



An Interactive Simulation

Frankenfish or Superfood?

Soc Gen 108

Tiffany Chen, Eghosa Ogbeide, Clara Song,
Ruby Tang, Jaqueline Villa-Casarrubias

What is the Controversy?

In this interactive simulation, we will explore the controversy regarding the **sale of the first genetically modified (GM) salmon (AquAdvantage)** that was FDA approved in 2015 and marked safe for **consumption**.

The Case for Superfood

These fish grow twice as fast as wild salmon. Despite being genetically modified, they are considered biologically identical to wild salmon. They have great potential to help combat food insecurity because they can be sold at lower cost.

The Case for Frankenfish

However, these fish are transgenic (contain foreign genetic material), so their effect on the environment and human body is poorly understood. Furthermore, their existence is rooted in the corporatization and colonization of an animal sacred to indigenous people.

CONTINUE

Who Created the GM Salmon?

AquaBounty is a biotechnology company founded in 1991. Their ultimate vision is to create a “**fresh, affordable Atlantic salmon** that’s ready to feed – and change – the world”.

CONTINUE



“A Better Way to Raise Atlantic Salmon.”



Instructions

Throughout this interactive simulation, you will explore the world from the **perspective of a salmon**. You will start off as an egg, and grow into an adult salmon. This will comprise **five different stages**: roe, development, identity formation, maturation, and fate.

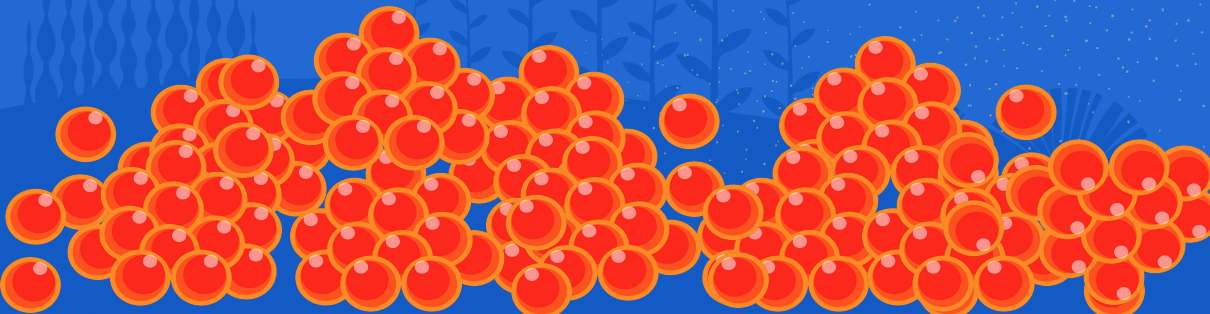
While growing up, you will face questions about your identity – do you want to end up as a **wild salmon or a genetically modified (GM) salmon**? What are the biological, social, legal, ethical, cultural, and economic implications of your decision?

Throughout the simulation, you will be able to click to continue your journey and think about your final fate!

CONTINUE

Stage 1

Egg (Roe)



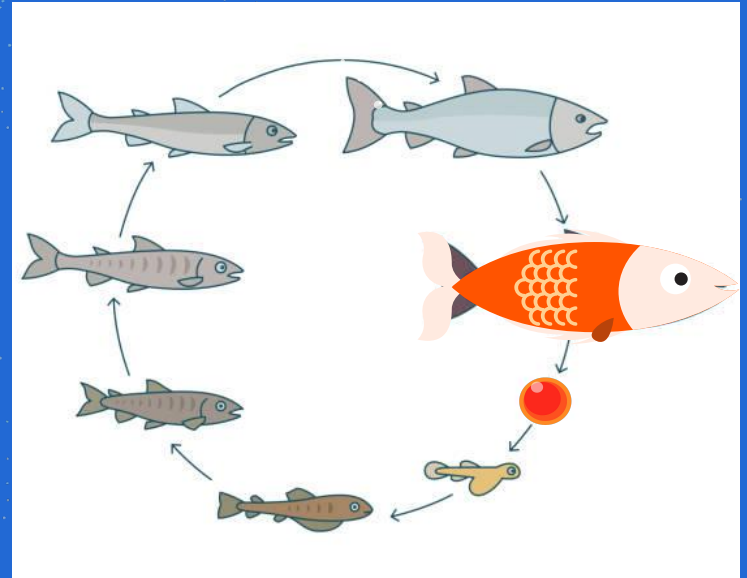
CONTINUE

Why Am I Important to Humans?

When I develop into a full grown salmon:

- I am a source of healthy protein for many humans!
- I contain **high levels of omega-3 fatty acids!**
 - This helps people **reduce coronary heart issues**
 - Having one serving of me per week can help **reduce heart related deaths by 36%**
(Smith et. al., 2010)

I am also very **symbolic to indigenous communities** and I am used for sacred rituals!



CONTINUE

An underwater scene with a blue background. In the upper half, there are several cartoon salmon swimming. In the lower half, there are several green cartoon fish with grumpy expressions. The background is decorated with stylized seaweed and coral. The text "Stage 2 Development" is centered in the middle.

Stage 2 Development

Now, since you have learned about the basics of your identity as a salmon, you will now be faced with important questions regarding your growth and development.

[CONTINUE](#)

Where Do You Want to Live?



Wildlife

Click on the following to learn more about the **benefits** of being a wild salmon!

Lack of Farming
Pollutants



Environmental
Contributions



CONTINUE



BACK

Lack of Farming Pollutants

Wild salmon often get to avoid many of the common pollutants affecting farmed and GM salmon, such as . . .

Pesticides



Food Waste



Antibiotics



Feces



Environmental Contributions

Wild salmon make numerous contributions towards supporting their surrounding environment, such as by . . .

Supporting Natural Ecosystems

- Acting as keystone species to support different energy chains
- Supporting plants and other organisms through release of nitrogen



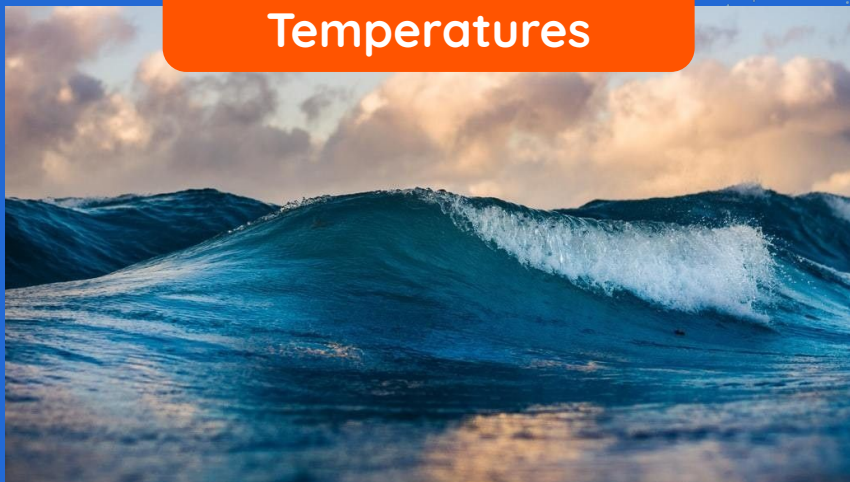
Keeping Water Clean

- Essential part of maintaining stream flow
- By digging nests (redds), salmon help flush debris downstream to cleanse rivers and water sources

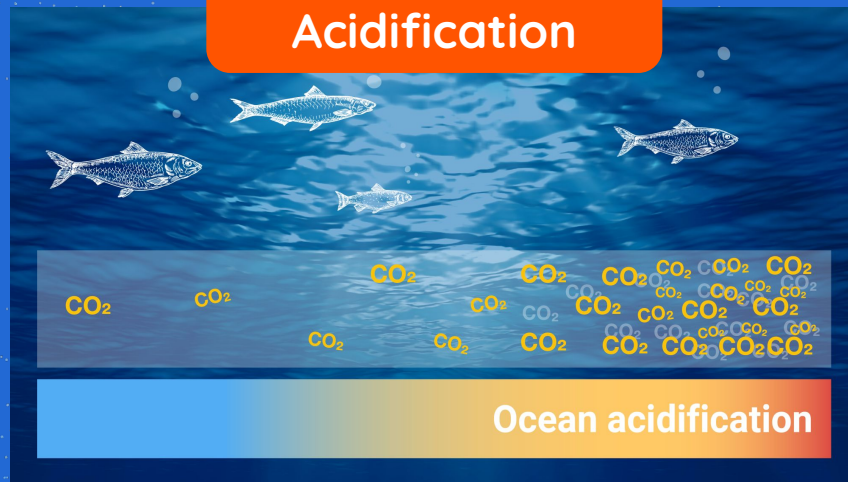
Wildlife

Click on the following to learn more about the **dangers** faced by wild salmon!

Increased Water
Temperatures



Ocean
Acidification



CONTINUE

BACK

Increased Water Temperatures



Increased vulnerability to disease:
higher risk of being infected by
pathogens, leading to weakened
survival skills



Decreased ability to avoid predators
due to warmer waters slowing down
swimming speed of juvenile
salmonids

BACK

Ocean Acidification



Increase of toxins can impact embryonic development and lead to mortality and morphological abnormalities



Disruption of habitats can lead to reduction in available food and resources



Aquaculture

As a GM salmon, you will develop from an egg originally engineered at a facility on Prince Edward Island, Canada.



CONTINUE

What type of environment will I live in?

The containment facility at AquAdvantage has a high level of security.



Water Recirculation

The vast majority of water is recirculated, reducing discharge into the wild and subsequently the ability of a GM salmon to escape.



Physical Security

All buildings are locked and have a large number of cameras and sensors to monitor activity.



SOPs and Inspection

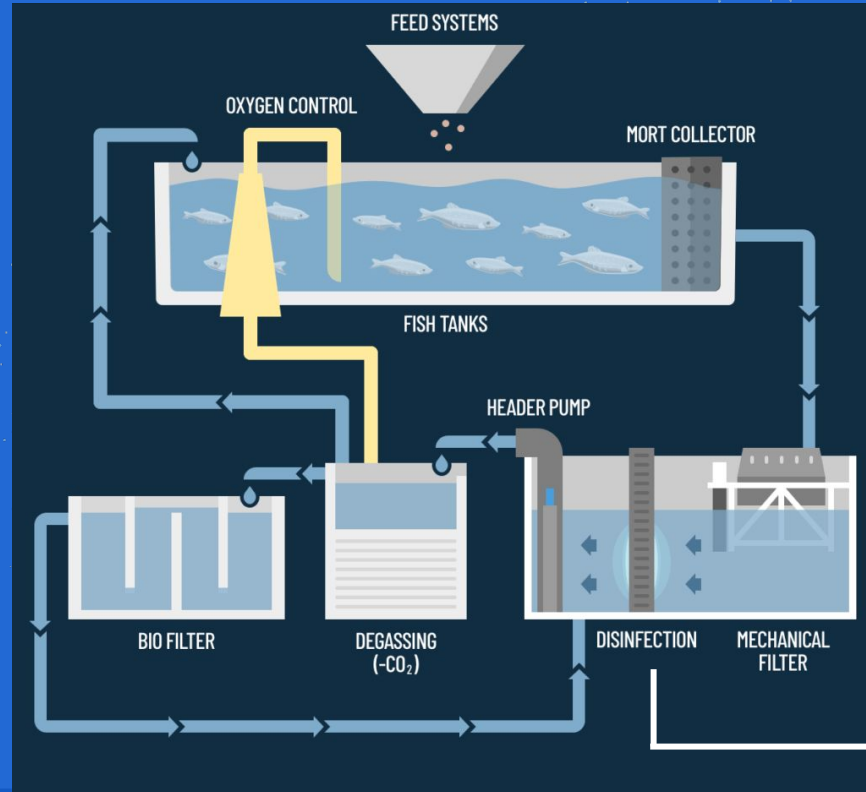
Employees are trained to respond to emergency fish escapement and facilities are constantly inspected.

[CONTINUE](#)

BACK

Water Recirculation

Recirculating Aquaculture Systems (RAS) used to raise GM salmon are designed to recirculate 99.7% of water



Fish farming technology company **Innovasea** will design the new RAS for AquaBounty's newest facility in Ohio

UV light and **ozone treatment** are used as disinfectant

BACK

Physical Security

Nets, screens, filters, tanks, and covers prevent unwanted escape



Lethal chemical (ex. chlorine pucks) and **temperature** conditions prevent escape



Cameras and sensors are checked 24/7 and **alarms** notify staff immediately



SOPs and Inspection

- 1 Ensure **only authorized personnel** are allowed to access and move throughout the facility
- 2 **Prevent potential predators** who could carry AquAdvantage salmon off-site from accessing the facility
- 3 Create **contingency plan** including backup measures in the event of an escapement
- 4 Thoroughly **train all employees and staff** and periodically conduct internal review
- 5 Outline **procedures** for cleaning, disinfection, equipment handling, and more

What are some of the most important factors affecting my health?



Food and Water Quality

Sufficient water filtration and nutrition of feed are needed to mitigate stress



Disease Monitoring

Fish should be regularly monitored for disease and quarantined if needed.



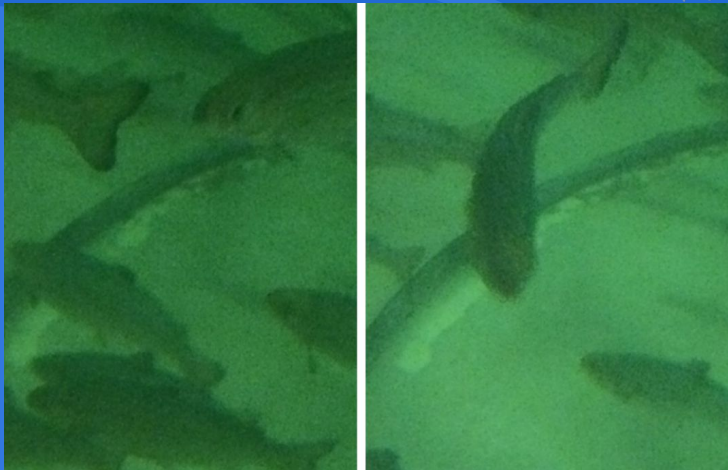
Regular Cleaning

Facilities should be kept clean and hygienic, and overcrowding should be avoided.

[CONTINUE](#)

Should I be worried about these conditions?

A recent report exposing AquaBounty for poor containment conditions was released by #BlockCorporateSalmon, a BIPOC-led campaign to protect wild salmon.



Fiberglass particles are present in fish tanks and could be an irritant for fish eyes, gills, and skin



High iron levels in well water used for feed could disrupt development of younger fish

[CONTINUE](#)

What is preventing me from escaping?

A recent bipartisan bill (HR 273) has been introduced by Rep. Young (R-AK-At-Large), Rep. Bonamici (D-OR-1), and Rep. DeFazio (D-OR- is 4) to prevent escapement of GM salmon.

- 1 GM salmon are not to be sold, transported, grown in a net-pen, or released into a natural environment.
- 2 Exception can be made if the fish are confined for research or if the Under Secretary of Commerce for Oceans and Atmosphere and the Director of the United States Fish and Wildlife Service review it first.
- 3 Enforcement will be done based on the 1976 Magnuson-Stevens Fishery Conservation and Management.

CONTINUE

From egg to alevin to now

Now that you know more about the type of environment you'd live in as a wild vs GM salmon, please select the type of fish you'd like to continue your journey with.

Genetically
Modified
Salmon

Here in this journey, you'll be able to select traits that will enhance your journey

Natural Wild
Salmon

Here in this journey, you'll continue the natural life of a wild salmon



Who am I?

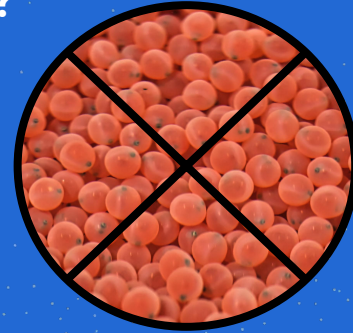


Click on the icon that you would like to enhance your journey!

Now that you're a genetically modified fish, what features would you like to enhance your journey?



Growth hormone gene for you to develop and mature at a much faster rate



Sterilization to roam free without the worries of becoming an invasive species in a new environment or interrupting the genetic makeup of that population

*Note that these are not the only features that make a salmon genetically modified, but for the purpose of our project we will be only covering these two features

CONTINUE

Growth Hormone

- Wow look at how big you've grown! With this growth hormone enhancer gene you'll not only **grow and develop at a faster rate** than all the salmon in the school, but you'll also be the biggest salmon and talk of the stream!
- Development for a typical salmon to reach full adulthood takes **18 months**, however using a targeted hormone gene to genetically cross and recombine with an alternate phenotypic expression, **growth and development rate will accelerate at a quicker time**
- Research studies have inserted transgenes where Atlantic salmon can obtain the growth features of ocean pouts that speed up development and maturation **without alternating their physical appearance** (Du et al., 1992)

Explore other features

I'll drop the workout regimine plus the recipes in my Fish Tok (;

Woah Sal looks good! They're definitely going to make it to NFL Draft!

Woah Sal looks good! I wonder if they got a Brazilian Fish Lift?

Woah I want to be like Sal when I grow up!



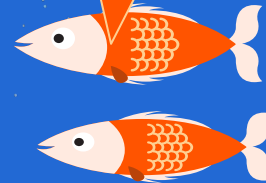
Sterilization

Explore other features

Why take a plan B? When you can be Plan Free! As a GM salmon you'll be able to not have to worry about spreading your seed across the streams! No worrying about disrupting the gene flow of mixed salmon populations or if that alevin is yours!

- Through **gynogenesis and triploid techniques** we can target your egg to sterilize you via chromosome duplication or develop an all-female line that will not result in reproduction of future generations
- Research has shown the great success of each technique in **mitigating any disruption in the ecology and environment** of salmon populations (Refstie et al., 1982)
- **Warning:** Side effects may include shorter survival and developmental rates and high mortality rate, and possible baby fever amidst your wild salmon friends

In the case of Salomon vs Salena, Salomon you are NOT the father!



WOOO
HOO!
YESS




Who am I?

- Now that you've chosen a life as a wild salmon, you will continue on your journey moving through streams and jumping through rapids to age and grow into the adult salmon you will become
- You'll develop a sense of persistence and perseverance as you develop at a longer rate than GM salmon, but your tenacity and willpower will be celebrated even amongst the visitors that enter your habitat



CONTINUE

The background is a vibrant blue underwater scene. It features several green fish with square heads and sad expressions, some with visible stitches. There are also orange and white striped fish. The scene is decorated with stylized coral, seaweed, and bubbles. The text is centered in the upper half of the image.

Stage 3 Identity Formation

Now that you are growing up, you will learn more complex questions regarding wildlife vs. GM salmon.

[CONTINUE](#)

What do I do in an escapement?

A huge storm has just weakened the structural integrity of a land-based aquaculture facility, resulting in a huge escapement of GM salmon! Whose perspective would you like to see?



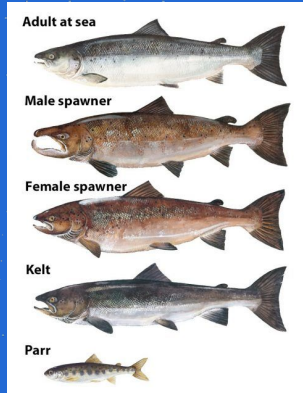
Escapement into the Wild

Click any of the following to learn more about the ability of wild and GM salmon to survive and reproduce (otherwise known as “fitness”) in the wild!

Surrounding
Habitat



Fecundity



Foraging Ability



DONE

Surrounding Habitat

- The water surrounding the Prince Edward Island facility is **saltwater**
- As Atlantic salmon are anadromous (live in freshwater and reproduce in saltwater), they cannot survive in saltwater until they undergo **smoltification**, involving:
 - Body shape modification
 - Increased reflectance
 - Increased ability for osmoregulation

If you are a wild salmon, you would only encounter GM salmon in the wild if they were mature. Either way, your survival is likely not at stake.

If you are a GM salmon, you would die unless you have already undergone smoltification.

Fecundity

Ploidy of GM Salmon



● Triploid

● Diploid

- **Fecundity**, or the ability of an offspring to reproduce, is prohibited by triploidy
- ~95% of GM salmon are **triploid and sterile** (abnormal chromosome number) following pressure shocking
- ~5% are **diploid and capable of natural reproduction**

If you are a wild salmon, you are diploid and can reproduce with other wild salmon but most likely not with GM salmon.

If you are a GM salmon, there is a 5% chance you could reproduce with wild salmon.

Foraging Ability

- GM salmon typically exhibit greater foraging ability than wild salmon
- However, they are more likely to exhibit riskier behavior, such as foraging despite the presence of predators



If you are a wild salmon, you might not be able to forage as well, but you'd have a stronger natural instinct for predator avoidance

If you are a GM salmon, you might be a good forager, but this could also get you killed!

Let's assume GM salmon became established in the wild. What now?

Please click on all of the following and click on "done" when you have finished exploring.

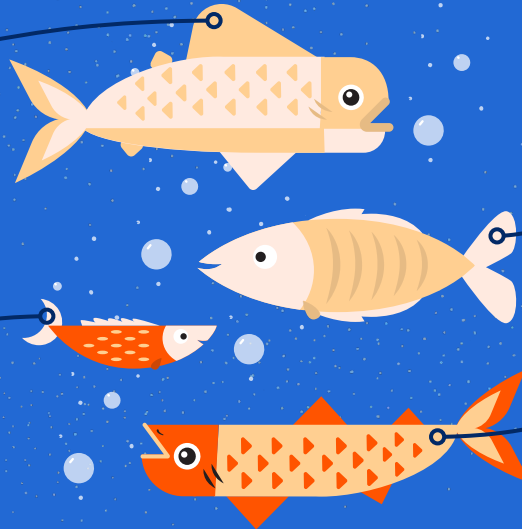
Reproduction
with Wild
Salmon

Secondary
Toxicity

Competition
with Native
Species

Disease
Transmission

DONE



Reproduction with Wild Salmon

- Transgene spread can occur **vertically** (sexual transfer of genetic information), with natural selection following shortly after.
- As GM salmon generally have diminished fitness compared to wild salmon, they could introduce deleterious modifications into the wildlife gene pool.



Poor swimming performance

Due to lack of need for strong swimming in captivity, GM salmon often do not swim as well as wild salmon.



Decreased predator avoidance

GM salmon tend to swim closer to the surface, exposing them to predation threats.



More rapid development

As GM salmon develop more rapidly than wild salmon, they also emerge and become susceptible to predation earlier.

[BACK](#)

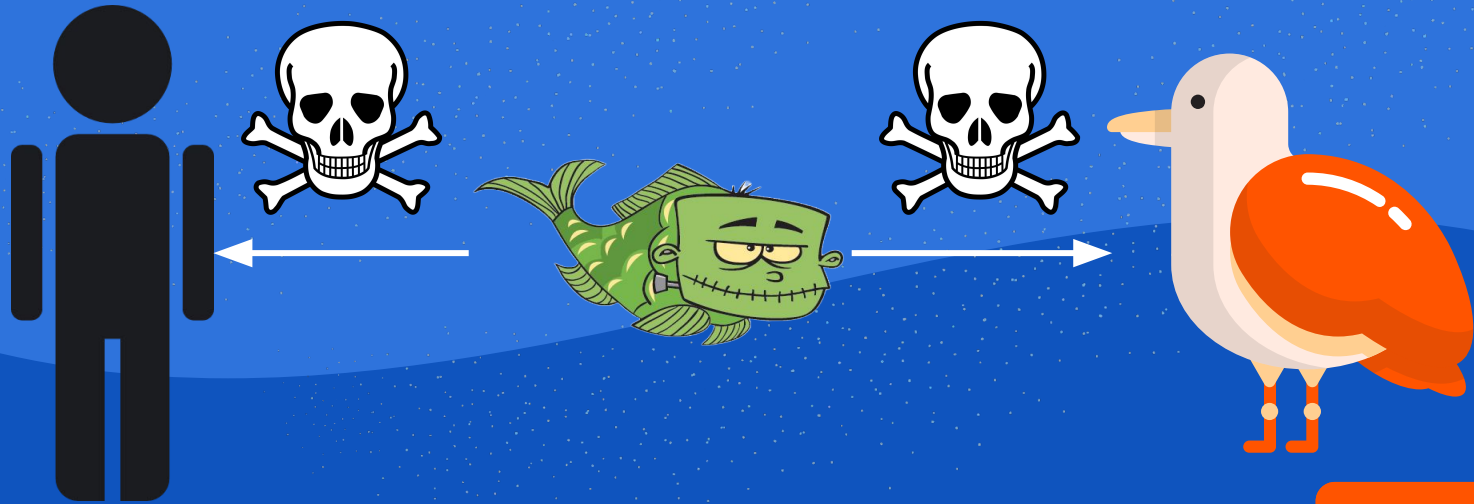
Competition with Native Species

- Once escaped, GM salmon can increase the competition for limited resources and food.
- A transgene could . . .
 - **Increase the range of environmental conditions the GM salmon can survive in.** This could allow establishment in environments in which salmon are not normally found.
 - **Enhance growth and nutrient use efficiency.** This could allow salmon to better survive and proliferate than wild salmon.
- Establishment of GM salmon in a non-native environment could have downstream effects on predation and resource competition for both conspecifics and other species.

BACK

Secondary Toxicity

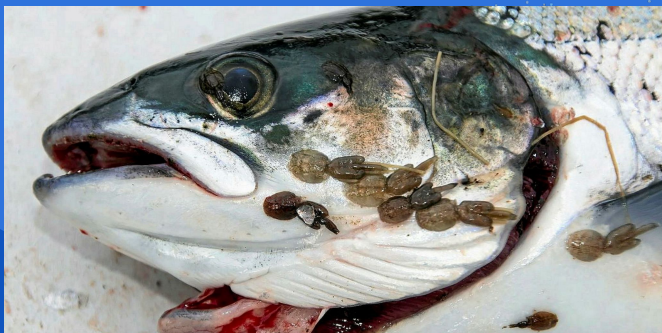
Consumption of salmon with modified gene sequences could be hazardous to humans or animals (such as birds and other wildlife). These salmon could potentially have also acquired toxic agents while in their containment facility.



BACK

Disease Transmission

As aquatic organisms, GM salmon have great dispersal ability. As a result, they also have great propensity for disease transmission. The following are some of the most common diseases and parasites found in Atlantic salmon.



Sea lice infestation



Red skin disease



Salmon Rickettsial Disease

[BACK](#)

How does the process of genetically modifying salmon work in aquaculture?

Click on each process to learn more about them!

Transgene Insertion

Transgene insertion and production occur when one inserts an exogenous or artificial gene into the targeted organisms genome via the DNA nuclei of the cell

Gynogenesis

A process in which the embryo genome originates exclusively from female origin, following embryogenesis stimulation by a male gamete (Portemer et al., 2015)

Triploidy

Sterile fish that have three sets of chromosomes, unlike fertile fish with two chromosomes

CONTINUE

BACK

Transgenic Fish

- In this brief video, we explore the process of transgenic zebrafish that illuminate different fluorescent colors based on select genes, that provides a great understanding of **how transgene insertion works**.
- Although zebrafish are significantly smaller than salmon, this clip provides how this process of insertion in aquatic animals can be done!



LEARN MORE

Transgenic Salmon in Research

- Several studies have shown that this **process of inserting transgenes** into Atlantic salmon and other salminoids have been **successful**
- In one study researchers injected antifreeze protein gene promoters from ocean pouts into chinook salmon. As a result the amount of growth hormones in these new transgenic salmon were significantly greater than their control group of non transgenic salmon. (Du et al., 1992)
 - Furthermore, these salmon developed at a faster rate than the traditional salmon, as their **growth rate within the year was up to 6 times greater** than the non-transgenic salmon

Transgenic Salmon in Research

- In a comparative analysis of wild type salmon and transgenic coho salmon, researchers explored and investigated the influence of a growth hormone transgene in the two groups (Kodama et al., 2018)
 - As both fish shared identical parental genetic background, researchers were able to identify whether it's the same loci or different loci that influences the phenotypic behavior of the wildtype and transgenic coho salmon.
 - From the sequencing and genetic mapping of each fish, researchers noted significant genetic alterations in the transgenic coho salmon that were associated with its phenotypic behavior

Gynogenesis

- **Gynogenesis** is a form of asexual reproduction that can be used to either produce pure lines or **all female populations** where the genetic makeup is solely from the female parent (Donaldson & Devlin, 1996)
- In an experiment researchers wanted to determine the possibility of producing all sterile female using gynogenesis techniques in coho salmon (Refstie et al., 1982)
- **Results:** They successfully produced all sterile female in their experimental groups; however, the **diploid gynogenetic fish had a slower growth rate and higher mortality rate** than the controlled group of coho salmon

BACK

Triploid Fish

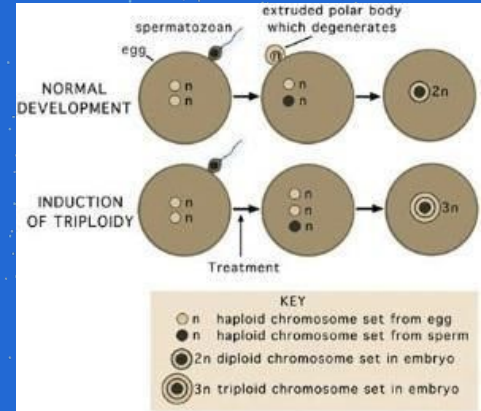
- In this brief video, we learn the process of creating **triploid fish** (trout)
- Triploid fish are **NOT genetically modified** as there is no insertion or crossing of genes but rather the **manipulation of chromosomes** in the egg cells of these fish
- Triploid fish are generated for aquaculture and containment to **protect biodiversity** in native habitats



LEARN MORE

Triploidy Fish (cont'd)

- Much research and work developing these triploid fish has been used for GM salmon
- In one study, triploid progeny were produced in Atlantic salmon using **moderate thermal shocks after fertilization** (Quillet & Gaignon, 1990)
 - Gynogenetic yields were high, and all **triploid groups had high survival and development rates, but were lower than control groups** wild salmon
- In addition, the use of triploid fish have been used to help **minimize the negative effects of genetic interactions and shifts** between wild salmon and escaped farmed salmon (Cotter et al., 2000)



How are GMO fish identified?

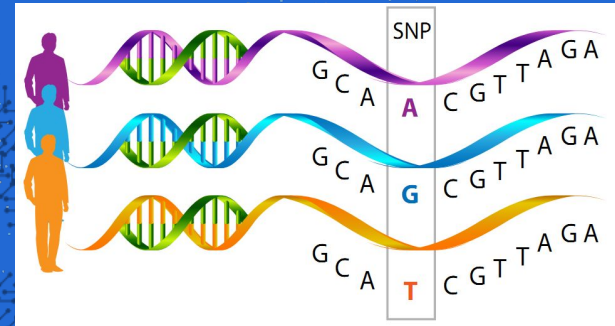
Trait identification via gene chip

A gene chip is a genomic tool that speeds up the identification of fish, or other sea creatures, that carry desired traits. Some of these include increased growth rates or resistance to disease and parasites.



SNP identification

A single nucleotide polymorphism (SNP) is a genomic variant at a single base position in DNA. SNP arrays are a type of microarray that can detect single base changes.



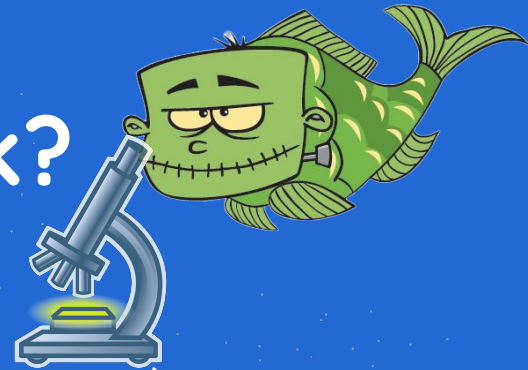
CONTINUE

Wait, So, How Does it Work?

Okay here's how SNP array identification may work:

1. Find a sibling
2. Take a small tissue sample - such as a fin clipping (ouch, sorry!)
3. Puree and analyze it
4. Use SNP array assessment evaluate for desired traits
5. If optimal alleles are found, it can be selected for further breeding (lucky you?)

SNP arrays are routinely used to genotype rainbow trout and Atlantic salmon. However, genomic selection through these tools is quite expensive, so it will mostly be used to identify traits of high economic value.



CONTINUE

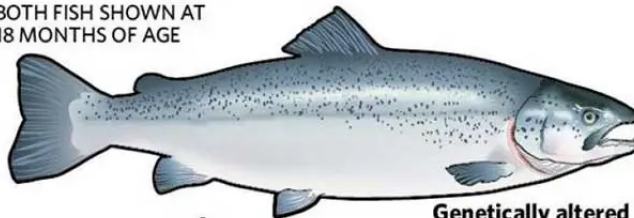
New “family” of salmon?

By using these techniques, in November 2015, **AquaAdvantage** became the **first FDA approved transgenic animal “safe for consumption”**

Scientists at AquaBounty Technologies combined Atlantic salmon, Pacific Chinook Salmon, and ocean pout to create me so that I am bigger & faster to grow!



BOTH FISH SHOWN AT
18 MONTHS OF AGE




Genetically altered
Length: 24 in. (61 cm)
Weight: 6.6 lb (3.0 kg)



Normal DNA
Length: 13 in. (33 cm)
Weight: 2.8 lb (1.3 kg)



CONTINUE

The background is a deep blue gradient representing an underwater environment. It features several stylized salmon swimming in various directions. There are also white bubbles of different sizes scattered throughout. On the right side, there are silhouettes of seaweed and coral. In the bottom right corner, there is a bright orange button with the word 'CONTINUE' in white capital letters.

Stage 4

Maturation

Since you are now a mature salmon, you will be faced with philosophical questions to think about for your final fate– GM salmon or Wild Salmon– in terms of what you symbolize to consumers

CONTINUE

What do I mean to consumers as a wild salmon?

Sustainability and
Nutrition



Transparency and
Social Responsibility



CONTINUE

BACK

Sustainability and Nutrition

For many, consuming wild salmon is a practice of **sustainability** and **environmental conscientiousness**



Many people are for consuming wild salmon, because of its **natural nutritional benefits** and also for those that enjoy the sport of fishing and its delicious payoff after a day's reel



BACK

Transparency and Social Responsibility

- In a New York Times article, **more than 75%** of pollers said that they **would not eat GM salmon**
- Many retail grocery stores and restaurant chains have **refused to sell or serve GM salmon** to customers along the lines of **sustainability and staying transparent** to build and retain that customer base and relationships
- There's a common thread of **social responsibility** in many of these companies mission statements that unveil the role of sustainability



What do I mean to consumers as a GM salmon?

- One of the common themes and threads of quantitative market research when it comes to genetically modified foods is the **lack of transparency or knowledge** that produces **skepticism** amongst consumers
- Click [here](#) to learn more about these common threads in GM Market Research!

An underwater scene with three orange and white fish swimming towards the right. There are blue coral-like plants on the left and right sides, and small white bubbles floating in the water. The background is a dark blue gradient with a pattern of small white dots.

CONTINUE

GM Market Research

- In a quantitative study, researchers surveyed participants asking questions about the **labeling of GM salmon** as well as the **likelihood of them purchasing the product**
 - People who were not informed about GM salmon are more likely to pay market price for organic, natural salmon. Those that were informed and received information about the GM salmon were more likely to purchase it at its value (Weir et al., 2021)
- Even in developing countries like Malaysia, research has shown many people are **concerned about this biotechnology** and have a greater bias towards nature and natural living things (Amin et al., 2014)
- Many argue the **“playing God”** trope as a sense of hostility and apprehensiveness, challenging the laws of nature

CONTINUE

Are GM salmon safe to eat?

The FDA “determined that AquAdvantage Salmon meets the statutory requirements for safety and effectiveness”

Critiques emphasize that the FDA **did not perform intensive long-term research** on human health when approving AquAdvantage safe for consumption

With the consumption from any GM foods, there is always a risk of:

- Allergies:** Transgenic techniques can cause new expression of proteins that can cause an allergic reaction (Watson et. al, 2016)
- Adverse health effects** (ie, mortality, tumor formation, cancer, low fertility, organ abnormalities) (Shen et. al, 2022)
- Transfer of **antibiotic resistance** (Bawa et. al., 2012)



CONTINUE

Why are GM salmon back under review?

2015-2020

A coalition consisting of environmental justice, food safety, and fishing groups filed a lawsuit against the FDA, citing lack of evaluation for environmental consequences of AquAdvantage salmon

2020

US District Court of Northern California judge ruled that the FDA must conduct further environmental assessment of the salmon to evaluate what would happen if it were to establish itself in the wild.

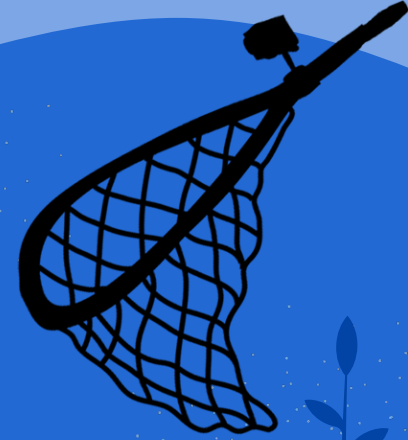
2022

FDA released a draft environmental assessment and held a public meeting in December 2022



Stage 5

Fate



In your last and final fate, you will be faced with social and cultural issues, where you will finally decide whether to choose to be a wild salmon or GM salmon

A stylized illustration of a campfire with orange and yellow flames. The fire is set on a dark blue base with orange coral-like shapes. The background is dark blue with faint silhouettes of seaweed and plants.

CONTINUE

How do You Want to Sacrifice your Life?

Now that you have learned about wild vs. GM salmon, choose how you want to sacrifice your life.

Native Ritual
(Wild Salmon)



Help Fight Food
Insecurity
(GM Salmon)



Help Fight Food Insecurity!

900 million people

Undernourished in 2013 (Qaim et. al, 2013)

GM Salmon could:

1. Improve availability & accessibility of salmon due to faster growing stage and affordable pricing (Qaim et. al, 2013)
 - a. In the long-run, this can help reduce coronary heart issues on a global scale (Smith et. al, 2010)
2. Influence food safety and quality



CONTINUE

GM Salmon: Fast Food?

Since **GM salmon is cheaper and faster to develop** compared to wild salmon, you are being sold to a fast food company due to your cheap cost when bought in bulk.

Therefore, you'll most likely be in a \$2 fish sandwich

Now since you have learned about both perspectives from a GM salmon and Wild Salmon, do you want to end your fate or learn about native rituals?



Click here to be sold
to a fast food
restaurant as a GM
Salmon

Click Here to Learn
about Native Rituals
as a Wild Salmon

****Note: this is not the only way GM salmon can be used. For the purposes of our project, we chose fast food****

You Are at a Native American Ritual!

What your life will look like here:

Salmon is a very important part of Native American and Indigenous communities' spiritual and cultural identity, as they consider it a gift from their Creator.

Common practices include yearly special ceremonies and traditional salmon fishing.



[Click here to learn more about specific native tribes!](#)

What you symbolize:

Fertility
Renewal
Prosperity



“We need the salmon for our survival as a distinct people. It is so connected into our lives that if the salmon disappear, so will we.”

Tribal Relationships to Salmon

The Tlingit



The Ahtna



The Central Yup'ik



Click on the fish
to see where
you are!



CONTINUE

The Tlingit

- Occupants of the NW shores and islands of N. America from the Bering River to Dixon entrance
- Salmon stream ownership one of the most important forms of property
- Respect for salmon shown through: crying out a **greeting** when fish jump out of the water, **singing** and **dancing** for them as they enter streams, **carefully handling** them when harvesting, and **releasing their spirit** so they can return to their underwater and be reborn.



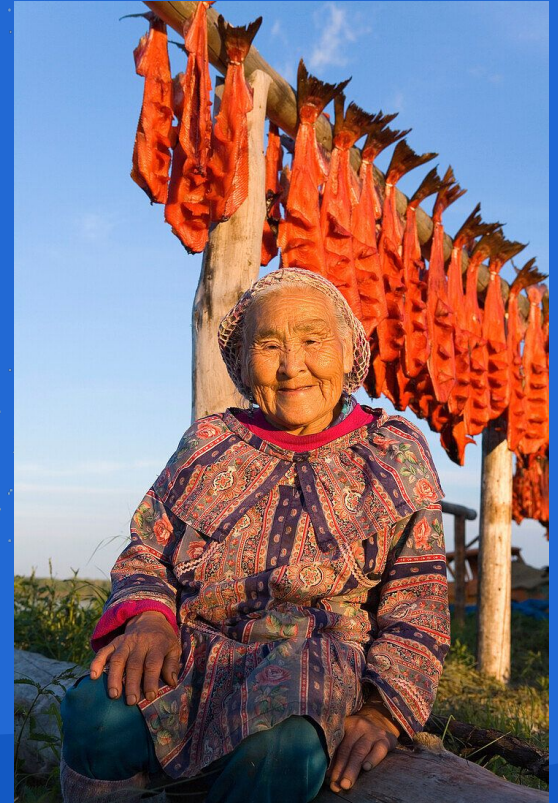
The Ahtna

- Live in the Copper River valley above Miles Lake and in the upper Susitna valley to the West
- View animals and fish as spiritual forms who gave/give themselves to humans, are controlled by powerful spiritual being, and with whom relations are governed by rules called “engii,” symbolizing power
- Wear **special clothing** as they perform welcome **songs** and **dances** during the arrival of salmon each year.

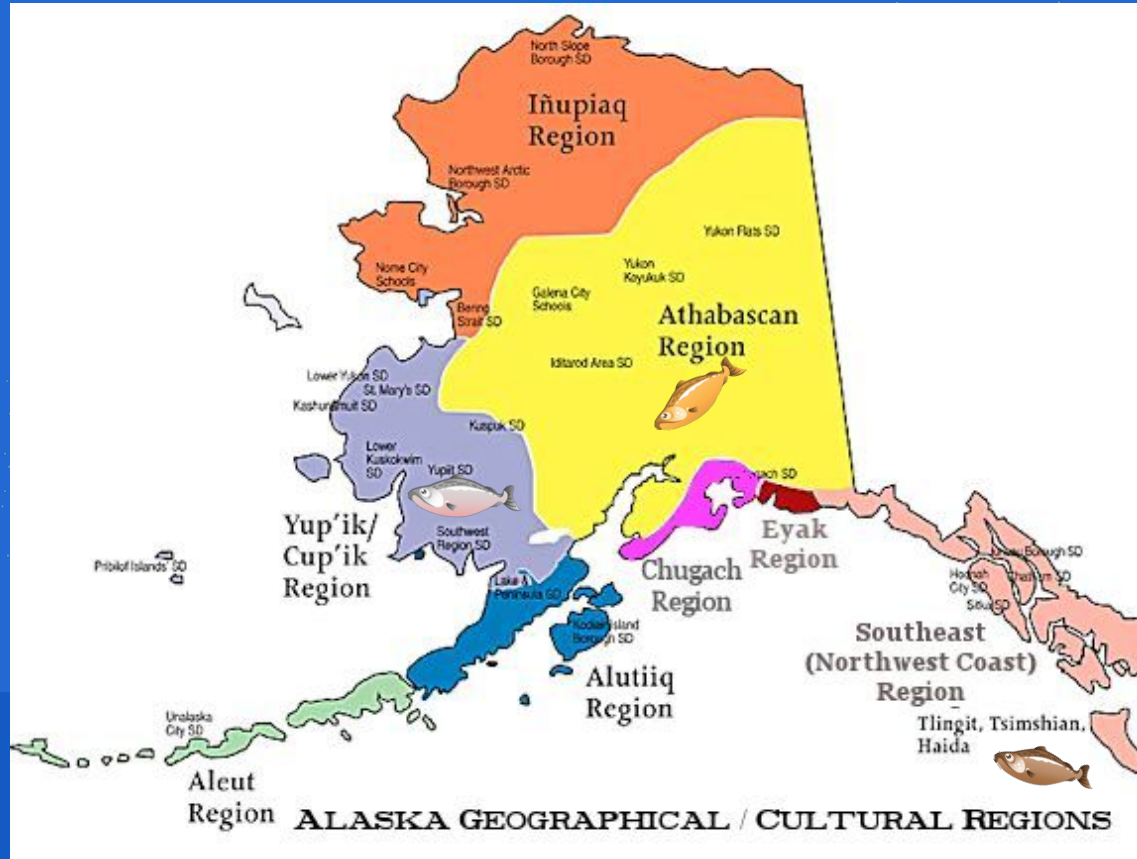


The Central Yup'ik

- Occupants of the region from the Nushagak River in Bristol Bay N and W to the coast of Norton Sound
- Believe that all living/other forms have spirits that are sentient, attentive, communicative, and volitional
- Salmon are honored in **spiritual ceremonies** conducted by the “angalquk” (shaman) who communicates with spiritual forces. The central Yup'ik wear **masks** during communal celebrations with **dances** and **songs**.



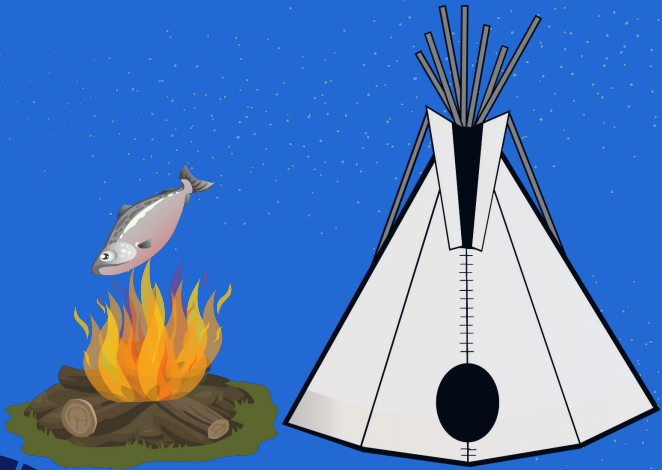
Woah, Where Am I Found?



BACK

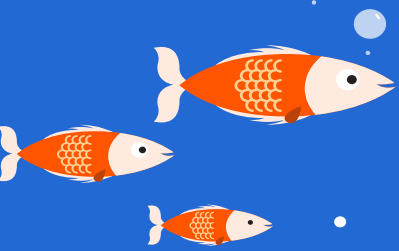
Wild Salmon: Native Ritual (cont'd)

Now since you have learned about the perspective of a wild salmon, do you want to end your fate as a wild salmon used for a native ritual or do you want to learn more the GM salmon fate?

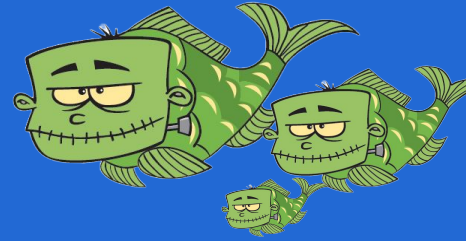


[Click here to be sacrificed in a Native Ritual](#)

[Click here to learn more about the GM Salmon fate](#)



Congratulations!



You have reached the end of your journey with us! Whether you have chosen life as a wild or GMO salmon, you are serving a valuable purpose to various communities.

Thank you and don't forget to just keep swimming!



Brief Summary

Here's a short video that will provide you with a brief overview of GMO salmon and their possible future. After finishing the video, buckle down and brace yourself for the rest of the journey!



CONTINUE

References

- Ahrens, R. N. M., & Devlin, R. H. (2011). Standing genetic variation and compensatory evolution in transgenic organisms: A growth-enhanced salmon simulation. *Transgenic Research*, 20(3), 583–597. <https://doi.org/10.1007/s11248-010-9443-0>
- AquaBounty Exposed Report. (2022, October 25). Uprooted and Rising. https://docs.google.com/document/d/1FysnUssU4lvPQljNI3nWnWEVkn4Yj1CYQgu3f9YXIAo/edit?usp=embed_facebook
- Bawa, A., & Anilakumar, K. (2012, December 19). Genetically Modified Foods: Safety, risks and public concerns-A Review - *Journal of Food Science and Technology*. Retrieved February 3, 2023, from https://link.springer.com/article/10.1007/s13197-012-0899-1?sa=U&ei=kNb_VPK0MchWoAT4IIGQBw&ved=0CNkBEBYwIA&usg=AFQjCNFZgE2UQXib7c642VvM6TBOSla8vw
- Best Management Practices for Finfish Aquaculture in Connecticut. (n.d.). Retrieved February 10, 2023, from <https://portal.ct.gov/-/media/DOAG/Aquaculture/Aquaculture-permitting-and-guidance/Best-Management-Practices-for-Finfish-Aquaculture-in-CT.pdf>
- Carothers, C., Black, J., Langdon, S. J., Donkersloot, R., Ringer, D., Coleman, J., Gavenus, E. R., Justin, W., Williams, M., Christiansen, F., Samuelson, J., Stevens, C., Woods, B., Clark, S. J., Clay, P. M., Mack, L., Raymond-Yakoubian, J., Sanders, A. A., Stevens, B. L., & Whiting, A. (2021). Indigenous peoples and salmon stewardship: A critical relationship. *Ecology and Society*, 26(1), art16. <https://doi.org/10.5751/ES-2259-2289>
- Companies raising salmon on land face pushback over sustainability and genetic engineering. (2022, September 29). In PBS NewsHour. <https://www.pbs.org/newshour/show/companies-raising-salmon-on-land-face-pushback-over-sustainability-and-genetic-engineering>
- D'Agaro, E., Favaro, A., Matiussi, S. et al. Genomic selection in salmonids: new discoveries and future perspectives. *Aquacult Int* 29, 2259–2289 (2021). <https://doi.org/10.1007/s10499-021-00747-w>
- Devlin, R. H., Sundström, L. F., & Leggatt, R. A. (2015). Assessing Ecological and Evolutionary Consequences of Growth-Accelerated Genetically Engineered Fishes. *BioScience*, 65(7), 685–700. <https://doi.org/10.1093/biosci/biv068>

References

- Du, S. J., Gong, Z., Fletcher, G. L., Shears, M. A., King, M. J., Idler, D. R., & Hew, C. L. (1992). Growth Enhancement in Transgenic Atlantic Salmon by the Use of an “All Fish” Chimeric Growth Hormone Gene Construct. *Bio/Technology*, 10(2), Article 2. <https://doi.org/10.1038/nbt0292-176>
- Dunham, R. A., & Su, B. (2020). Genetically Engineered Fish: Potential Impacts on Aquaculture, Biodiversity, and the Environment. In A. Chaurasia, D. L. Hawksworth, & M. Pessoa de Miranda (Eds.), *GMOs: Implications for Biodiversity Conservation and Ecological Processes* (pp. 241–275). Springer International Publishing. https://doi.org/10.1007/978-3-030-53183-6_11
- Ekstrom, J. A., Suatoni, L., Cooley, S. R., Pendleton, L. H., Waldbusser, G. G., Cinner, J. E., ... & Portela, R. (2015). Vulnerability and adaptation of US shellfisheries to ocean acidification. *Nature Climate Change*, 5(3), 207-214. doi:10.1038/nclimate2508
- Environmental Release of Genetically Engineered Animals with Gene Drives. *Global Policy*, 10(4), 554–568. <https://doi.org/10.1111/1758-5899.12699>
- Food and Water Watch, Consumers Union, and The Center for Food Safety. (2012, February 7). Petition to Deem ABT Technologies’ Genetically Engineered AquAdvantage Salmon An Unsafe Food Additive. Retrieved February 11, 2023, from <https://www.centerforfoodsafety.org/files/fdafoodadditivepetitiongesalmon.pdf>
- Hernandez, J. (2022, January 5). GMO is out, 'bioengineered' is in, as new U.S. food labeling rules take effect. NPR. Retrieved February 10, 2023, from <https://www.npr.org/2022/01/05/1070212871/usda-bioengineered-food-label-gmo>
- Hobbs, R. S., & Fletcher, G. L. (2008). Tissue specific expression of antifreeze protein and growth hormone transgenes driven by the ocean pout (*Macrozoarces americanus*) antifreeze protein OP5a gene promoter in Atlantic salmon (*Salmo salar*). *Transgenic Research*, 17(1), 33–45. <https://doi.org/10.1007/s11248-007-9128-5>

References

- INSTITUTE FOR FISHERIES RESOURCES; PACIFIC COAST FEDERATION OF FISHERMEN'S ASSOCIATIONS; GOLDEN GATE SALMON ASSOCIATION; KENNEBEC REBORN; FRIENDS OF MERRYMEETING BAY; CASCADIA WILDLANDS; CENTER FOR BIOLOGICAL DIVERSITY; ECOLOGY ACTION CENTRE; FRIENDS OF THE EARTH; FOOD AND WATER WATCH; and CENTER FOR FOOD SAFETY, Plaintiffs, v. SYLVIA MATHEWS BURWELL, Secretary of the United States Department of Health and Human Services; DR. ROBERT M. CALIFF, M.D., Commissioner of the United States Food And Drug Administration; the UNITED STATES FOOD AND DRUG ADMINISTRATION; and the UNITED STATES FISH AND WILDLIFE SERVICE, Defendants., Case 3:16-cv-01574 (THE UNITED STATES DISTRICT COURT FOR THE NORTHERN DISTRICT OF CALIFORNIA March 30, 2016).
- Kim, Y., Kim, S., & Arora, N. (2022). GMO Labeling Policy and Consumer Choice. *Journal of Marketing*, 86(3), 21–39. <https://doi.org/10.1177/00222429211064901>
- Kodama, M., Naish, K. A., & Devlin, R. H. (2018). Influence of a growth hormone transgene on the genetic architecture of growth-related traits: A comparative analysis between transgenic and wild-type coho salmon. *Evolutionary Applications*, 11(10), 1886–1900. <https://doi.org/10.1111/eva.12692>
- Mathis, J. T., H. T. The highly productive fisheries of Alaska are located in seas projected to experience strong global change. (2014, July 18). Ocean acidification risk assessment for Alaska's fishery sector. *Progress in Oceanography*. Retrieved February 3, 2023, from <https://www.sciencedirect.com/science/article/pii/S0079661114001141>
- Marques, A., Nunes, M. L., Moore, S. K., & Strom, M. S. (2010, February 21). Climate change and seafood safety: Human health implications. *Food Research International*. Retrieved February 3, 2023, from <https://www.sciencedirect.com/science/article/pii/S0963996910000682>
- Marushka, L., Kenny, T.-A., Batal, M., Cheung, W. W. L., Fediuk, K., Golden, C. D., Salomon, A. K., Sadik, T., Weatherdon, L. V., & Chan, H. M. (n.d.). Potential impacts of climate-related decline of seafood harvest on nutritional status of Coastal First Nations in British Columbia, Canada. *PLOS ONE*. Retrieved February 3, 2023, from <https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0211473>

References

- Moreau, D. T. R., Conway, C., & Fleming, I. A. (2011). Reproductive performance of alternative male phenotypes of growth hormone transgenic Atlantic salmon (*Salmo salar*). *Evolutionary Applications*, 4(6), 736–748. <https://doi.org/10.1111/j.1752-4571.2011.00196.x>
- Moreau, D. T. R., & Fleming, I. A. (2012). Enhanced growth reduces precocial male maturation in Atlantic salmon. *Functional Ecology*, 26(2), 399–405. <https://doi.org/10.1111/j.1365-2435.2011.01941.x>
- National Academies of Sciences, Engineering, and Medicine. (2002). *Animal Biotechnology: Science-Based Concerns*. National Academies Press.
- Nat Geo WILD (Director). (2017, March 30). The Salmon's Life Mission | Destination WILD. <https://www.youtube.com/watch?v=aPf4qtCDRtE>
- Olesen, I., Myhr, A. I., & Rosendal, G. K. (2011). Sustainable Aquaculture: Are We Getting There? Ethical Perspectives on Salmon Farming. *Journal of Agricultural and Environmental Ethics*, 24(4), 381–408. <https://doi.org/10.1007/s10806-010-9269-z>
- Parsons, M., Taylor, L., & Crease, R. (2021). Indigenous Environmental Justice within Marine Ecosystems: A Systematic Review of the Literature on Indigenous Peoples' Involvement in Marine Governance and Management. *Sustainability*, 13(8), Article 8. <https://doi.org/10.3390/su13084217>
- Qaim, M., & Kouser, S. (2013). Genetically modified crops and food security. *PLoS ONE*, 8(6). doi:10.1371/journal.pone.0064879
- Qin, G., Qin, Z., Lu, C., Ye, Z., Elasad, A., Bangs, M., Li, H., Zhang, Y., Huang, Y., Shi, H., Gosh, K., Abass, N. Y., Vo, K., Odin, R., Bugg, W. S., Backenstose, N. J. C., Drescher, D., Taylor, Z., Braden, T., ... Dunham, R. A. (2022). Gene Editing of the Catfish Gonadotropin-Releasing Hormone Gene and Hormone Therapy to Control the Reproduction in Channel Catfish, *Ictalurus punctatus*. *Biology*, 11(5), 649. <https://doi.org/10.3390/biology11050649>
- Reid, A. J., Young, N., Hinch, S. G., & Cooke, S. J. (2022). Learning from Indigenous knowledge holders on the state and future of wild Pacific salmon. *FACETS*, 7, 718–740. <https://doi.org/10.1139/facets-2021-0089>
- Rep. Young, D. [R-A.-A. L. (2021, July 29). Text - H.R.273 - 117th Congress (2021-2022): Prevention of Escapement of Genetically Altered Salmon in the United States Act (07/29/2021) [Legislation]. <http://www.congress.gov/>

References

- Shen, C., Yin, X., Jiao, B., Li, J., Jia, P., Zhang, X., . . . Liu, J. (2022, January 13). Evaluation of adverse effects/events of genetically modified food consumption: A systematic review of Animal and Human Studies - Environmental Sciences Europe. Retrieved February 3, 2023, from <https://enveurope.springeropen.com/articles/10.1186/s12302-021-00578-9>
- Sheridan, J. A., & Bickford, D. (2011, October 16). Shrinking body size as an ecological response to climate change. Nature News. Retrieved February 3, 2023, from <https://www.nature.com/articles/nclimate1259>
- Smith, M. D., Asche, F., Guttormsen, A. G., & Wiener, J. B. (2010). Genetically modified salmon and full impact assessment. Science, 330(6007), 1052-1053. doi:10.1126/science.1197769
- Stokstad, E. "New genetic tools will deliver improved farmed fish, oysters, and shrimp. Here's what to expect." Science. 19 Nov. 2020, <https://www.science.org/content/article/new-genetic-tools-will-deliver-improved-farmed-fish-oysters-and-shrimp-here-s-what>
- Thompson, M., Saltzman, M., & Bittman, M. (2019, June 22). Future of Food: This genetically engineered salmon may hit U.S. markets as early as 2020. Retrieved February 10, 2023, from <https://www.pbs.org/newshour/show/future-of-food-this-genetically-engineered-salmon-may-hit-u-s-markets-as-early-as-2020>
- TODAYonline (Director). (2015, August 8). Transgenic Fish. <https://www.youtube.com/watch?v=4iWbN7rGFhs>
- U.S. Food and Drug Administration, Center for Drug Evaluation and Research. FREEDOM OF INFORMATION SUMMARY ORIGINAL NEW ANIMAL DRUG APPLICATION NADA 141-454 opAFP-GHc2 rDNA construct in EO-1a lineage Atlantic salmon (AquAdvantage Salmon), November 19, 2015. Retrieved February 10, 2023, from <https://www.fda.gov/media/93801/download>
- Vandersteen, W. E., Leggatt, R., Sundström, L. F., & Devlin, R. H. (2019). Importance of Experimental Environmental Conditions in Estimating Risks and Associated Uncertainty of Transgenic Fish Prior to Entry into Nature. Scientific Reports, 9(1), Art. 1. <https://doi.org/10.1038/s41598-018-35826-1>

References

- Watson, R. R., & Preedy, V. R. (2016). Chapter 40: Allergen Analysis in Plants and Use in the Assessment of Genetically Modified Plants. In *Genetically modified organisms in food: Production, safety, Regulation and Public Health* (pp. 455-460). Amsterdam: Elsevier Science/Academic Press.
- Weir, M. J., Uchida, H., & Vadiveloo, M. (2021). Quantifying the effect of market information on demand for genetically modified salmon. *Aquaculture Economics & Management*, 25(1), 1–26. <https://doi.org/10.1080/13657305.2020.1803447>

