# AquAdvantage salmon

From Wikipedia, the free encyclopedia

**GMO: AquAdvantage salmon** is the trade name for a genetically modified Atlantic salmon developed by AquaBounty Technologies. A growth hormone-regulating gene from a Pacific Chinook salmon and a promoter from an ocean pout were added to the Atlantic's 40,000 genes. These genes enable it to grow year-round instead of only during spring and summer. The purpose of the modifications is to increase the speed at which the fish grows, without affecting its ultimate size or other qualities. Conventional salmon growers publicly challenged the claimed growth rates.[1] The fish grows to market size in 16 to 18 months rather than three years.[2] The latter figure refers to varieties whose growth rate has already been improved by 2:1 as a result of traditional selective breeding.

## Contents



## Aquaculture

*Main article: Aquaculture*

Commercial aquaculture is the most rapidly growing segment of the agricultural industry, accounting for more than 60 million tons in 2012, versus 90 million tons of wild caught fish. That year, aquaculture output exceeded beef output for the first time. While land-based agriculture is increasing between 2% to 3% per year, aquaculture has been growing at an average rate of approximately 9% per year since 1970. As of 2011, Salmon aquaculture produced 1.9 million tons of fish.[3]

## Genetic modification

Genetic modification occurs when incorporated gene construct opAFP-GHc2 is transferred into the Atlantic salmon (Salmo salar) and gene construct OnMTGH1 is transferred into the Coho salmon (Oncorhynchus kisutch)[4][5] These transferred genes allow the genetically modified fish to achieve accelerated growth rates, which confer longer survival and reproductive success.[6]

## Production

AquaAdvantage built a 100-ton/year aquaculture facility in landlocked highlands in Panama, a fraction of the 230,000 ton global output of farmed Atlantic salmon.

## Concerns

Aquaculture that uses conventionally bred salmon, mostly Atlantic salmon, cultivates the fish in net pens. In North America, this occurs mostly in coastal waters off Washington State, British Columbia and Maine. However, the application for FDA approval of AquAdvantage salmon specified land-based tank cultivation with no ocean involvement.[7]

Critics raised concerns about potential environmental impacts if these fish reached rivers or oceans. Modeled

invasion scenarios in semi-natural environments suggest that genetically modified salmon would outcompete wild-type salmon.[8][9][10][11] However, the researcher who developed the "Trojan gene" hypothesis frequently cited by critics of this salmon has discounted this scenario and describes it as an "urban myth".[12]

Whole Foods, Trader Joe's, Aldi, and other grocery stores throughout the country have announced that they would not offer AquAdvantage.[13]

### Survival in new habitats

Wild-Type Atlantic Salmon (*Salmo salar*).

Fish can learn to feed on new prey after leaving hatchery environments. These adaptations could pose a risk if genetically modified salmon were to be released into the wild.[14]

Genetically modified salmon can potentially survive twice as long as wild specimens. The ability of genetically modified salmon to grow faster does not mean they are preferentially preyed upon, and this leads to increased survival. In a competition scenario, such as a release of genetically modified fish from a salmon farm into the wild, the genetically modified salmon could initially outcompete wild-type salmon for food. This success would allow the genetically modified salmon's greater survival.[8][14]

### Rate of growth

Genetically modified fish have the potential to feed more efficiently than wild-type salmon. This leads to an accelerated growth rate during their first year after birth. These fish have the capability to grow eleven times faster than wild-type salmon. This characteristic allows genetically modified salmon to mature more rapidly and gives them the ability to reproduce in less than two years.[6][8] This accelerated maturity implies that genetically modified salmon can reproduce at a much faster rate than wild-type salmon.[6]

### Smoltification

Smoltification is the process of salmon adapting from freshwater to marine water. GM salmon can potentially achieve smoltification in only one year. This could allow genetically modified fish to reach freshwater quicker. The ability to reach freshwater first could allow genetically modified salmon to acces more food with less competition from wild-type salmon.[9]

### Potential benefits

Under simulated models, both prococial parr and anadromous GM male salmon lack reproductive success and have a reduced number of surviving offspring. Additionally, they lack in swimming capabilities as compared to wild-type salmon.[6][9][10][15] AquAdvantage specimens consume more energy when swimming than wild-type salmon. This is most likely due to the type of muscle fibers. GM fish's muscle fibers are smaller in diameter than wild-type salmon. The force a specific muscle can generate is proportional to the diameter of the muscle, and with a smaller muscle diameter, GM salmon produced less force than their wild type counterparts.[15]

GM salmon's lack of fertilization success can be attributed to nest fidelity, quivering frequency, and spawn participation.[9] Under simulated competition environments, 94% of siring occurred by wild-type salmon, while only 5.4% was attributed to genetically modified salmon.[6] This advantage allows more than twice as many wild-type offspring to be produced.[6] Other characteristics that could cause wild-type males to be chosen more frequently could be the lack of growth of the kype, the hooked jaw of a male, and red coloration on anadromous males, which demonstrates sexual maturity to females.

Using *in vitro* analysis, genetically modified salmon's ejaculate was much less concentrated, had a lower sperm count, and decreased sperm velocity, which can decrease GM salmon's fertilization success.[6]

### Potential solutions

AquaBounty proposes to address these concerns by cultivating only sterile females. They claim escapees could not reproduce, either natively or by interbreeding with wild stocks, because they are all triploid, with three sets of chromosomes.[16] They plan to provide farmers with eggs rather than fish.[2] The company proposed that AquaAdvantage fish only be raised in land-based facilities.[17]

## FDA review

The Food and Drug Administration (FDA) has an ongoing review of AquaBounty Technologies application as the first genetically modified animal to enter the United States food supply. The developer submitted its first data set to the FDA in 1996 and has raised 10 generations of the fish.[18]

In September 2010, an FDA advisory panel indicated that the fish is "highly unlikely to cause any significant effects on the environment" and that it is "as safe as food from conventional Atlantic salmon"[19][20] Kathleen Jones of the FDA's Center for Veterinary Medicine said:

> “ In conclusion, all of the data and information we reviewed ... really drive us to the conclusion that AquAdvantage salmon is Atlantic salmon, and food from AquAdvantage salmon is as safe as food from other Atlantic salmon.[21] ”

However the FDA advisory panel also concluded that more research was necessary.[22]

In October 2010, 39 lawmakers asked the FDA to reject the application. Other groups requested that the fish carry a label identifying its transgenic origin.[20] Concerns included alleged flaws in sterilization, isolation and excessive antibiotic use.[18] In 2012, the major shareholder of AquaBounty Technologies said that he doubted that approval would be granted for the AquAdvantage salmon in a US election year.[23]

On 25 December 2012, the FDA published a draft Environmental assessment for Aquadvantage salmon.[24] The FDA also published a preliminary Finding of No Significant Impact.[25] There was to be a 60 day period for the public to comment before the FDA reviewed Aquadvantage salmon again, which was arbitrarily extended until May 2013.[26][27] As of May 2013, the public comment period officially ended. The FDA is now scheduled to finalize its assessment.[13] As of August 2013, no decision had been announced.

## See also

- Genetically modified fish

## Notes

1. ^ Salmobreed 2011.
2. ^ **a b** Blumenthal 2010
3. ^ FAO 2012, p. 21.
4. ^ Higgs et al. 2009, pp. 127-137.
5. ^ Raven et al. 2008, pp. 26-37.
6. ^ **a b c d e f g** Fitzpatrick et al. 2011, pp. 185-191.
7. ^ von Mogel, Karl Haro (24 April 2013). "Interview with Ron Stotish at BIO" (http://www.biofortified.org/2013/04/interview-with-ron-stotish-at-bio/).
8. ^ **a b c** Sundström & Devlin 2010, pp. 447-460.
9. ^ **a b c d** Moreau, Conway & Fleming 2011, pp. 736–748.
10. ^ **a b** Hu & Zhu 2010, pp. 401-408.
11. ^ Ahrens & Devlin 2010, pp. 583-597.
12. ^ Zajac, Andy (November 26, 2010). "Foes of GE salmon raise specter of 'Trojan gene' effect" (http://latimesblogs.latimes.com/greenspace/2010/11/ge-salmon-foes-cite-trojan-gene.html). *Los Angeles Times*.
13. ^ **a b** Ledford 2013.
14. ^ **a b** Sundström et al. 2009, pp. 762-769.
15. ^ **a b** et al. 2003, pp. 753-766.
16. ^ Ron 2010
17. ^ "Is Genetically Modified Salmon Safe?" (http://news.discovery.com/animals/fish-salmon-genetically-modified.htm). Discovery News. February 11, 2013. Retrieved 2013-05-08.
18. ^ **a b** Naik 2010.
19. ^ FDA 2010.
20. ^ **a b** Mundy & Tomson 2010
21. ^ Carollo 2010
22. ^ Hedlund 2012
23. ^ Pollack 2012.
24. ^ FDA December 2012.
25. ^ FDA May 2012.
26. ^ Federal Register 2012.
27. ^ Reardon 2012.

## References


- Ahrens, Robert N. M.; Devlin, Robert H. (2010). "Standing genetic variation and compensatory evolution in transgenic organisms: A growth-enhanced salmon simulation" (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3090570). *Transgenic Research* **20** (3): 583–97. doi:10.1007/s11248-010-9443-0 (http://dx.doi.org/10.1007%2Fs11248-010-9443-0). PMC 3090570 (//www.ncbi.nlm.nih.gov/pmc/articles/PMC3090570). PMID 20878546 (//www.ncbi.nlm.nih.gov/pubmed/20878546).
- Blumenthal, Les (August 2, 2010). "Company says FDA is nearing decision on genetically engineered Atlantic salmon" (http://www.washingtonpost.com/wp-dyn/content/article/2010/0801AR2010080103305.html). *Washington Post*. Retrieved August 2010.
- Carollo, Kim (20 September 2010). "Surprise: FDA Panel Unable to Reach Conclusion on Genetically Modified

Salmon Public Hearing Concludes, No Vote or Recommendation by FDA" (http://abcnews.go.com/Health/WellnessNews/fda-unable-reach-conclusion-genetically-modified-salmon/story?id=11682586). ABC News. Retrieved October 2010.

- Doward, Jamie (September 26, 2010). "GM food battle moves to fish as super-salmon nears US approval" (http://www.guardian.co.uk/environment/2010/sep/26/gm-food-battle-salmon). *The Guardian*. Retrieved October, 2010.
- Fitzpatrick, John L.; Akbarashandiz, Hamid; Sakhrani, Dionne; Biagi, Carlo A.; Pitcher, Trevor E.; Devlin, Robert H. (2011). "Cultured growth hormone transgenic salmon are reproductively out-competed by wild-reared salmon in semi-natural mating arenas". *Aquaculture* **312** (1–4): 185–91. doi:10.1016/j.aquaculture.2010.11.044 (http://dx.doi.org/10.1016%2Fj.aquaculture.2010.11.044).
- Hedlund, Steven (25 May 2012). "Measure requiring GM salmon study rejected" (http://www.seafoodsource.com/newsarticledetail.aspx?id=15870). Seafood Source. Retrieved 3 October 2012.
- Higgs, D.A.; Sutton, J.N.; Kim, H.; Oakes, J.D.; Smith, J.; Biagi, C.; Rowshandeli, M.; Devlin, R.H. (2009). "Influence of dietary concentrations of protein, lipid and carbohydrate on growth, protein and energy utilization, body composition, and plasma titres of growth hormone and insulin-like growth factor-1 in non-transgenic and growth hormone transgenic coho salmon, *Oncorhynchus kisutch* (Walbaum)". *Aquaculture* **286** (1–2): 127–37. doi:10.1016/j.aquaculture.2008.08.036 (http://dx.doi.org/10.1016%2Fj.aquaculture.2008.08.036).
- Ledford, Heidi (2013). "Transgenic salmon nears approval". *Nature* **497** (7447): 17–8. doi:10.1038/497017a (http://dx.doi.org/10.1038%2F497017a). PMID 23636372 (//www.ncbi.nlm.nih.gov/pubmed/23636372).
- Lee, C. G.; Devlin, R. H.; Farrell, A. P. (2003). "Swimming performance, oxygen consumption and excess post-exercise oxygen consumption in adult transgenic and ocean-ranched coho salmon". *Journal of Fish Biology* **62** (4): 753–66. doi:10.1046/j.1095-8649.2003.00057.x (http://dx.doi.org/10.1046%2Fj.1095-8649.2003.00057.x).
- Moreau, Darek T. R.; Conway, Corinne; Fleming, Ian A. (2011). "Reproductive performance of alternative male phenotypes of growth hormone transgenic Atlantic salmon (*Salmo salar*)" (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3352541). *Evolutionary Applications* **4** (6): 736–48. doi:10.1111/j.1752-4571.2011.00196.x (http://dx.doi.org/10.1111%2Fj.1752-4571.2011.00196.x). PMC 3352541 (//www.ncbi.nlm.nih.gov/pmc/articles/PMC3352541).
- Mundy, Alicia; Tomson, Bill (1 October 2010). "Industry Fights Altered Salmon" (http://online.wsj.com/article/SB10001424052748704789404575524313700416460.html?mod=googlenews_wsj). *Wall Street Journal*. Retrieved September, 2010.
- Naik, Gautam (September 21, 2010). "Gene-Altered Fish Closer to Approval" (http://online.wsj.com/article/SB10001424052748703989304575503891676987232.html). *Wall Street Journal*.
- Pollack, Andrew (21 May 2012). "An Entrepreneur Bankrolls a Genetically Engineered Salmon" (http://www.nytimes.com/2012/05/22/business/kakha-bendukidze-holds-fate-of-gene-engineered-salmon.html?pagewanted=all). *The New York Times*. Retrieved 3 October 2012.
- Raven, P.A.; Uh, M.; Sakhrani, D.; Beckman, B.R.; Cooper, K.; Pinter, J.; Leder, E.H.; Silverstein, J. et al. (2008). "Endocrine effects of growth hormone overexpression in transgenic coho salmon". *General and Comparative Endocrinology* **159** (1): 26–37. doi:10.1016/j.ygcen.2008.07.011 (http://dx.doi.org/10.1016%2Fj.ygcen.2008.07.011). PMID 18713628 (//www.ncbi.nlm.nih.gov/pubmed/18713628). `|displayauthors=` suggested (help)
- Reardon, Sarah (28 December 2012). "Approval for gene-modified salmon spawns controversy" (http://www.newscientist.com/article/dn23035-approval-for-genemodified-salmon-spawns-controversy.html). *New Scientist*. Retrieved 2 January 2013.
- Ron, Benny (November 23, 2010). "Genetically Engineered Salmon Eggs Designed to Grow on Land" (http://www.aquaculturehub.org/profiles/blogs/genetically-engineered-salmon). Retrieved November, 2010.
- Sundström, L. Fredrik; Devlin, Robert H. (2010). "Increased intrinsic growth rate is advantageous even under ecologically stressful conditions in coho salmon (*Oncorhynchus kisutch*)". *Evolutionary Ecology* **25** (2): 447–60. doi:10.1007/s10682-010-9406-1 (http://dx.doi.org/10.1007%2Fs10682-010-9406-1).
- Sundström, L. Fredrik; Tymchuk, Wendy E.; Lõhmus, Mare; Devlin, Robert H. (2009). "Sustained predation effects of hatchery-reared transgenic coho salmon *Oncorhynchus kisutch* in semi-natural environments". *Journal of Applied Ecology* **46** (4): 762–9. doi:10.1111/j.1365-2664.2009.01668.x (http://dx.doi.org/10.1111%2Fj.1365-2664.2009.01668.x).
- Hu, Wei; Zhu, Zuoyan (2010). "Integration mechanisms of transgenes and population fitness of GH transgenic fish". *Science China Life Sciences* **53** (4): 401–8. doi:10.1007/s11427-010-0088-2 (http://dx.doi.org/10.1007%2Fs11427-010-0088-2). PMID 20596905 (//www.ncbi.nlm.nih.gov/pubmed/20596905).
- "Briefing Packet: AquAdvantage Salmon" (http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/VeterinaryMedicineAdvisoryCommittee/UCM224762.pdf). Food and Drug Administration Center for Veterinary Medicine. 20 September 2010.
- "Draft Environmental Assessment and Preliminary Finding of No Significant Impact Concerning a Genetically Engineered Atlantic Salmon" (http://www.gpo.gov/fdsys/pkg/FR-2012-12-26/pdf/2012-31118.pdf) **77** (247). Federal Register. 26 December 2012. Retrieved 2 January 2013.
- "Environmental Assessment for AquAdvantage Salmon" (http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/VeterinaryMedicineAdvisoryCommittee/UCM224760.pdf). United States Food

and Drug Administration. 25 December 2012. Retrieved 2 January 2013.
- "Preliminary Finding of No Significant Impact AquAdvantage Salmon" (http://www.fda.gov/downloads/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/UCM333105.pdf). United States Food and Drug Administration Department of Health and Human Services. 4 May 2012. Retrieved 2 January 2013.
- "Salmobreed challenges GMO Salmon" (http://www.salmobreed.no/newsletters/en/newsletter_5_2011.pdf) (Press release). Salmobreed. November 2011. Retrieved 2013-01-18.
- FAO (2012). "THE STATE OF WORLD FISHERIES AND AQUACULTURE" (http://www.fao.org/docrep/016/i2727e/i2727e.pdf) (PDF). FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Retrieved 2013/08/22.

## External links

- AquAdvantage (http://www.aquabounty.com/products/aquadvantage-295.aspx)
- Obama administration 'bailed out' GM salmon firm (http://www.guardian.co.uk/environment/2011/oct/18/gm-salmon-aquabounty) *The Guardian*, 18 October 2011.