon or look for other seafood options.

Alternate Approaches

Many consumers love seafood, and people around the world rely on fish as a source of protein. With various wild fish populations depleted, aquaculture is likely to be supplying increasing amounts of fish for food. However, not all fish farming methods are equal. There are viable, more ecologically sustainable options for providing food for our global population than GE fish. There is no reason to approve GE animals like salmon for food. They would likely cost more to grow, increase risks to wildlife and the environment, interfere with traditional jobs, and produce a lower-quality product for consumers.

Not All Will Be Sterile

AquaBounty claims that it will test each commercial batch of eggs it produces to ensure their sterility; however, this batch testing only needs to show a higher than 95 percent sterility rate, meaning that the company will almost certainly be producing some — and possibly many thousands or millions — of fertile fish through the course of its operations.[66] In fact, the company's current plan is to test just 200 eggs per batch of 100,000 to 200,000 eggs to determine at least 95 percent sterility, and if there are concerns, to test up to only another 700 eggs, for a potential total of 900 eggs.[67] That means less than 1 percent of each batch will be tested. AquaBounty once boasted it has 15 million eggs on order.[68] With a 5 percent fertility rate, this means 750,000 salmon eggs could be produced that might develop into fertile fish. Even the FDA has called AquaBounty's claim to raise only sterile fish "potentially misleading" because up to 5 percent of eggs sold for grow-out could be fertile.[69] AquaBounty's assurances to produce sterile fish that will be unable to intermix with wild fish if they do escape hardly seem sufficient given the severe consequences that even a small number of fertile GE salmon could have on wild populations.

Recirculating aquaculture systems (RAS) are closed, controlled, bio-secure systems for growing fish. Since RAS retain and treat water within the system, they reduce waste discharges and the need for chemicals and antibiotics to grow many kinds of fish. RAS can be efficient in production and space usage, growing a variety of different fish and plants close to their markets. RAS can provide a diversity of products: Tilapia, catfish, black seabass, salmon, shrimp, clams and oysters are just a few examples of seafood that can be raised in these systems. RAS can also be operated in tandem with aquaponics — the practice of growing plants in water rather than soil — to grow a variety of herbs, fruits and vegetables such as basil, okra, lettuce, tomatoes and melons. RAS range from small-scale urban aquaculture systems that can be in individual homes, to larger, commercial-scale farms. Raising non-GE fish in RAS would provide a variety of sustainable, locally grown seafood and produce options.

Another option for ecologically sustainable, inexpensive and high-volume seafood production is careful marine shellfish aquaculture, which includes clams, oysters and mussels. Shellfish get their food by filtering microscopic algae and other small particles from water and do not require any added food. In contrast, most finfish aquaculture uses some small, wild fish as feed in order to grow larger fish, a costly and inefficient practice that depletes an important source of protein, as described earlier. Some shellfish farming operations can benefit the surrounding environment by reducing excess nutrients in the water as they feed. Shellfish are a low-input form of seafood production that could occur in many areas globally to inexpensively provide food for local communities.

Conclusion

AquaBounty has heralded that its GE salmon will be effective in meeting the growing global demand for food.[67] Increased production costs, lower nutritional values, higher inputs of small prey fish, questionable growth rates, plus likely negative impacts on wild salmon and the environment all outweigh any benefit offered by GE salmon. AquaBounty is likely to be the largest beneficiary from the introduction of GE salmon into our food system — not hungry people around the world. Better options exist, in the form of non-GE fish produced in closed recirculating aquaculture systems and responsible shellfish aquaculture. These can provide food with lower input levels and higher nutritional values to local populations.

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65 Kaufman, "Frankenfish for Tomorrow's Dinner?" *The Washington Post,* 2000.
66 FDA, VMAC, "Briefing Packet: AquAdvantage Salmon," 115.
67 Dr. Ronald Stotish, President and CEO of AquaBounty, AquaBounty Technologies, Inc. "VMAC Meeting to Consider AquAdvantage Salmon" press release August 25, 2010. Available at http://www.aquabounty.com/investors/press-305.aspx

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