

Genetic pollution of the environment and biotechnological methods of protecting gene pools of wild-living fish

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Genetic pollution – admixture of wild gene pools and domesticated (farmed) gene pools

Search International edition

The Guardian

News website of the year

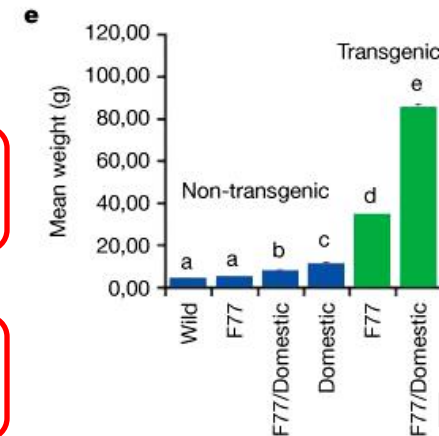
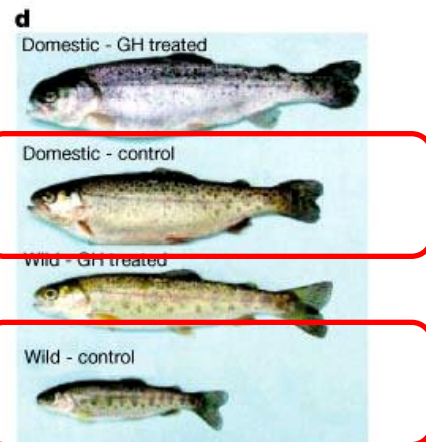
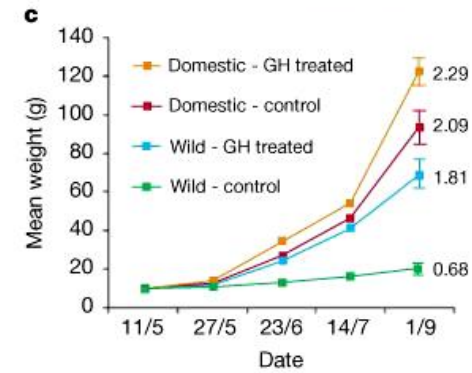
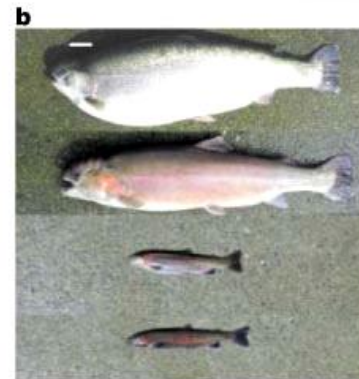
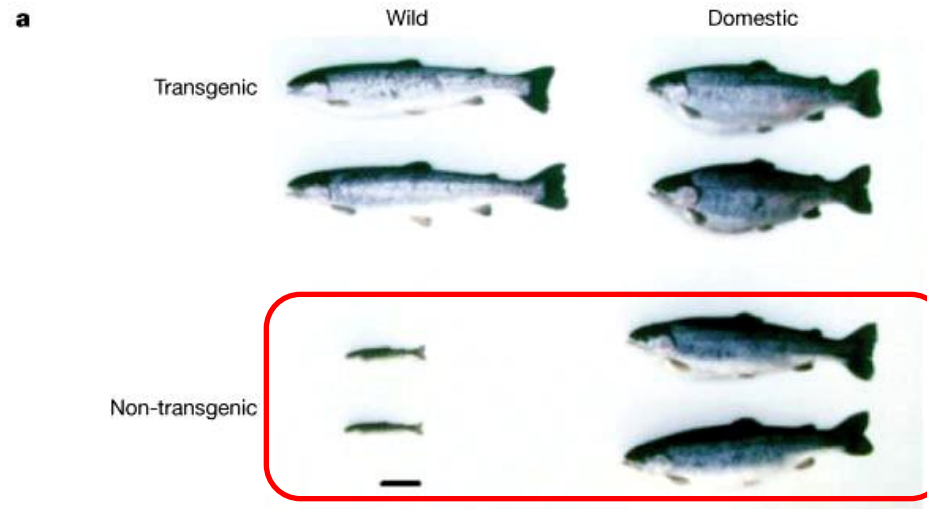
South Africa: wild animals at risk of 'genetic pollution'

Scientists say lions and rhinos among species at risk from breeding of trophy animals



wild vs. provided from selective breeding programs

Domesticated fish differ from the wild ones....



Farmed fish (that are domesticated) escape easily....



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Thousands of salmon escape Marine Harvest farm in Norway

By Christine Blank
February 8, 2018

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Around 56,000 farmed salmon escaped from a Marine Harvest net pen in Nærøy, Trøndelag, Norway.

The escape occurred on 5 February, after a net containing 180,000 salmon was damaged during a maintenance procedure at its farm in Arnøyfjorden. Marine Harvest notified Norway's Directorate of Fisheries, which sent divers to the site. The escaped fish weigh around two kilos (4.41 pounds) each, according to Norway Today.

Marine Harvest is paying fishermen NOK 300 (USD 38, EUR 31) each for escaped fish.

The escaped salmon have been given medication to treat

intestinal worms, according to Marine Harvest. Marine Harvest said it is investigating the incident, in cooperation with the Directorate of Fisheries and suppliers.

Marine Harvest is already receiving criticism about its escape, Norway Today reported.

"In all of Norway, a total of 10,000 salmon escaped in 2017. This incident is five times as many," fish manager Anton Rikstad of the county governor in Trøndelag to Namdalsavis, told the newspaper.



Cermaq salmon escape after fire at Norway fish farm

News by Editorial staff - 31 July 2018

Up to 10,000 salmon may have escaped after a fire broke out at a Cermaq fish farm in Norway.

The fire – at the Ryggefjorden site, Finnmark, Northern Norway – damaged the net cages.

Between 1,000 and 10,000 fish may have escaped, Cermaq said in a press release.

The escaped fish weigh about 500 grams, untreated and fresh. There were about 162,000 fish in the cages when the fire broke out. The Directorate of Fisheries has been notified, the company added.

Norsk

Type search key

NORWEGIAN ENVIRONMENT AGENCY

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- NORWEGIAN ENVIRONMENT AGENCY
- Areas of activity
- Species and ecosystems
- Salmon, trout and Arctic char
- Pressures on salmonids

Escaped farmed fish

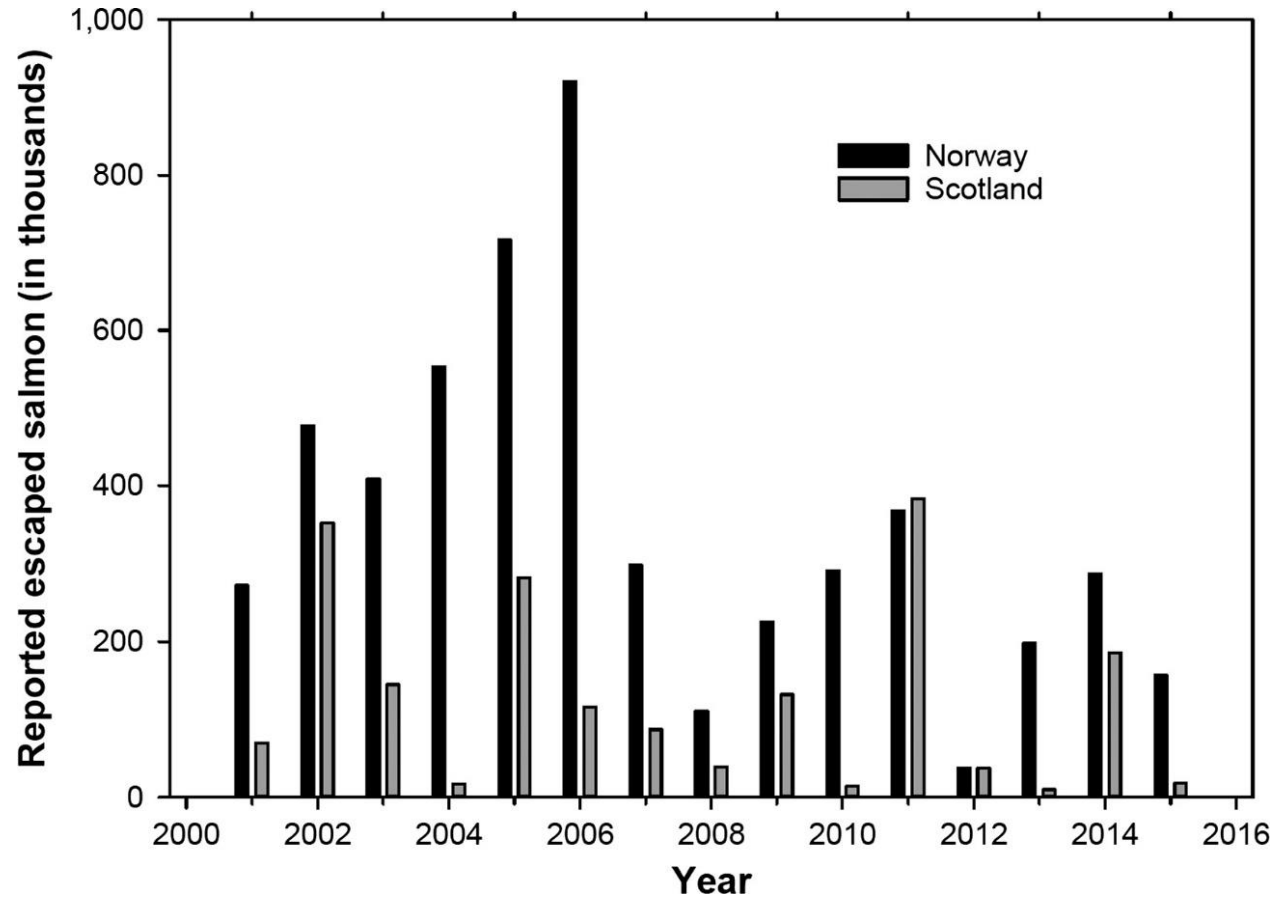
Escaped farmed salmon have an impact on wild salmon stocks. Some of the escapees migrate up rivers and spawn with wild salmon. Interbreeding can genetically weaken the wild stocks, which in turn can reduce wild salmon production in the rivers.

In addition to putting genetic pressure on wild salmon, escaped farmed salmon also carry sea lice infestation and fish diseases. The Norwegian Government's goal is that aquaculture will not contribute to permanent changes in the genetic characteristics of wild fish stocks.



Co-funded by the European Union

Farmed fish (that are domesticated) escape easily....



Farmed fish (that are domesticated) escape easily....

Okolo 50 tys. jesiotrów syberyjskich uciekło z hodowli do Bałtyku

Autor: PAP Data: 13-09-2017, 18:51

Okolo 50 tys. jesiotrów syberyjskich i rosyjskich uciekło pod koniec sierpnia br. z hodowli w Jeżyczkach (Zachodniopomorskie) w wyniku podniesienia się poziomu wody w Grabowej. Jak informuje ichtiolog ze Stacji Morskiej na Helu, ryby przedostały się do Bałtyku i stanowią potencjalne zagrożenie dla jesiotra ostronosego.



fot. shutterstock

Stocking programs including non-native fish species

Salmonid fishes in the Tatra National Park (Poland)



Brown trout (native)



rainbow trout
(non-native
that escaped
from the farm)



brook trout – non-native,
stocking programs)

Stocking programs including non-native fish species – interspecies hybridization that may result in production of non-viable offspring

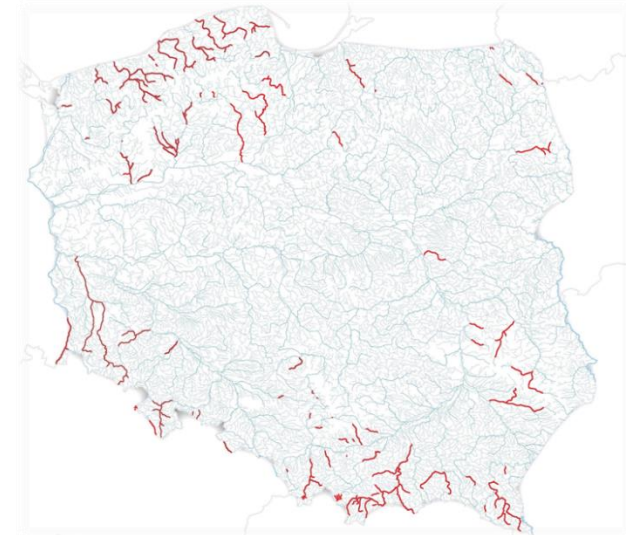


Salmo trutta x *Salvelinus fontinalis* = *pstrąg tygrysi*

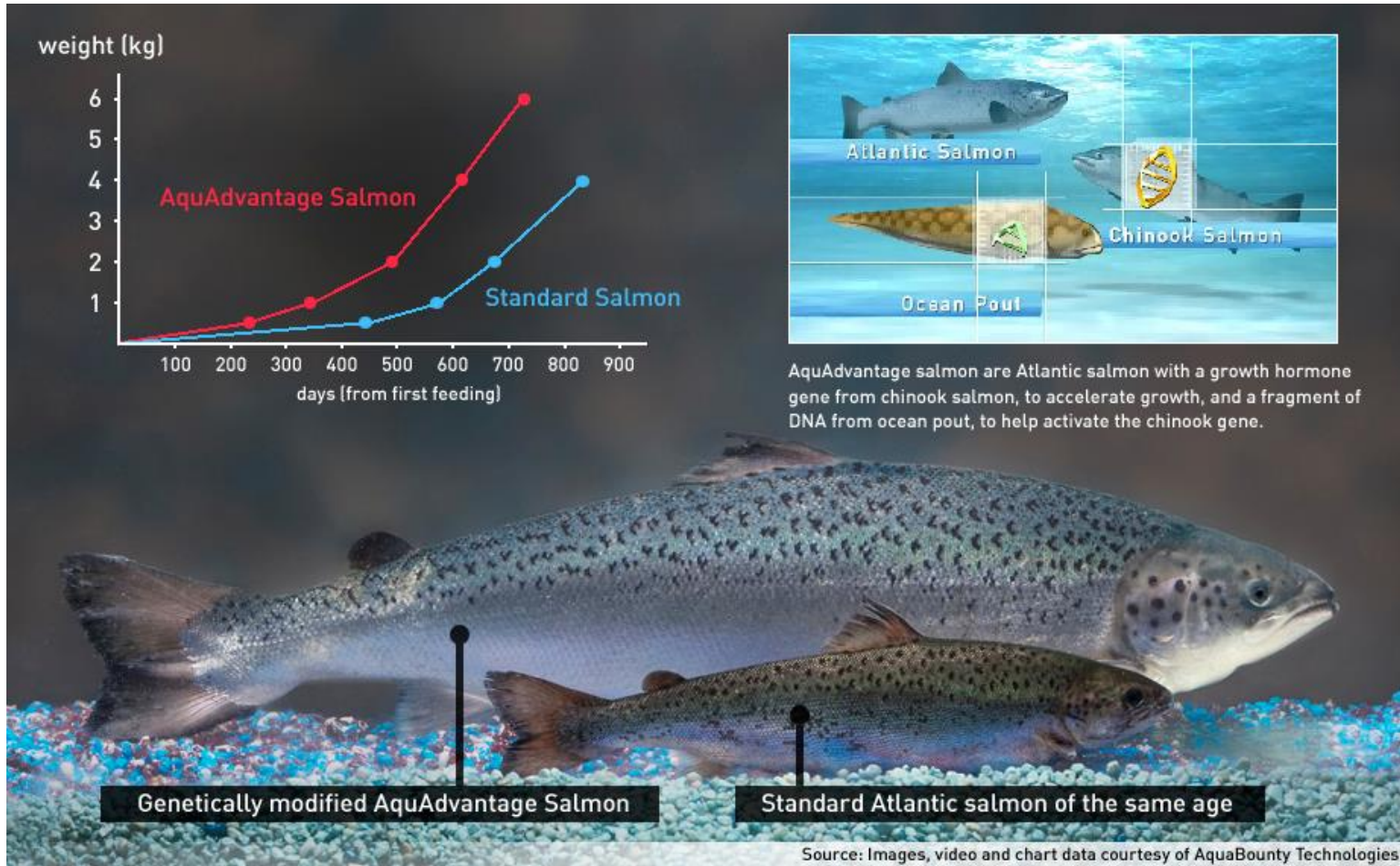


Stocking programs - genetic contamination of many local European grayling populations

European grayling (*Thymallus thymallus* L.)



Genetically modified fish may also escape and spread their modified genome into the wild.....



Genetically modified fish may also escape and spread their modified genome into the wild.....

The Zebrafish Model: A Powerful Tool for Answering Complex Questions

We knew the model was brilliant for academic research. Would it be as good for modeling human disease and discovering new drugs in an industrial setting?



Color

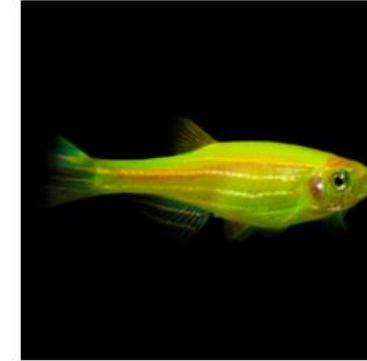
- Cosmic Blue
- Electric Green
- Galactic Purple
- Starfire Red
- Sunburst Orange

Fish Type

- Danio



Cosmic Blue Danio



Electric Green Danio



Galactic Purple Danio



Starfire Red Danio



Sunburst Orange Danio

NEWS | PLANTS & ANIMALS

Transgenic glowing fish invades Brazilian streams

Aquarium curiosity appears to be thriving after escape from fish farms and may threaten local biodiversity

11 FEB 2022 • 6:05 PM • BY SOPHIA MOUTINHO



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Genetically modified zebrafish (*Danio rerio*) are sold in fluorescent red, blue, and green. PAULO DE OLIVEIRA/MINDEN

Consequences of escapes of the farmed fish and stocking programs:

- **Ecological – competition for food and habitat.**
- **Zdrowotne – przenoszenie czynników chorobotwórczych.**
- **Genetic – contamination of many local populations with the non-native individuals, contamination of gene pools, introgression.**

Aquaculture is growing up, fish are escaping; so how to protect wild populations from the farmed/domesticated fish?

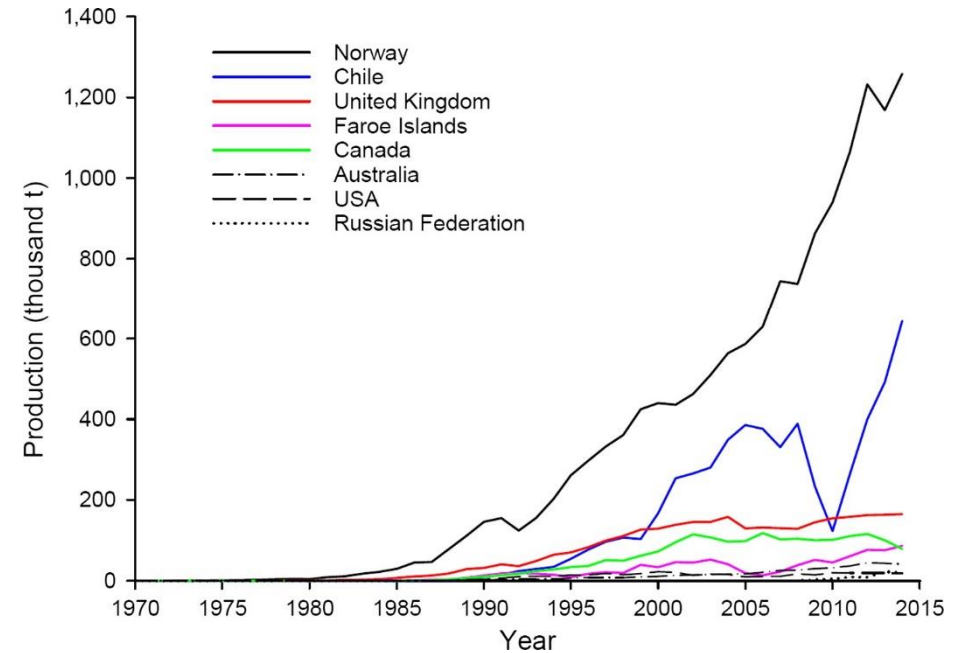
to apply a breeding program focusing on production of fish that are not able to mate with wild stocks....



ORIGINAL ARTICLE | [Open Access](#) |

Half a century of genetic interaction between farmed and wild Atlantic salmon: Status of knowledge and unanswered questions

Kevin A Glover ✉, Monica F Solberg, Phil McGinnity, Kjetil Hindar, Eric Verspoor, Mark W Coulson, Michael M Hansen, Hitoshi Araki, Øystein Skaala, Terje Svåsand



Production of sterile triploid individuals is one of them.....

Rufus Woods triploids taking the bait

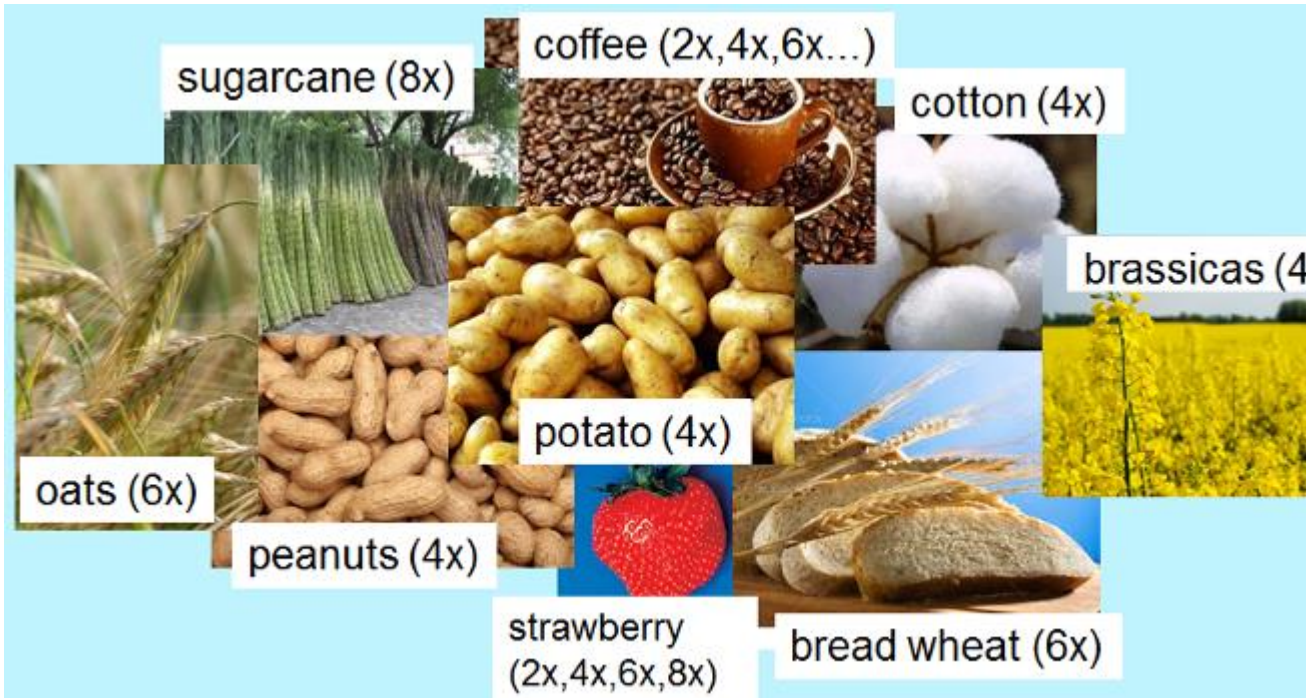
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Lisa Murray of Bellevue with a 13.1 pound triploid rainbow trout caught while bait fishing at Lake Rufus Woods in December 2011. (Anton Jones)

Polyploids are everywhere including our breakfast.....



Polyploidy

Examples of Polyploid Plants	
Name	Number
Common wheat	6N = 42
Tobacco	4N = 48
Potato	4N = 48
Banana	3N = 27
Boysenberry	7N = 49
Strawberry	8N = 56

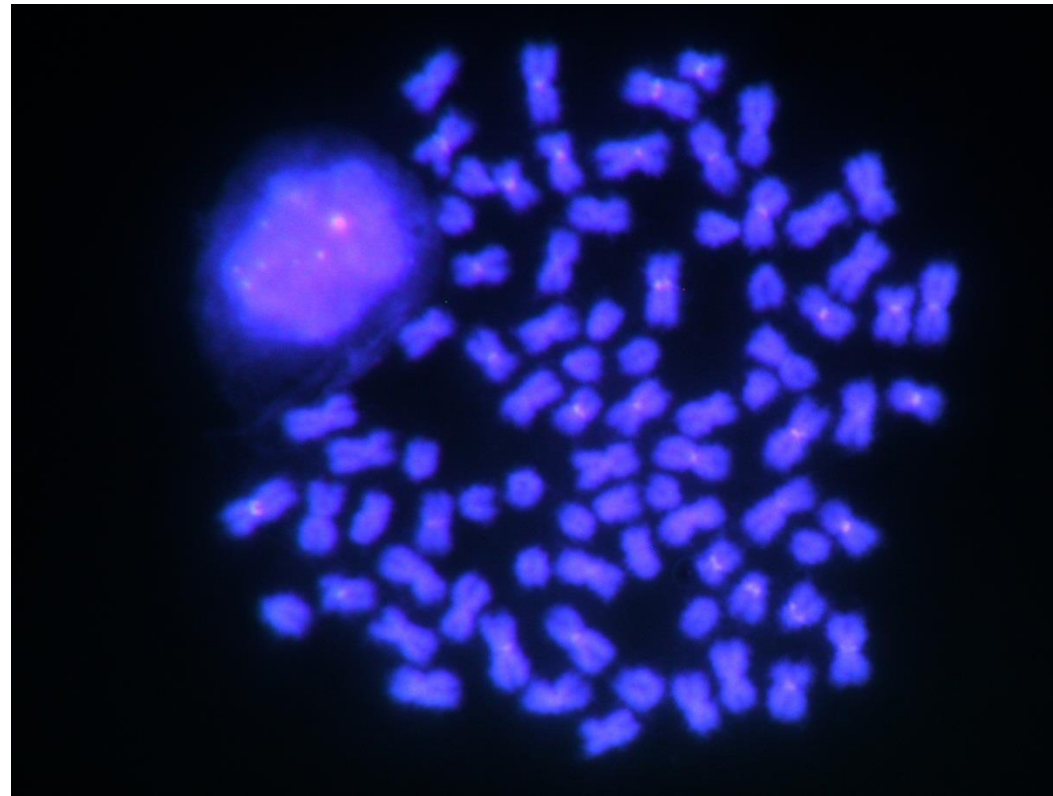
Many **ferns** are polyploid with chromosome number up to 400N



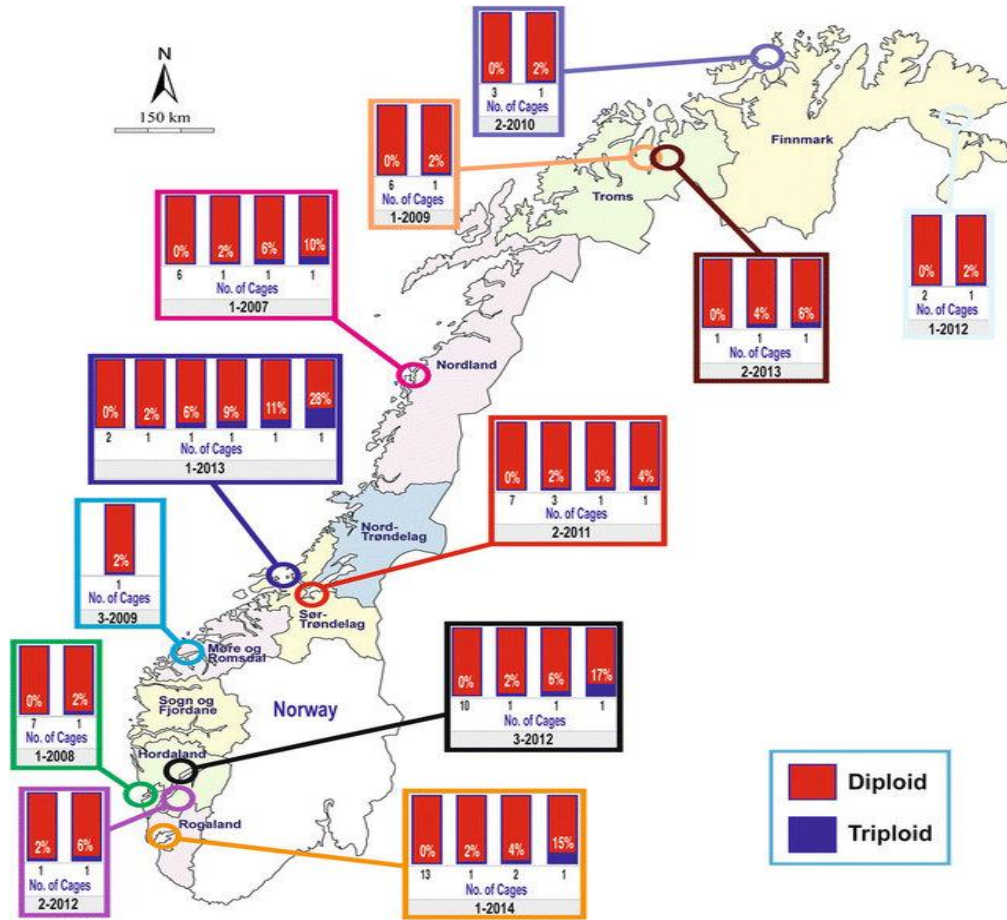
Natural triploids are around us.....



Spontaneous triploid rainbow trout with 90 chromosomes (3n)



Naturally-ocurred triploid farmed salmon



Ratio of spontaneous triploids among farmed in Norway salmon reach 20%



Aquaculture

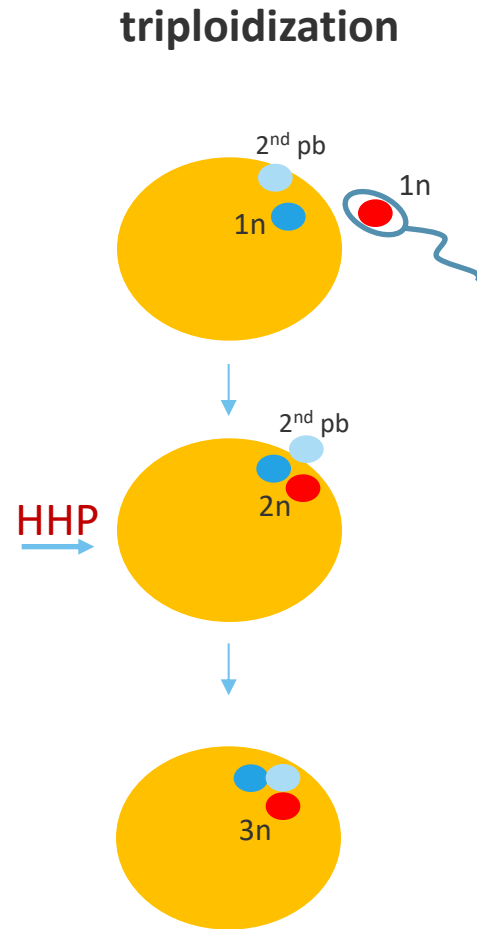
Volume 231, Issues 1–4, 5 March 2004, Pages 59–71



Effects of post-ovulatory oocyte ageing and temperature on egg quality and on the occurrence of triploid fry in rainbow trout, *Oncorhynchus mykiss*

Sandrine Aegerter, Bernard Jalabert

Mass production of triploids under aquaculture conditions is easy to perform!



Collection of gametes



Fertilization



Application of physical shock to fertilized eggs: 7 500 – 11 000 psi/3-5 min/20-40 min after insemination



Egg incubation



Ploidy confirmation

Sterile triploids in aquaculture - benefits



<http://abc.net.au>

<http://www.theoutdoorline.com>

TERJE REFSTIE AND TRYGVE GJEDREM

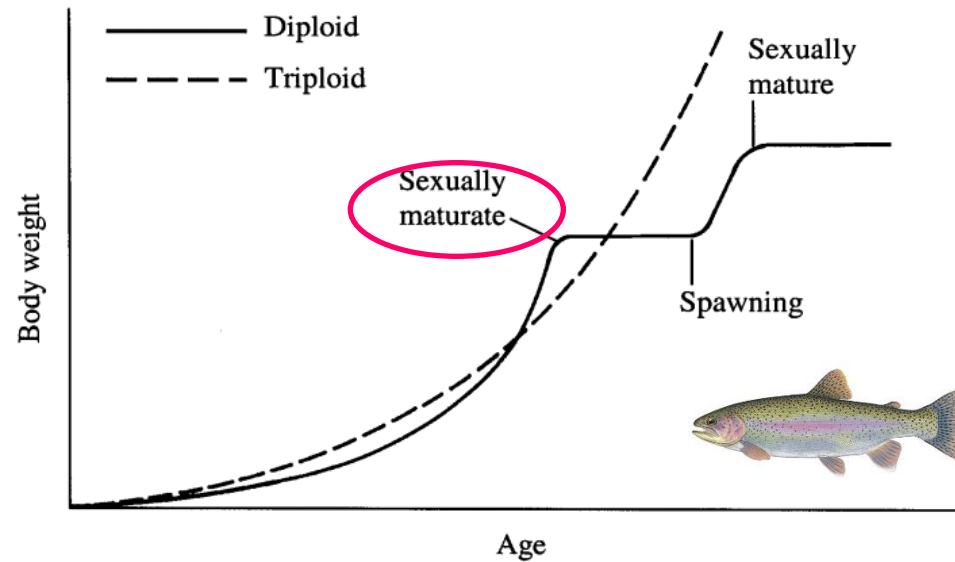


Figure 18.3 Growth curves for diploid and triploid fishes.

Trygve Gjedrem, 2010, Springer

Sterile triploids in aquaculture - benefits



Ikra stanowi nawet do ponad 20% masy ciała pstrąga tęczowego

TERJE REFSTIE AND TRYGVE GJEDREM

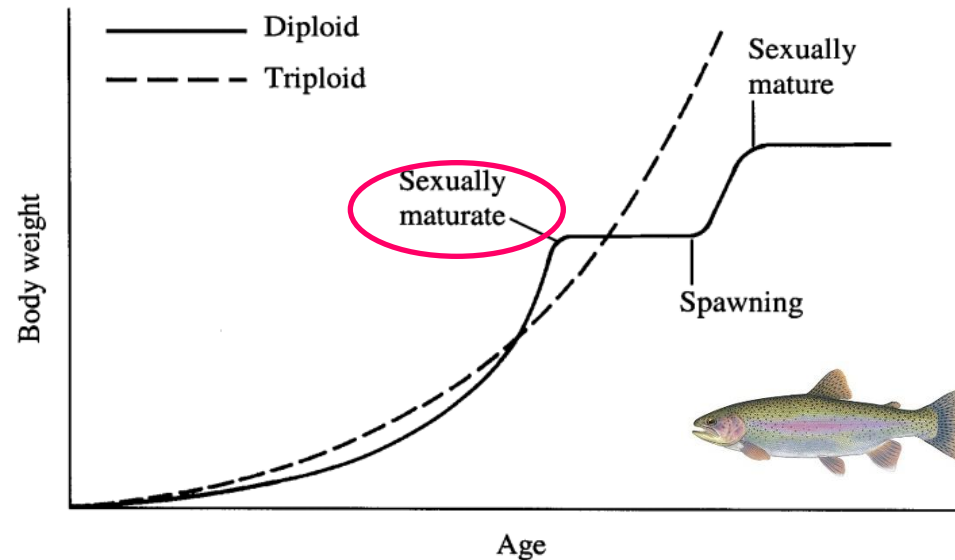


Figure 18.3 Growth curves for diploid and triploid fishes.

Trygve Gjedrem, 2010, Springer

Induction of triploid development in the European grayling



Gonads of triploid garyling

Application of high hydrostatic pressure (HHP) shock to induce triploid development in the European grayling (*Thymallus thymallus* L.)

Piotr Hliwa ^a, Ligia Panasiak ^b, Elzbieta Ziomek ^a, Rafal Rozyński ^c, Łukasz Leonowicz ^b, Joanna Grudniewska ^c, Stefan Dobosz ^c, Konrad Ocalewicz ^b



Behaviour of triploid specimens in the wild

Figure 1: Relative fighting ability of farmed triploid and diploid brown trout

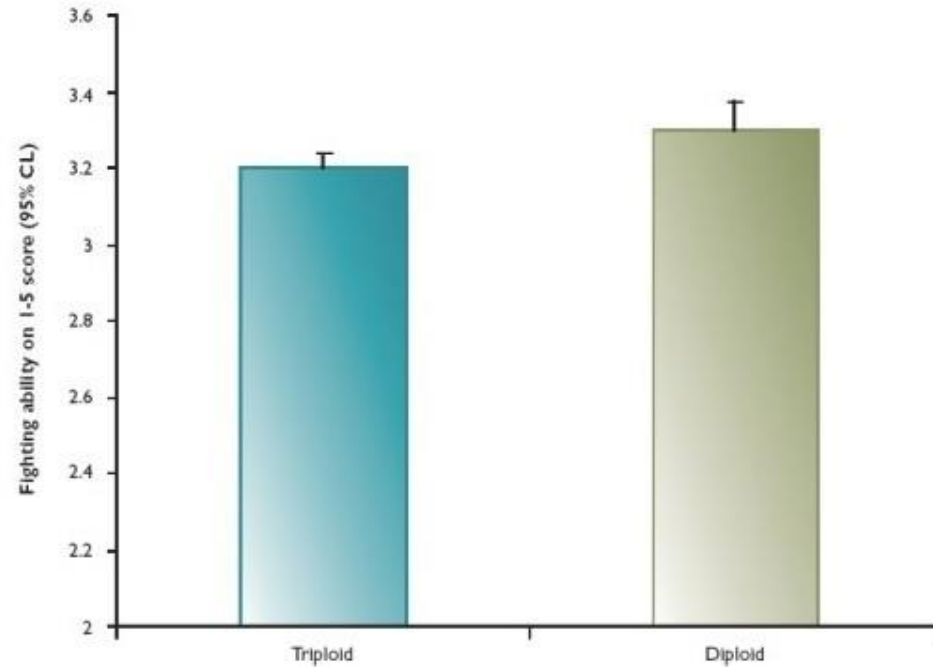
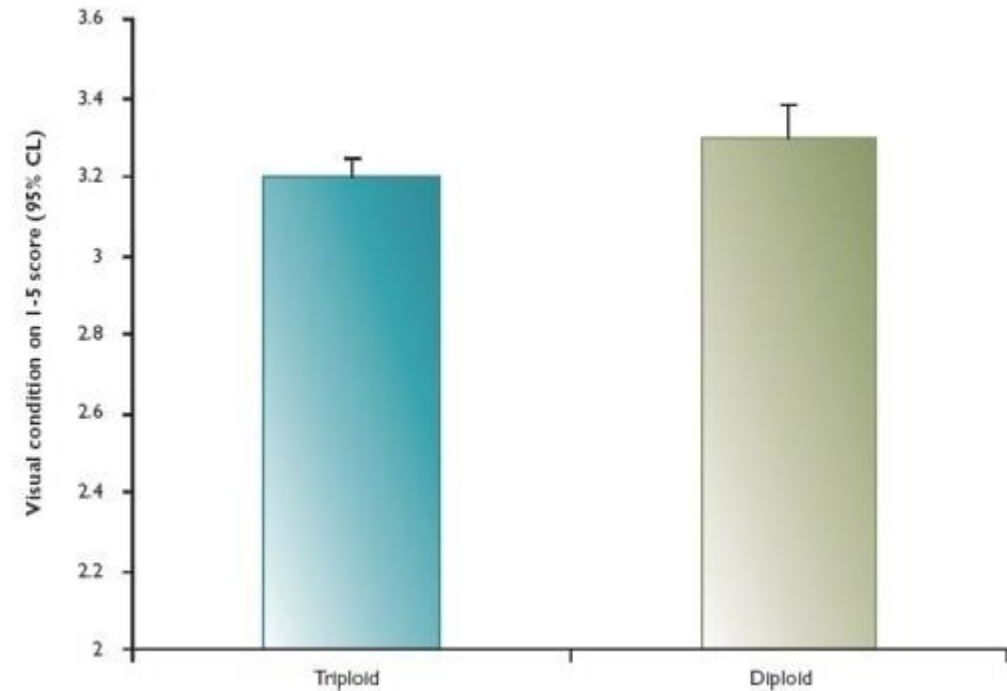


Figure 2: Relative visual condition of farmed triploid and diploid brown trout



Among the anglers surveyed there was very little perceived difference between triploid and diploid trout in terms of fighting ability or visual condition.

Stocking programs using triploid trout

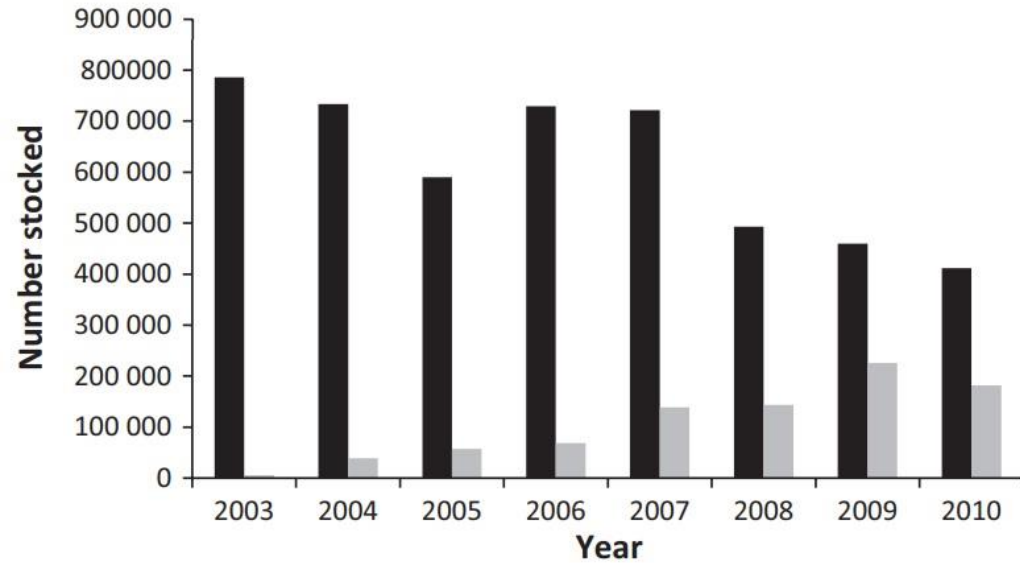


Figure 1. The number of diploid/ unspecified ■ and triploid ■ brown trout stocked into English and Welsh rivers 2003–2010. *Source:* Environment Agency/Cefas Live Fish Movements Database. © Crown copyright.

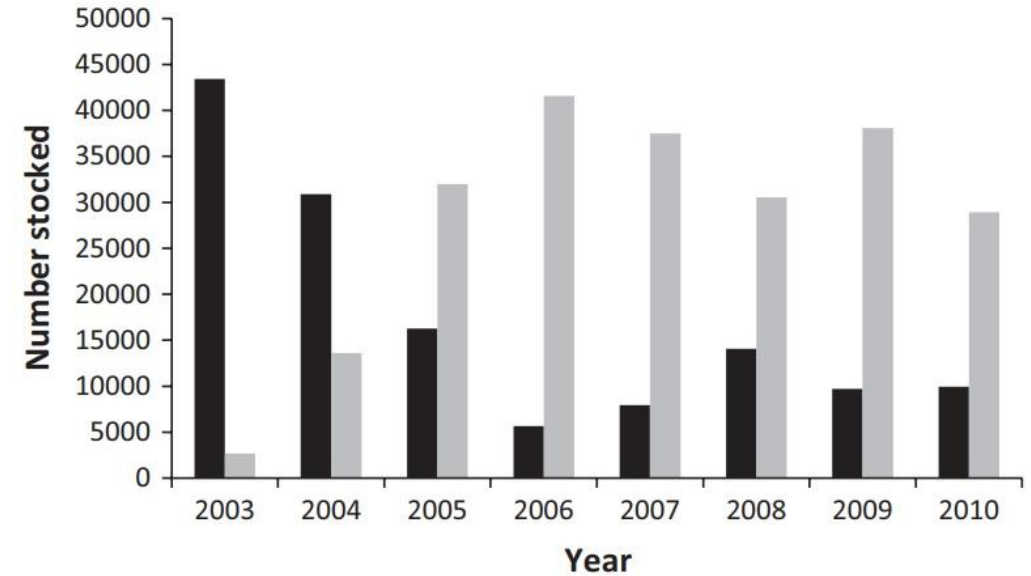


Figure 3. The number of diploid/unspecified ■ and triploid ■ rainbow trout stocked into English and Welsh rivers 2003–2010. *Source:* Environment Agency/Cefas Live Fish Movements Database. © Crown copyright.

Transgenic salmon (AquaAdvantage) is a sterile triploid as well....



AquaBounty salmon

Sterile triploids in aquaculture - disadvantages

Journal of Fish Diseases 2016, 39, 1509–1521

doi:10.1111/jfd.12492



Concurrence of lower jaw skeletal anomalies in triploid Atlantic salmon (*Salmo salar* L.) and the effect on growth in freshwater

G Amoroso¹, J M Cobcroft^{1,2}, M B Adams¹, T Ventura² and C G Carter¹

¹ Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, TAS, Australia

² Genecology Research Centre, School of Science and Engineering, University of the Sunshine Coast, Maroochydore DC, QLD, Australia

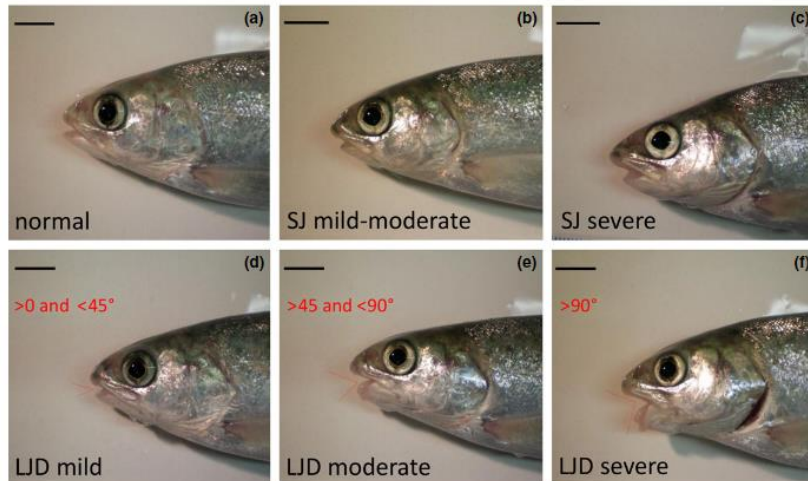


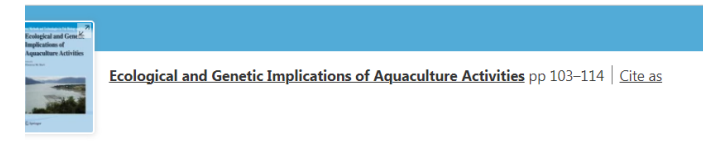
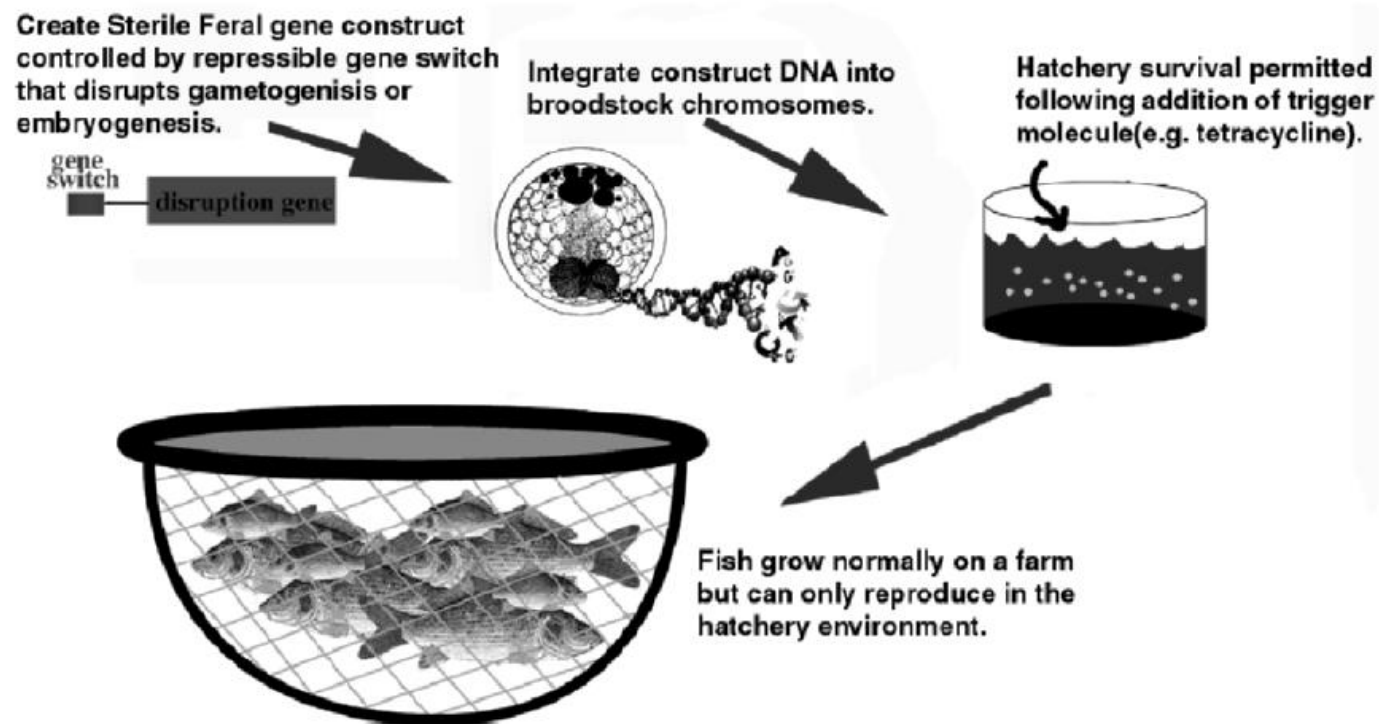
Figure 2 Classification and severity of lower jaw skeletal anomalies affecting Atlantic salmon (*Salmo salar* L.) individuals: (a) normal lower jaw, (b and c) shortened lower jaw (SJ) with severity discriminated as mild–moderate and severe, (d–f) lower jaw deformity (LJD) with three different degrees of severity determined by the angle of downward curvature (values in red text) mild, moderate and severe (scale bars are 1 cm).

1. Triploids are prone to body and skeletal deformations.
2. Interspecies differences in developmental disturbances; rainbow trout– scoliosis, brown trout – scoliosis and kiphosis.
3. Triploids are more sensitive than diploids to sub-optimal environmental conditions: water temperature, oxygen level, etc.

Alternative methods of fish sterilization – transgenesis

Preventing genetic pollution from aquaculture

109

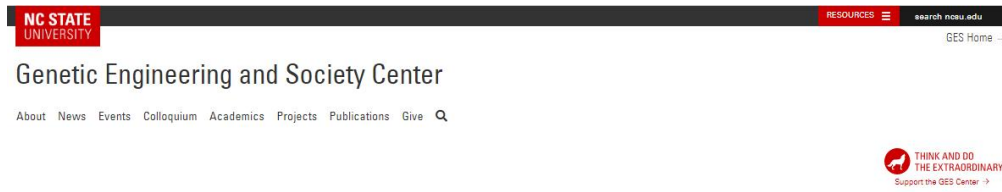


Preventing Genetic Pollution and the Establishment of Sterile Feral Populations: A Molecular Solution

[r.M. Grewe Ph.D.](#) [Jawahar G. Patil Ph.D.](#) [Daniel J. McGoldrick Ph.D.](#) [Peter C. Rothlisberg Ph.D.](#) [Steven J. Hardy Ph.D.](#) [Lyn A. Hinds Ph.D.](#) [Chris M. Hardy Ph.D.](#) [Soma Vignarajan](#) & [Ron E. Thresher Ph.D.](#)

Figure 1. Schematic of “Sterile Feral” concept. Gene switch refers to any spatially and temporally restricted species-specific promoter

Alternative methods of fish sterilization – CRISPR and genome editing



A Sterile Solution: How Crispr Could Protect Wild Salmon

JULY 21, 2021 | GUEST AUTHOR



Molecular biologist Anna Wargelius leads a research team that has created salmon that they call "sterile parents." The gene-edited fish can have their fertility restored, but will pass on the genetic modification, likely making their offspring sterile. Visual: Eriend A. Lorentzen / Institute of Marine Research

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Dnd knockout ablates germ cells and demonstrates germ cell independent sex differentiation in Atlantic salmon

Received: 15 September 2015

Accepted: 20 January 2016

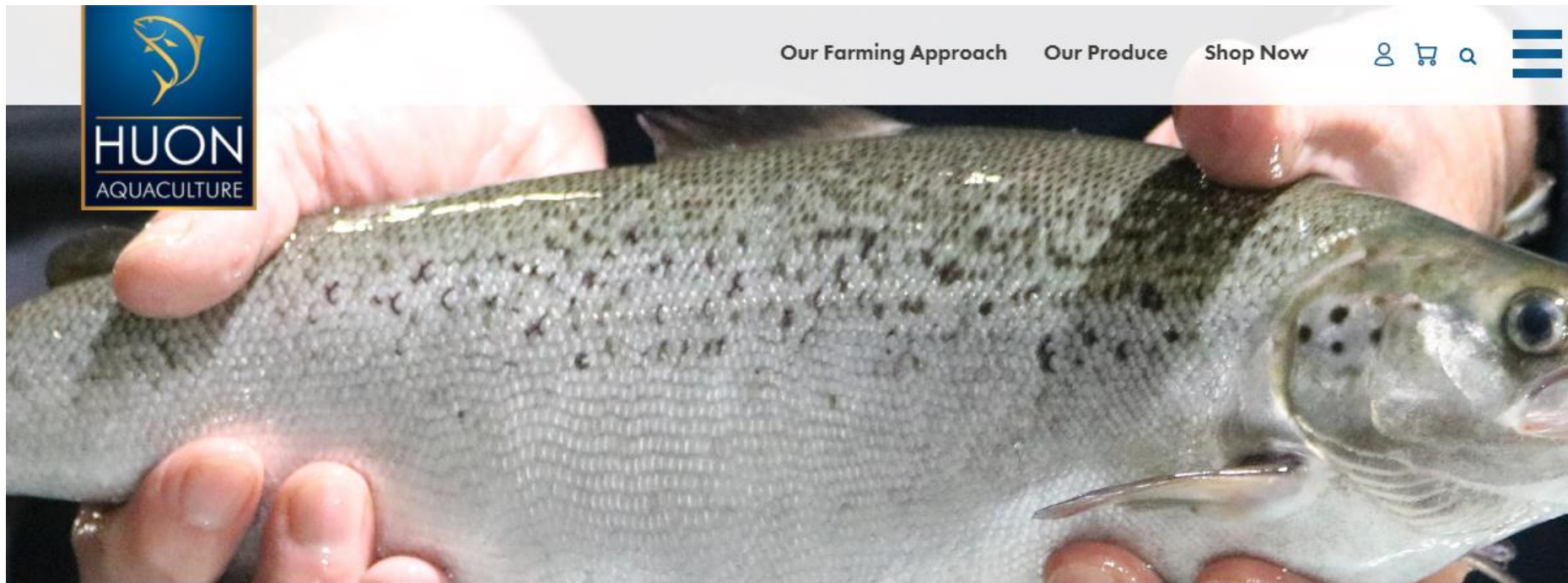
Published: 18 February 2016

Anna Wargelius¹, Sven Leininger^{1,*}, Kai Ove Skaftnesmo¹, Lene Kleppe¹, Eva Andersson¹, Geir Lasse Taranger¹, Rüdiger W Schulz^{1,2} & Rolf B Edvardsen¹

Introgression of farmed salmon escapees into wild stocks is a major threat to the genetic integrity of wild populations. Using germ cell-free fish in aquaculture may mitigate this problem. Our study investigated whether it is possible to produce germ cell-free salmon in F0 by using CRISPR-Cas9 to knock out *dnd*, a factor required for germ cell survival in vertebrates. To avoid studying mosaic animals, sgRNA targeting *alb* was simultaneously used as a visual tracer since the phenotype of *alb* KO is complete loss of pigmentation. Induced mutations for the tracer (*alb*) and the target (*dnd*) genes were highly correlated and produced germ cell-less fish lacking pigmentation, underlining the suitability of *alb* KO to serve as tracer for targeted double allelic mutations in F0 animals in species with prohibitively long generation times. This is also the first report describing *dnd* knockout in any fish species. Analyzing gene expression and histology of *dnd* KO fish revealed that sex differentiation of the somatic compartment does not depend on the presence of germ cells. However, the organization of the ovarian somatic compartment seems compromised in mutant fish.

disadvantages:

- Single egg injection of CRISPRs/Cas9,
- Sterility is not inherited....
- Gene knock-out DNA is still treated as a genetic modification (GMO).



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— **Triploids – the facts**

In simple terms, a triploid fish is a fish that is sterile. Across the Tasmanian Salmonid Industry, triploids are used to bridge the harvest gap between year classes to ensure continuous supply to the market.

Triploidy occurs naturally in wild populations due to environmental changes (usually water temperature fluctuations).

Triploids are thought to be safe stocking material that are unable to mate with wild individuals



Trout Stocking



The Environment Agency in England and Wales now requires all farmed brown trout stocked into rivers and some lakes to be infertile (triploid). These regulations were put in place in January 2015. Details are on the EA website archive - click [here](#).

The Scottish Government has a similar policy - details are [here](#).

This web page contains a lot of information on the topic of stocking farmed trout and includes videos, [scientific papers](#), and [case studies from fishing clubs](#).

3n fish have been used to stock rivers and lakes in UK, USA, Canada.



Rufus Woods triploids taking the bait



Many thanks to my collaborators!

Ela i Piotr



Marcin



Ligia i Rafała



Stefan

Łukasz i Robert



Thank you for the
attention!



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