THE CENTER FOR AQUACULTURE TECHNOLOGIES

Advancing Production and Sustainability in Aquaculture Through Genome Editing

The Center for Aquaculture Technologies
–CAT-

Our mission is to commercialize genetic technologies to improve the productivity and sustainability of aquaculture.

SERVICES

The organization's expertise spans *genotyping, genomics, breeding,* and *genome editing*, catering to an extensive range of aquatic species. The company's integrated services support businesses of all sizes, accelerating growth, promoting environmental stewardship, and advancing the industry.

GENOTYPING

GENOMICS

BREEDING

GENOME EDITING

Benefits of Sterility

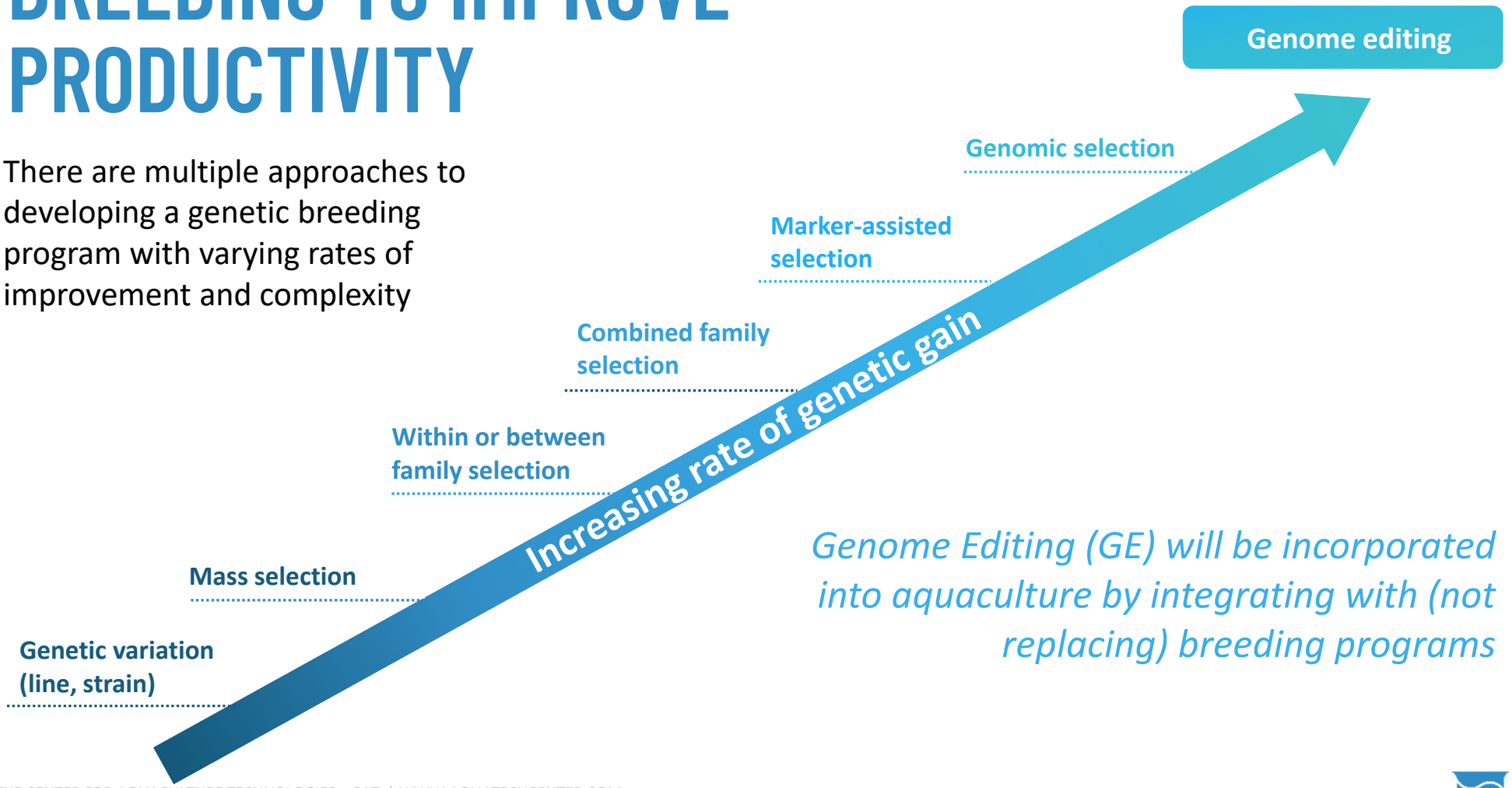
Implementation of genetic improvement and genetic technologies (biocontainment)

Environmental stewardship (permitting; escape monitoring; industry expansion)

Performance

BREEDING TO IMPROVE PRODUCTIVITY

There are multiple approaches to developing a genetic breeding program with varying rates of improvement and complexity



Genome Editing (GE) will be incorporated into aquaculture by integrating with (not replacing) breeding programs

WIKIPEDIA
The Free Encyclopedia

Cypress Island Atlantic salmon pen break

Article Talk

From Wikipedia, the free encyclopedia

On August 19, 2017, a net pen at a
hundreds of thousands of non-nativ

npr kpbs

NEWS CULTURE MUSIC P

The Salt WHAT'S ON YOU

REUTERS

World Business Markets Breakingviews Video

ENVIRONMENT JULY 12, 2018 / 1:40 PM / UPDATED 5 YEARS AGO

Chile fishermen race to recapture escaped salmon that could pose risk

WORLD & NATION

More than 160,000 non-native Atlantic salmon escaped into Washington waters in fish farm accident

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HOME > SCIENCE > VOL. 361, NO. 6405 > CHILE'S SALMON ESCAPE DEMANDS ACTION

LETTER

Chile's salmon escape demands action

DANIEL GOMEZ-UCHIDA, MARITZA SEPÚLVEDA, BILLY ERNST, TAMARA A. CONTADOR, SERGIO NEIRA, AND CHRIS HARROD Authors Info & Affiliations

SCIENCE · 31 Aug 2018 · Vol 361, Issue 6405 · pp. 857-858 · DOI: 10.1126/science.aau7973

220 1

After heavy winds and stormy conditions, about 650,000 salmon recently escaped from a net-pen aquaculture facility in southern Chile (*1*). This unintentional influx of salmon, a potentially invasive species in Chile (*2*), is just the latest of many escapes of farmed salmon and trout (*3*). The escape of these non-native species highlights the risk that such aquaculture facilities pose to native ecosystems (*3*, *4*).

FOOD FOR THOUGHT

'Environmental Nightmare' After Thousands Of Atlantic Salmon Escape Fish Farm

Global NEWS

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Norway charts fall in escaped salmon

By Vince McDonagh - 20th June 2022

Nearly all Atlantic salmon escape B.C. fish farm pen after damaging fire

By Sean Boynton · Global News
Posted December 22, 2019 4:02 pm · Updated July 7, 2023 1:01 am

Atlantic Salmon Example

Farmed salmon population of Norway

150,000,000

Wild salmon population of Norway

600,000

Escapes per year in Norway

200,000

Total farmed salmon harvested global

300,000,000

Total wild salmon global population

2,000,000

Escapes worldwide

1,500,000

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FISH

How a salmon farm disaster changed Northwest aquaculture forever

Thousands of salmon escaped into the Puget Sound. Then the controversy began.

Norway has the strictest aquaculture regulations in the world. Will other countries follow suit?

Researchers see big differences in the regulation of fish farming industries in countries that have wild salmon.

Anna Valberg
HEAD OF INFORMATION

Presented by:
FRIDTJOF NANSEN INSTITUTE

Wednesday 19. October 2022 - 10:58

Anti-Salmon-Farming Activists Are Playing a Global Game of Whack-a-Mole

Increasing regulation in several countries is forcing open-net-pen salmon farmers to pack up shop. But then what happens?

by Ashley Braun

May 3, 2023 | 1,300 words, about 6 minutes

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NATURAL RESOURCES

B.C.'s fish farming industry is in murky waters thanks to government regulations

Andrew Findlay Jul 6, 2023

AMERICAN AQUAFARMS PROPOSAL FAILS TO MEET REQUIREMENTS: A Q&A WITH ASF'S JOHN BURROWS

Maine Regulators Terminate Proposal for Massive Aquaculture Project

BY TOM CHENEY (TCHENEY@ASF.CA) AND JOHN BURROWS (JBURROWS@ASFMAINE.ORG)

Apr 22, 2022

NewScientist

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Life

Breeding with farmed fish is changing the life cycle of wild salmon

The evolutionary fitness of Atlantic salmon is being damaged by genetic contamination as wild fish breed with escapees from fish farms

By Adam Vaughan

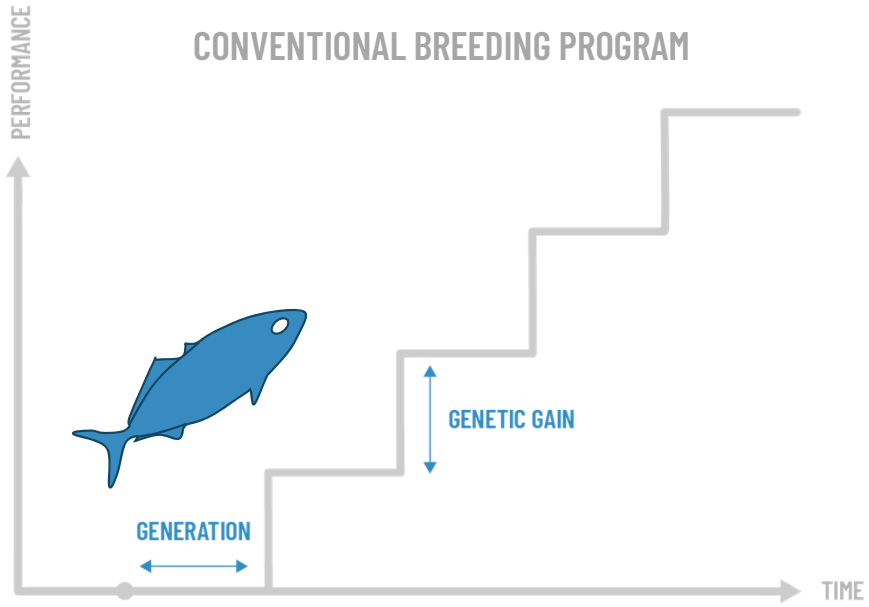
22 December 2021

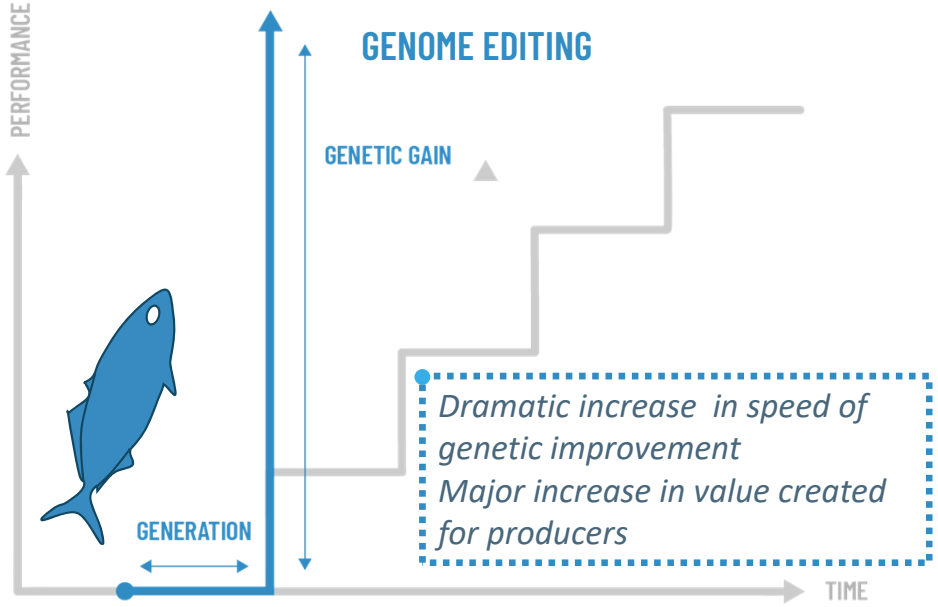
Other Examples

- Endangered cichlid populations and invasive potential of tilapia
- Seriola breeding programs in Hawaii limited to stocking F1, native species
- Many aquaculture regions are restricted to stocking native species

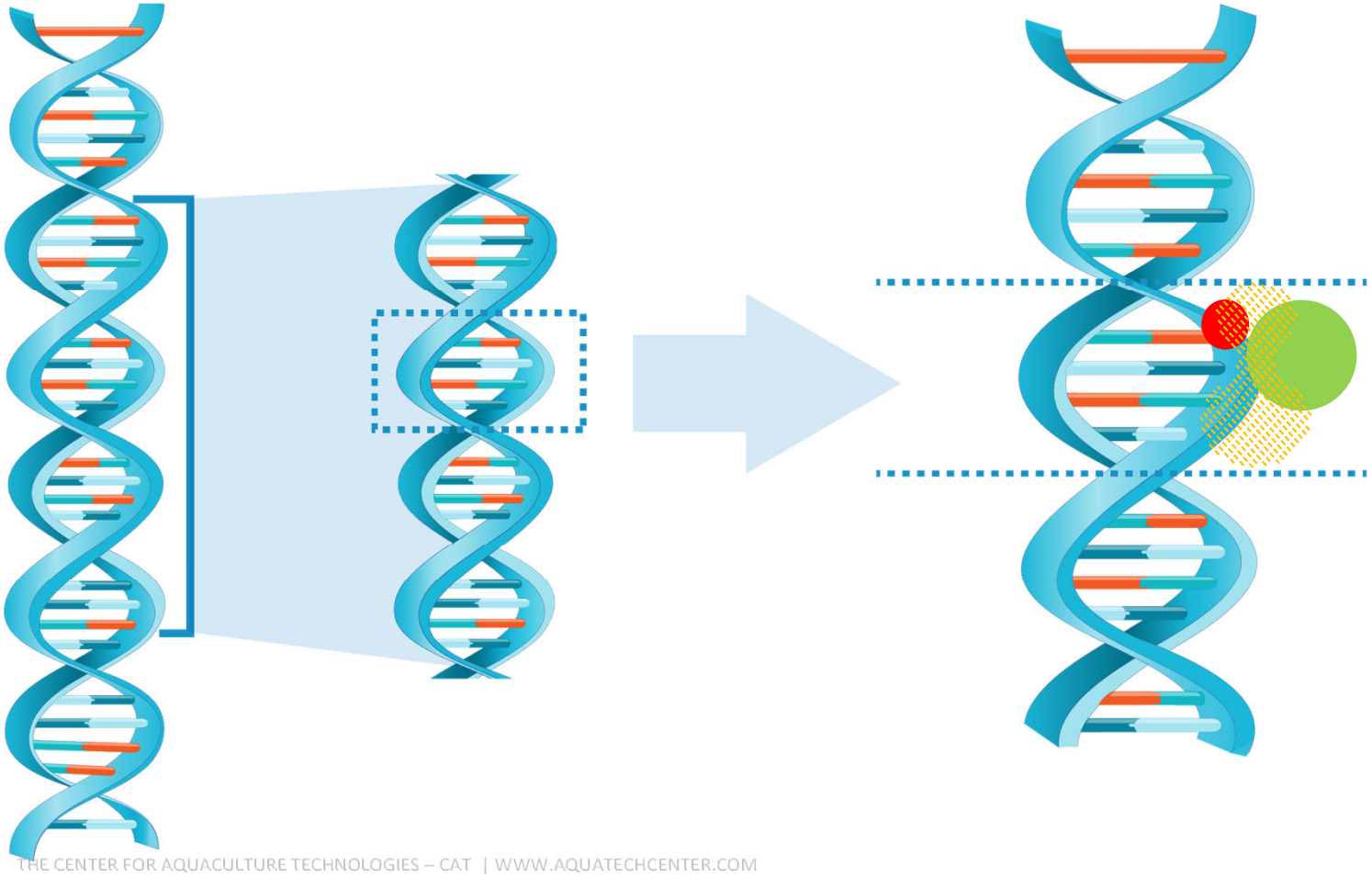
GENOME EDITING ACCELERATES GENETIC IMPROVEMENT

- Sterility
- Growth
- Yield
- Reduced environmental impact
- Feed efficiency
- Sex control: Monosex
- Disease resistance
- Survivability
- Reproduction
- Environmental tolerance
- Product quality
- Nutritional benefit



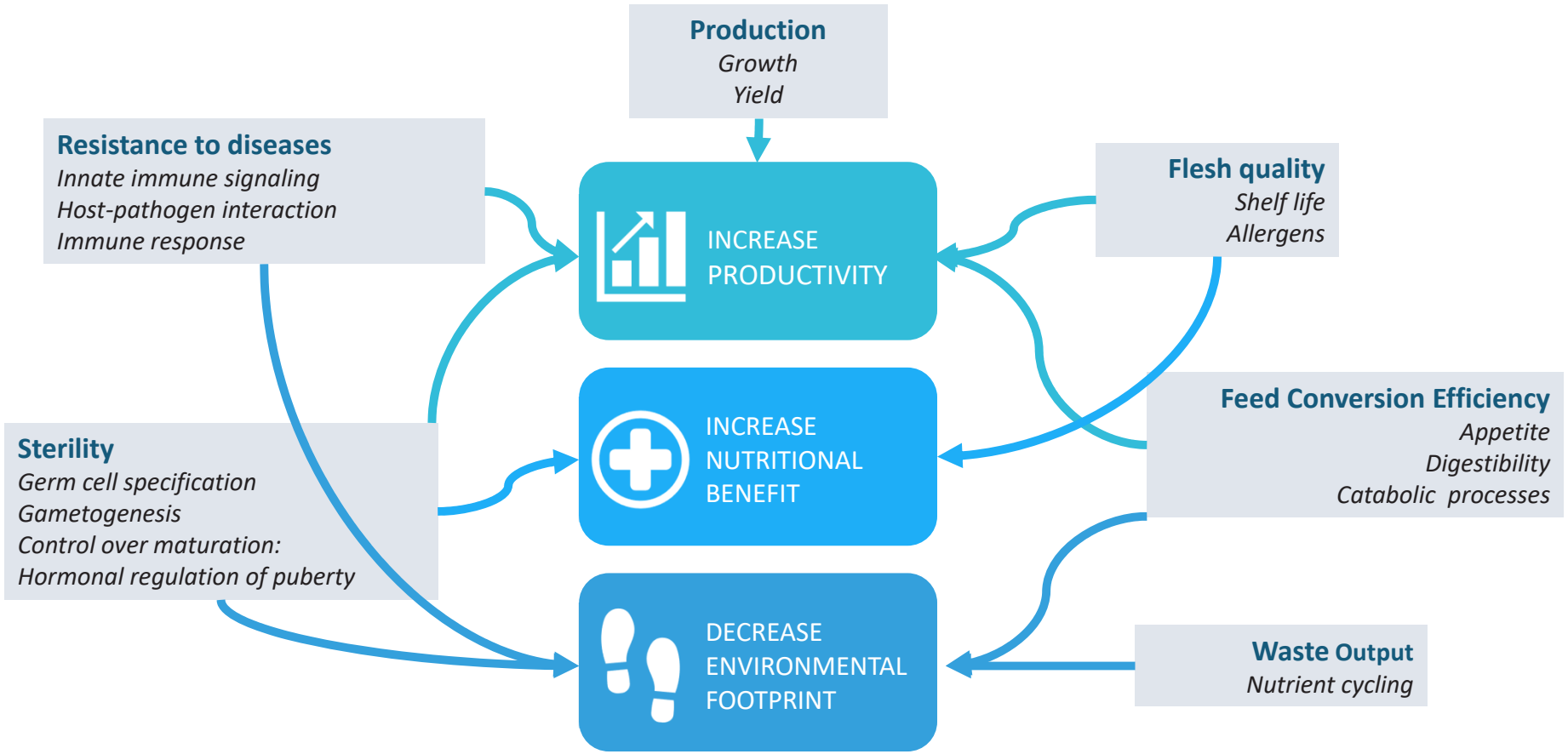


GENOME EDITING (GE)



- CRISPR
- New variant
- No new DNA

GENOME EDITING (GE) APPLICATIONS FOR AQUACULTURE



MOST FARMED GE AQUATIC SPECIES SHOULD BE 100% STERILE

- All aquaculture species are relatively wild
- Much of fish farming takes place within the wild environment
- Escapees could outcompete or interbreed with wild counterparts
- It is irresponsible to add major genetic changes like GE without sterility

Sterility

- Biocontainment is the key and 100% sterility is a direct route
- Eases regulatory burden for GE and subsequent biotechnologies for fish
- Allows commercialization of genetic improvement (protects investments in genetics)
- Improves performance in grow-out

* Animals raised in RAS environment may not require sterility

CAT regards sterility as a fundamental requirement for commercial application of Genome Editing in farmed aquatic animals.

Performance Benefits for Sterility

Growth Rate

Higher growth rate with redirection of energy from reproduction to somatic growth when maturation starts during growout

Uniformity in Size

Variation in growth rate associate with sexual maturation is minimized

Feed Conversion Efficiency (FCE)

Absence of re reproductive activity reduces energy expenditure and improves feed utilization

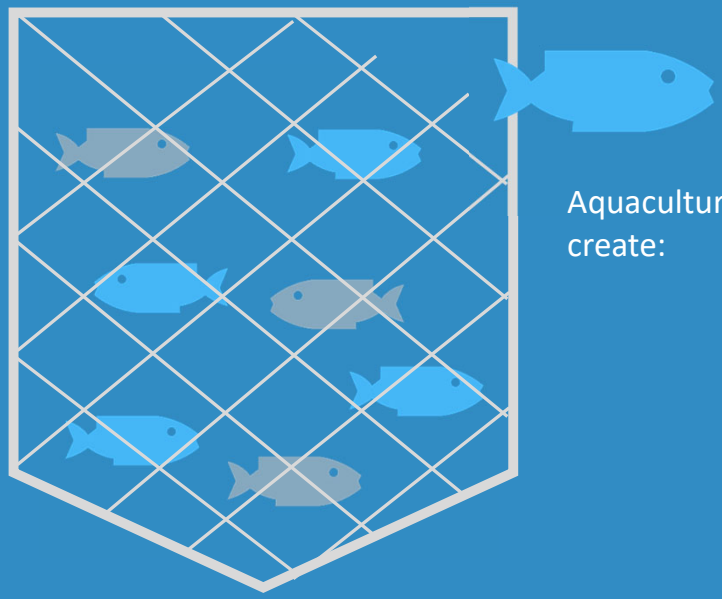
Behavioral Aspects

Reduced maturation behaviors such as aggression improve growth rates due to less stress and energy expenditure.

Economic Viability

Trait improvement directly relevant to profitability

Existing Concerns with Aquaculture

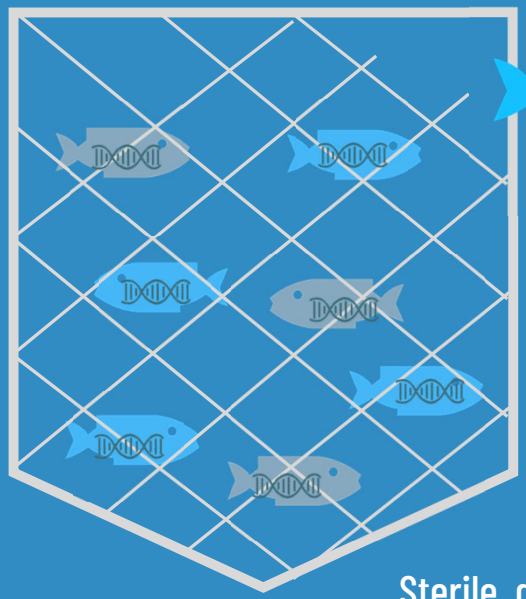


Aquaculture escapees may create:

- Genetic Contamination
- Decline in biodiversity
- Feral populations

Effective containment prevents farmed species' escape and minimize impacts on the environment and native species.

Sterility Is Part of the Solution



Sterile GE fish
minimizes the ecological and genetic impact on native species and habitats.

- Prevents Reproduction
- Ecosystem Balance
- Native populations
- Sustainable Aquaculture

Sterile, gene-edited animals provide solution to the escapee problem by addressing the root causes of ecological disruption, rather than simply managing the consequences.

Genome Editing Produces 100% Sterile Fish for Aquaculture

Genome edited broodstock
Fertile throughout adult life

Natural mating

100% sterile progeny

Commercial production

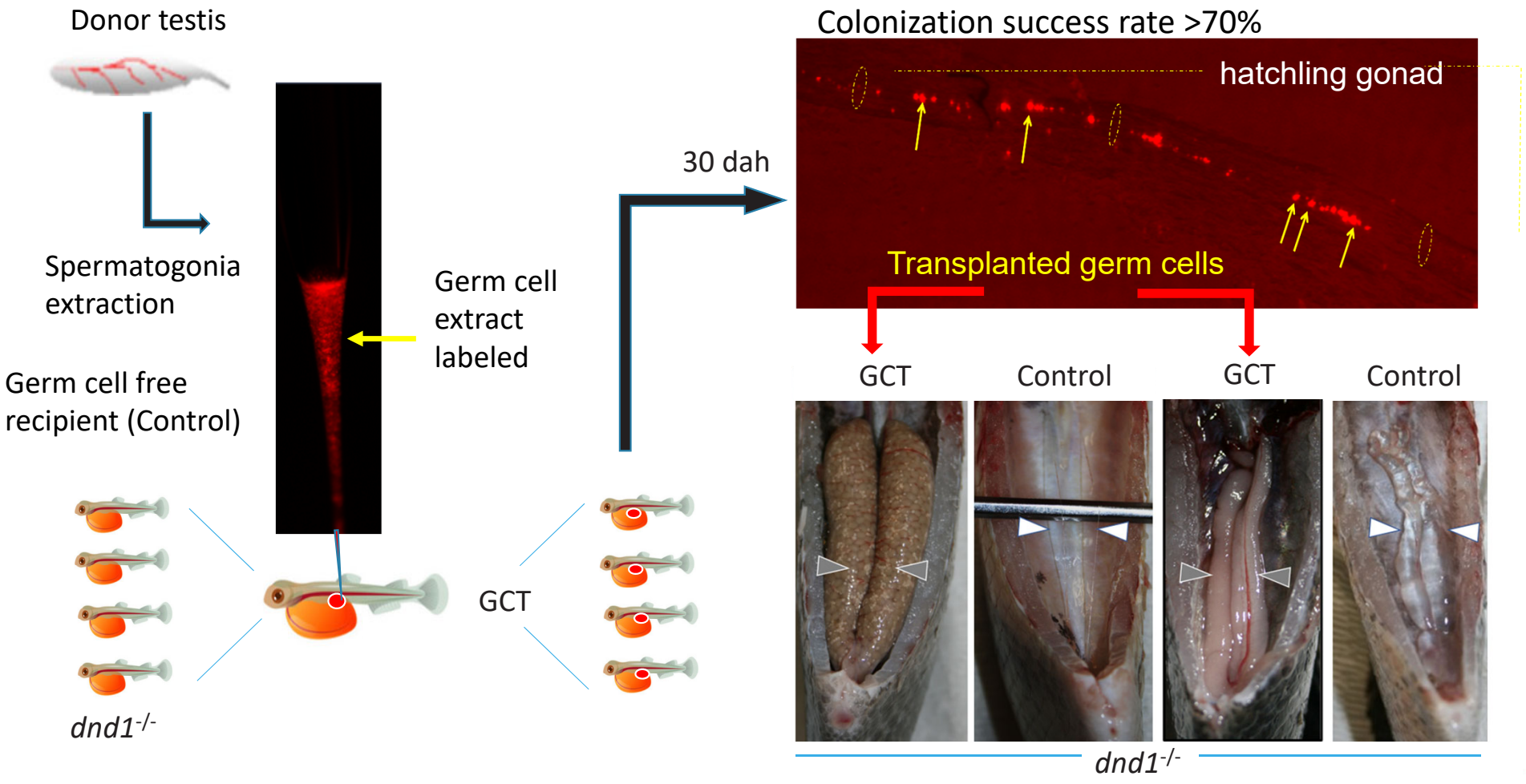
Value to producer, environment, and genetic improvement

♀ All female population

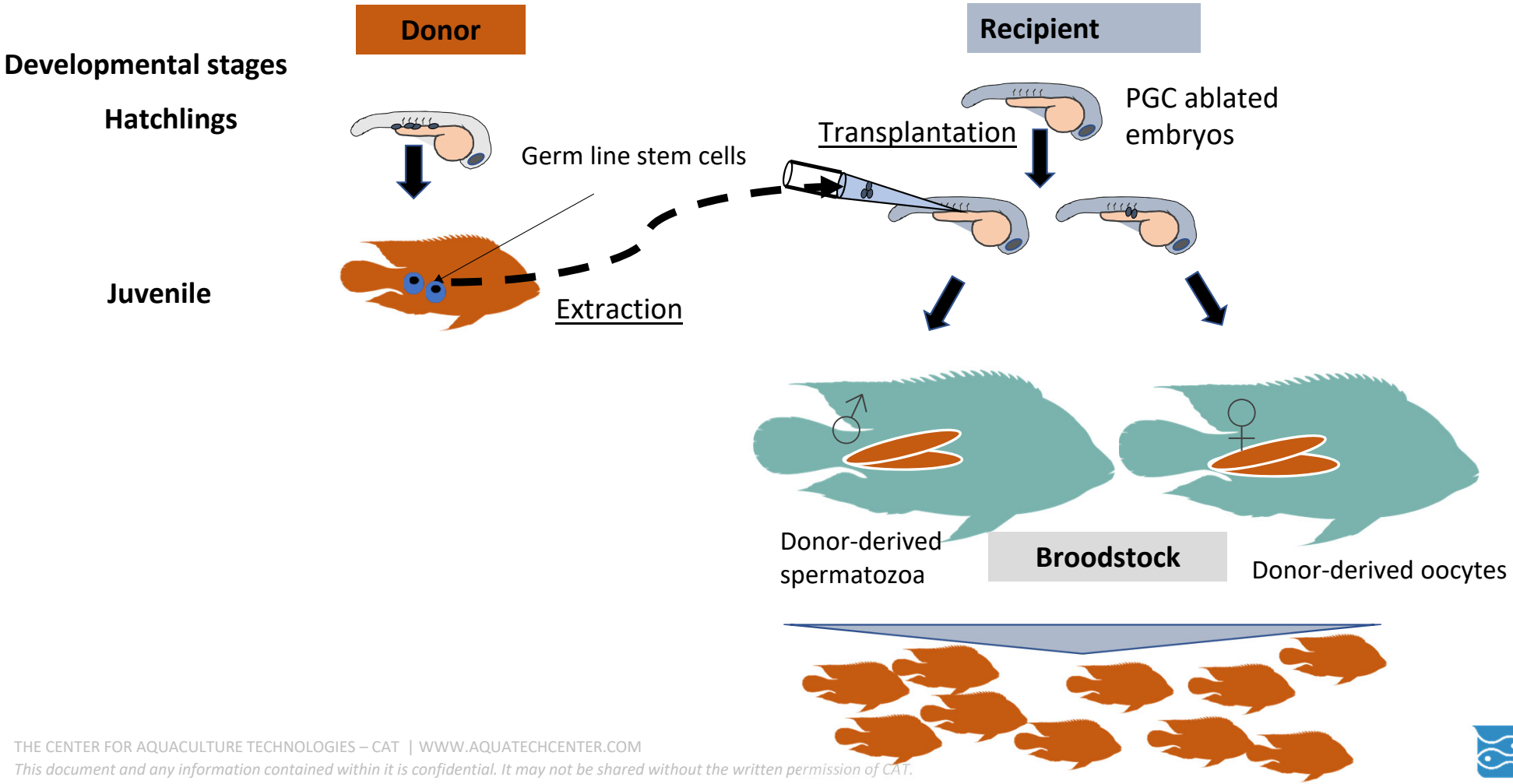
♂ All male population

METHOD OF GENERATING STERILE AND MONOSEX PROGENY
(US2019/046088; August 2019; Assignee: CAT)

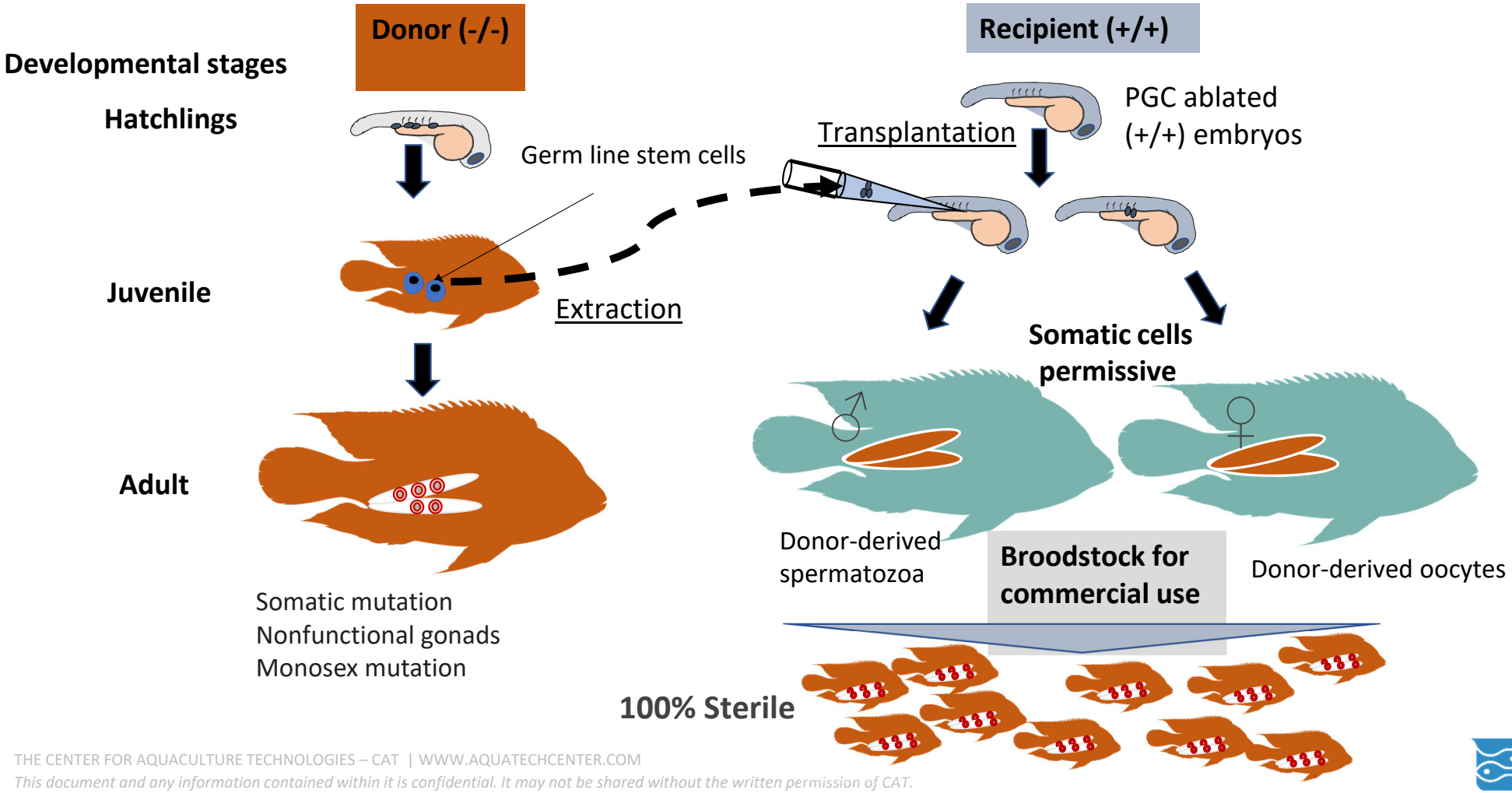
Efficient transplantation of germ cells into host embryos



Propagation via germ cell transplantation



Sterility via germ cell transplantation



Genome Editing Produces 100% Sterile Fish for Aquaculture

Genome edited broodstock
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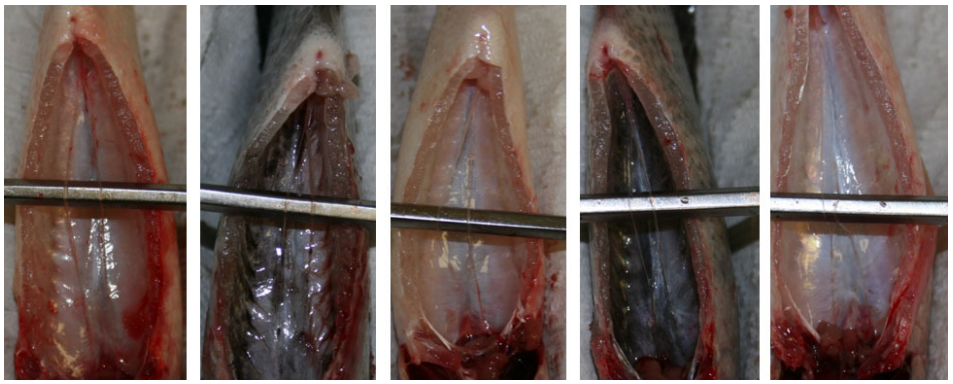
Value to producer, environment, and genetic improvement

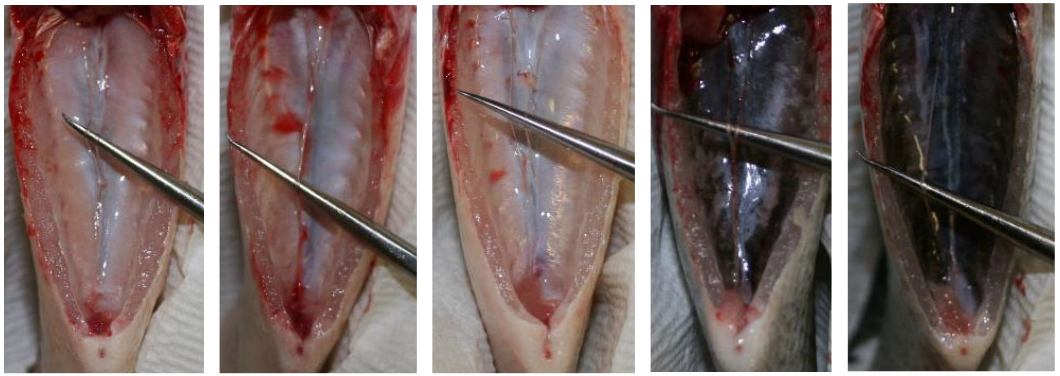
METHOD OF GENERATING STERILE AND MONOSEX PROGENY
(US2019/046088; August 2019; Assignee: CAT)

Sterility Is Stable

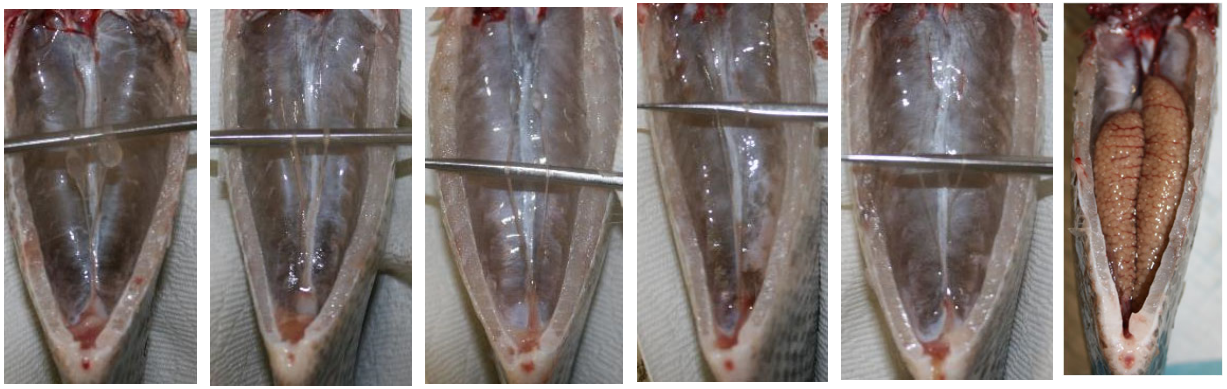
4 month



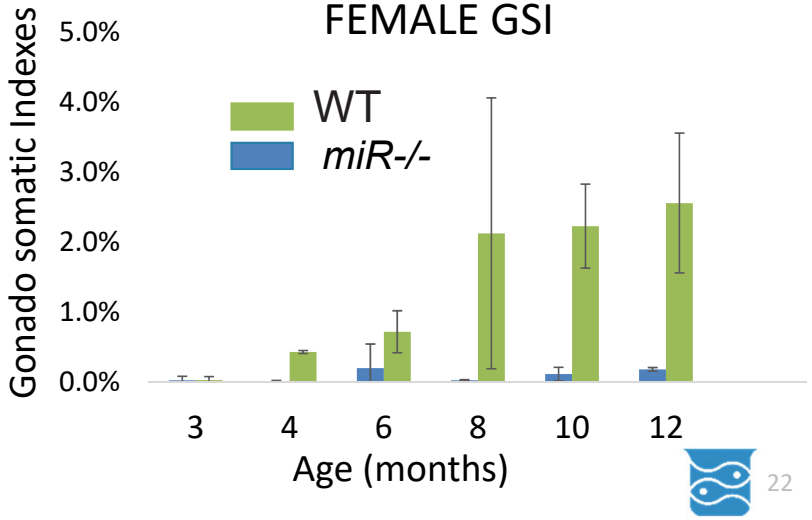
6 month



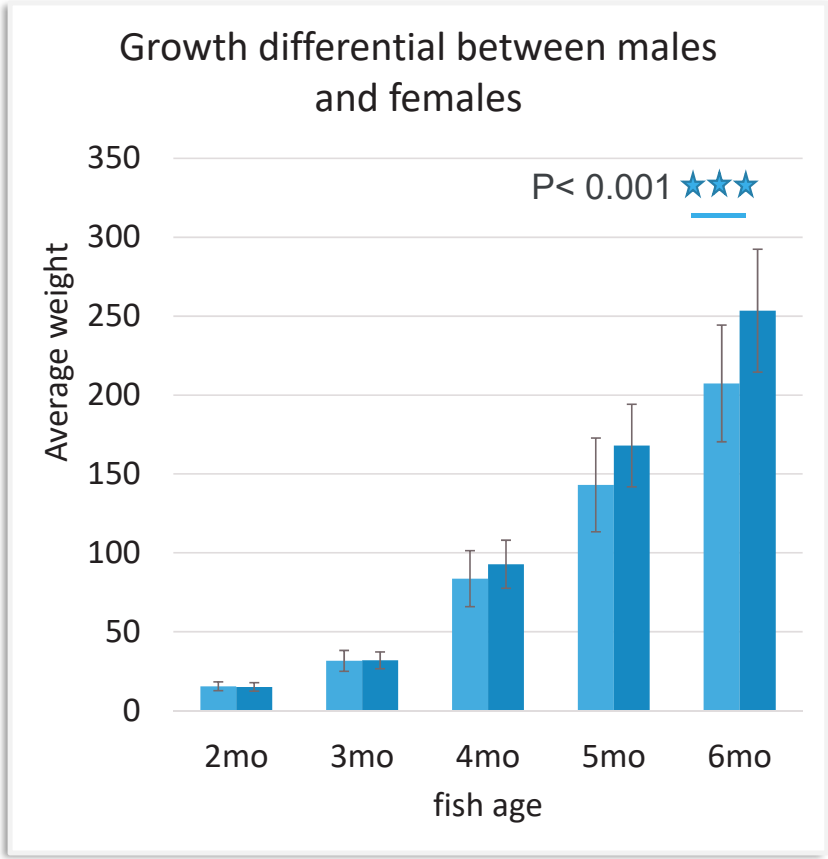
12 month



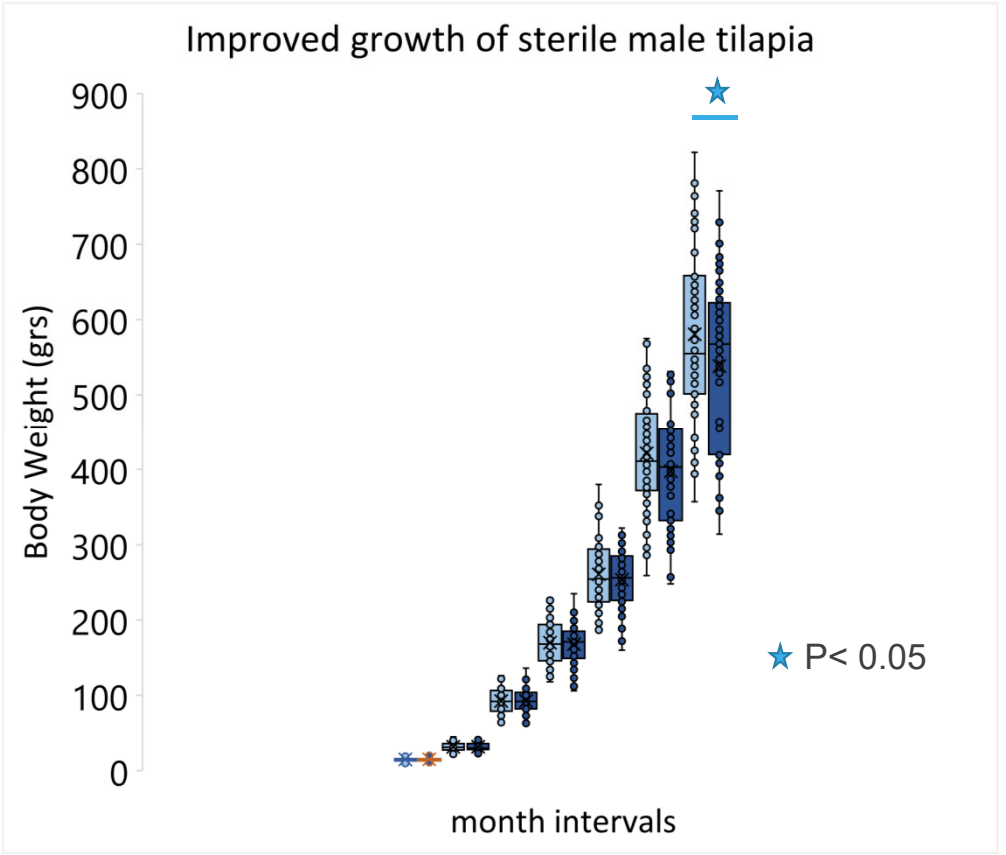
WT control



Growth benefits of all-male and sterile tilapia



+22% Males >Females



+12% Males Sterile > Males Fertile

Gene Edits Increase Performance in Tilapia

	Growth	Feed Efficiency	Filet Yield
Gene 1	68%	12%	nd
Gene 2	43%	11%	nd
Gene 3	8%	6%	35%

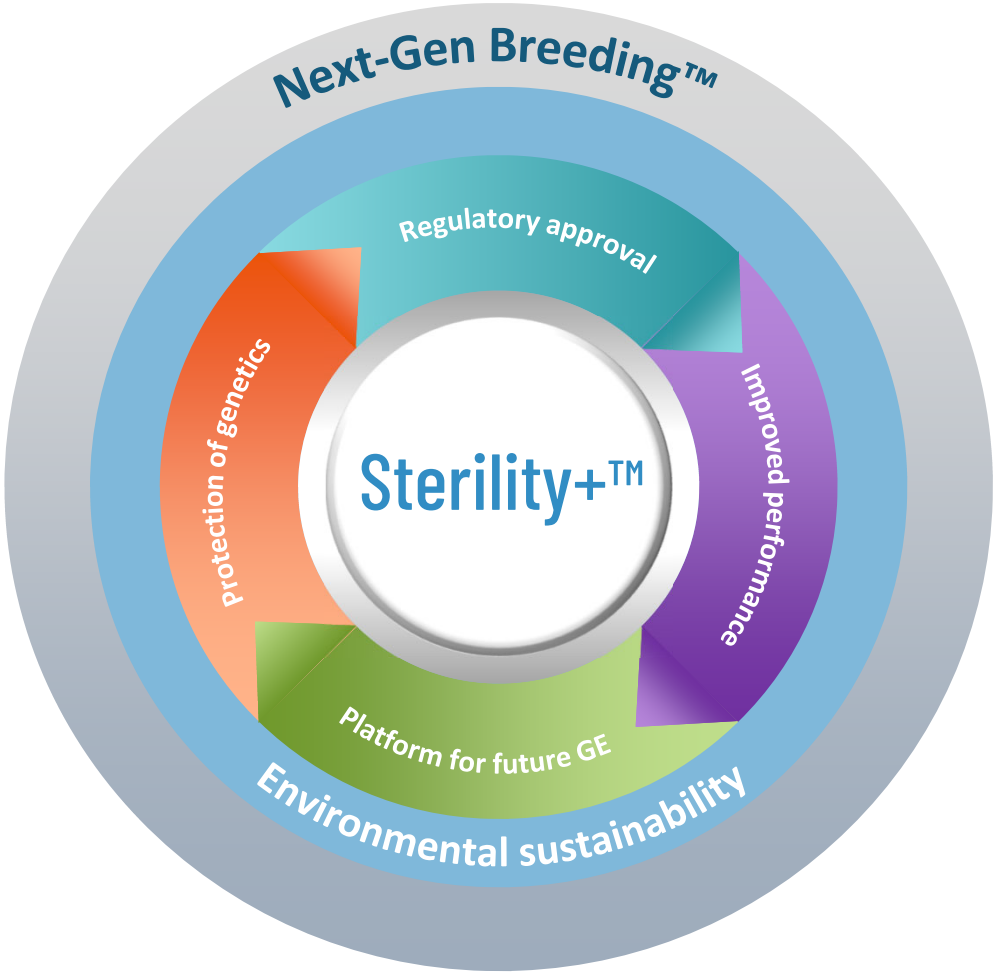
The Technology

Sterility+™ is a foundational technology

We believe sterility will be a requirement for the implementation of GE in aquaculture

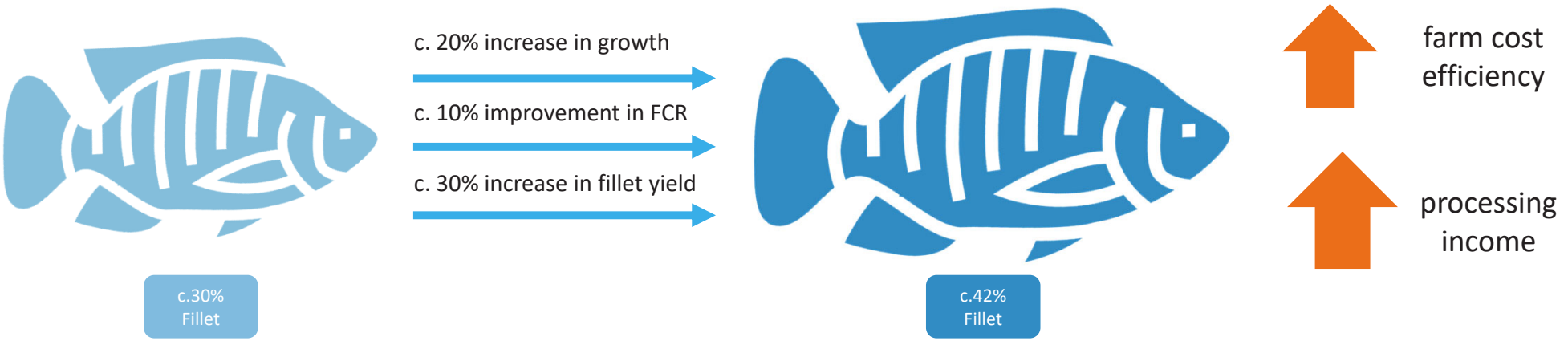
CAT has technology that can deliver 100% sterility in fish species, along with other benefits in performance.

Sterility + performance gains = Sterility+™



TRANSFORMATIONAL VALUE OF STERILITY+

- Genome Editing provides the opportunity for a transformational shift in profitability for the Brazilian tilapia industry (450k mt)



- Potential value in Brazil:
  - + Increase in value of c. **$260M to farmers and processors**
    - * Above figures assume constant prices – no market correction for improved performance

Summary

- 100% sterility is feasible with a genome editing approach
- Can help address concerns around farming and improve performance in aquaculture
- Can serve as a foundational technology on which to build biotechnologies for aquatic applications
  - Genome editing for traits
  - Solves a major concern of regulators & stakeholders

CAT Team
Xavier Lauth
Takeshi Umazume
Matt Josephson
Ashutosh Pudasaini
Yehwa Jin
Tuong Tran
Matt Stone and Facility Team

THANK YOU!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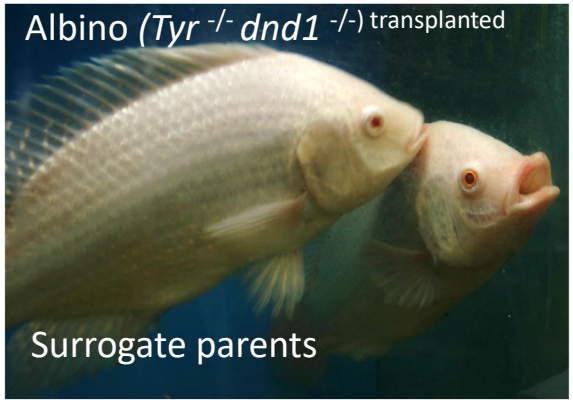
AQUACULTURE
TECHNOLOGIES
DELIVERING **RESULTS** YOU CAN USE.
www.aquatechcenter.com

Transplanted recipient produce all female sterile progeny

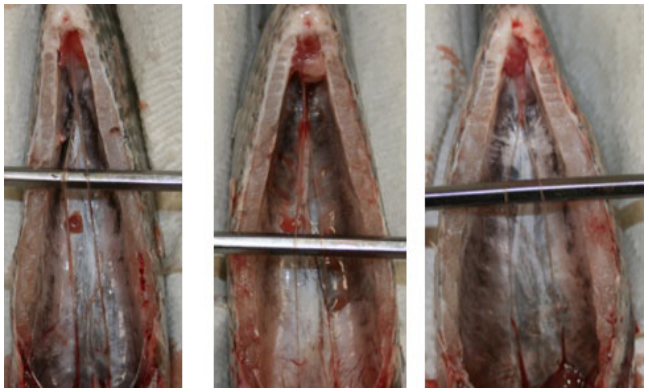


All female sterile progeny

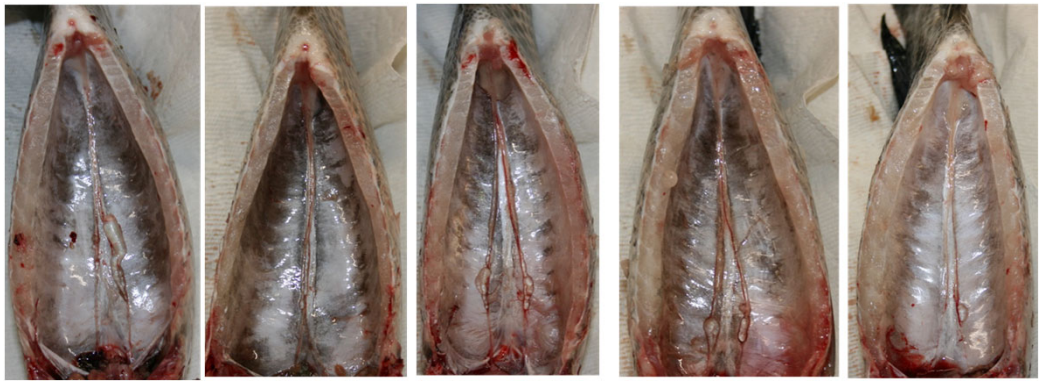
(Gsdf -/-,VTGAa -/-)-6 months old; 2022-(Gsdf -/-,VTGAb -/-)

WT control

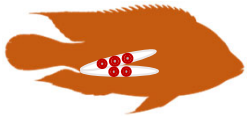
(Gsdf -/-,FSHR-/-)-6 months old

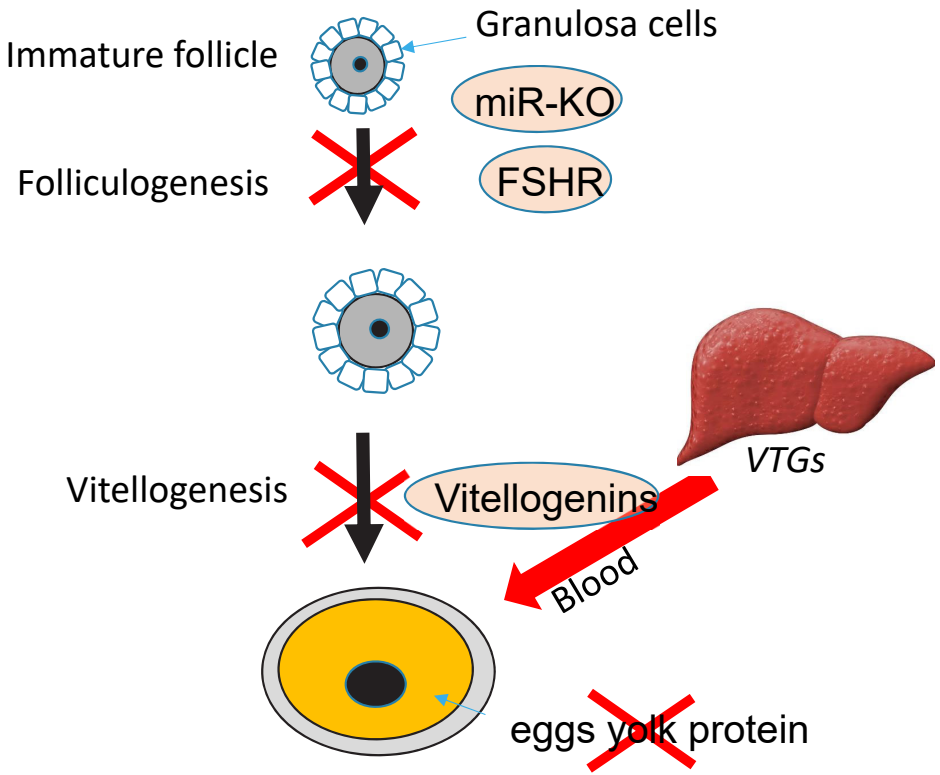


(Gsdf -/-,miR-/-)-6 months old



DISRUPTION OF GENES CONTROLLING OOGENESIS TO PRODUCE STERILE FEMALES

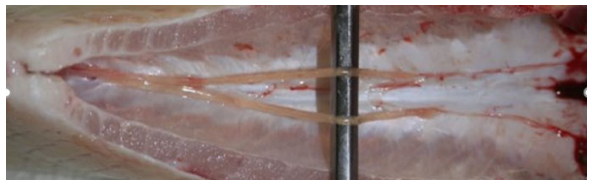




8 months old tilapia females

miR202$^{-/-}$

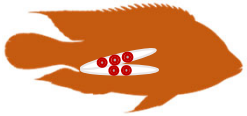
FSHR$^{-/-}$



VTGAb$^{-/-}$

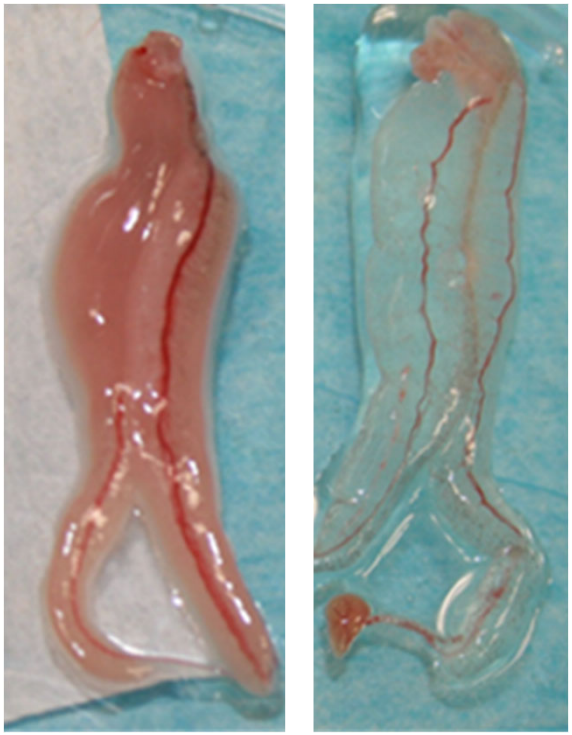
VTGAa$^{-/-}$

STERILITY IN miRNA-KO DEFICIENT TILAPIA MALES

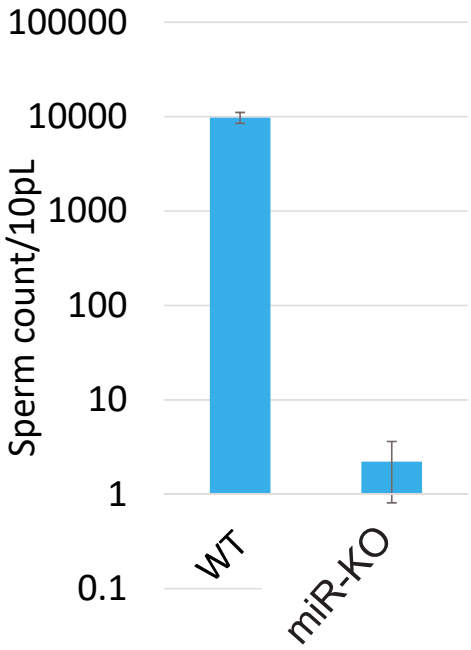


sexually immature

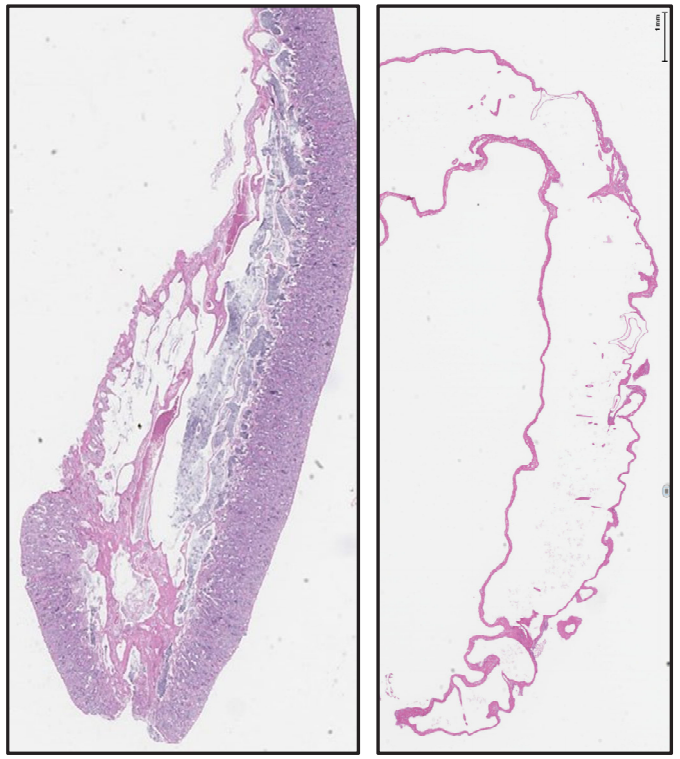
WT miR$^{-/-}$



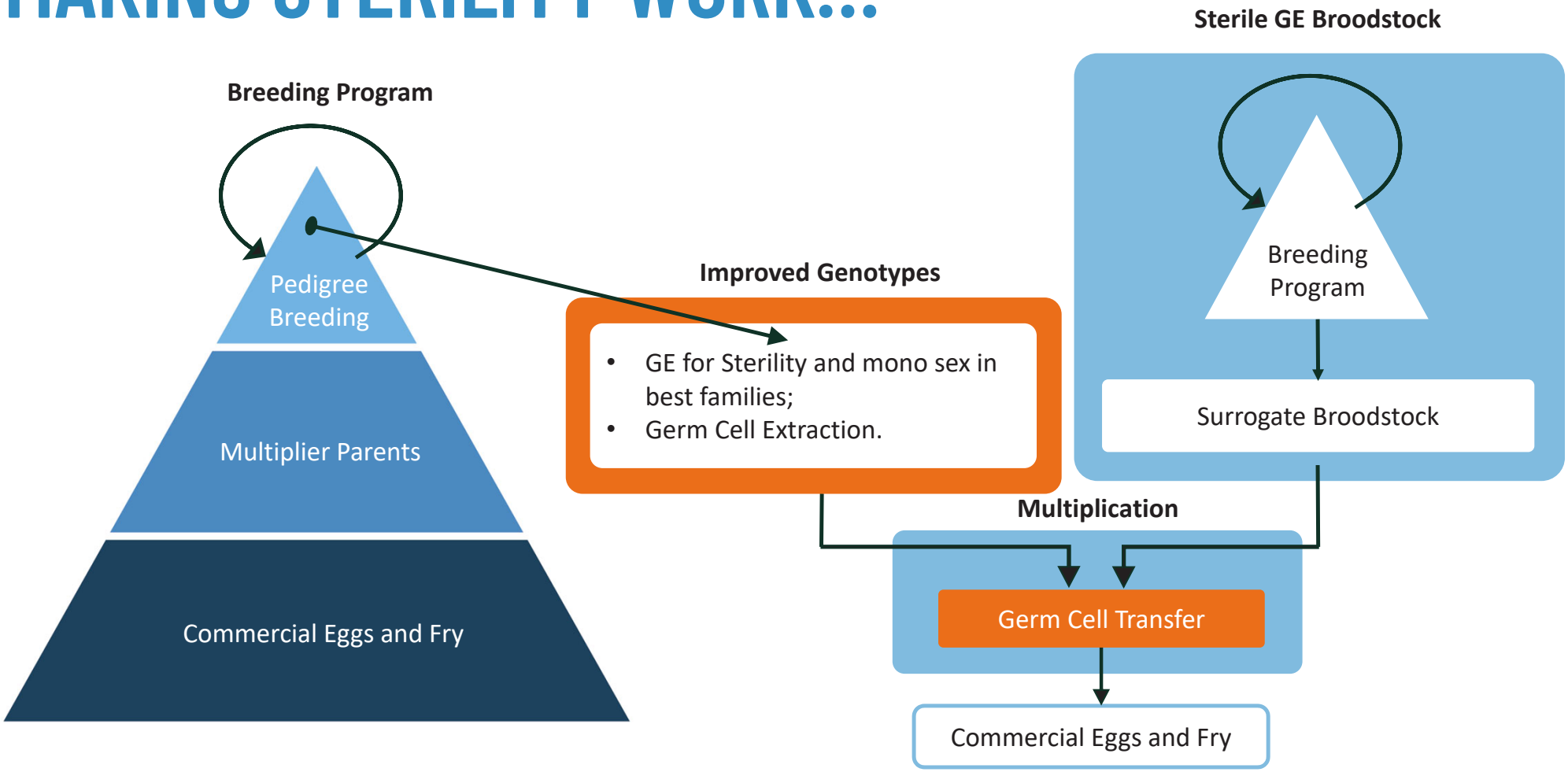
Sperm count



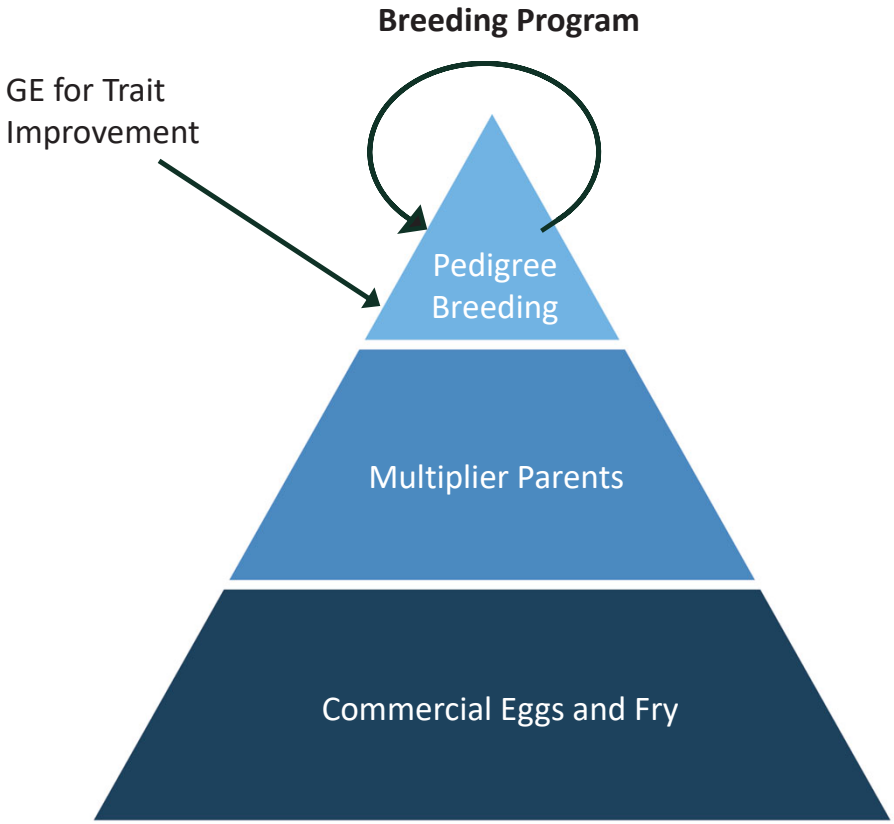
WT miR$^{-/-}$



MAKING STERILITY WORK...

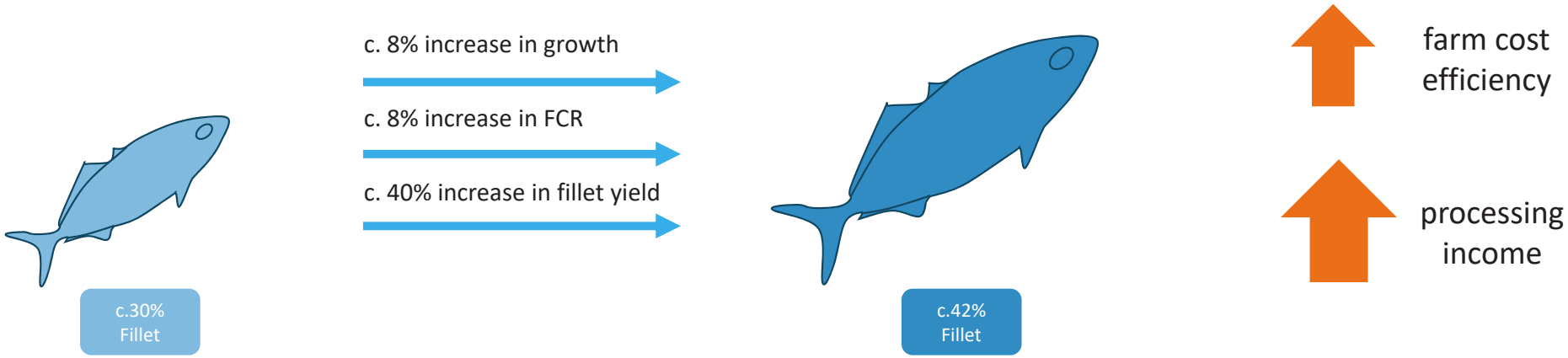


Integrating Edits Into a Breeding Nucleus



TRANSFORMATIONAL VALUE OF STERILITY

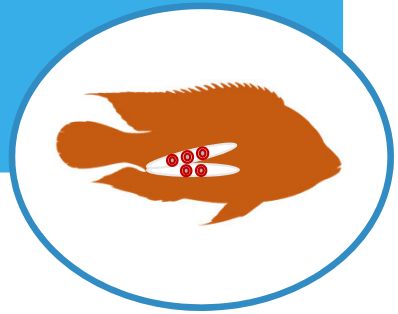
- Genome Editing provides the opportunity for a transformational shift in profitability for the Brazilian tilapia industry (400k mt)



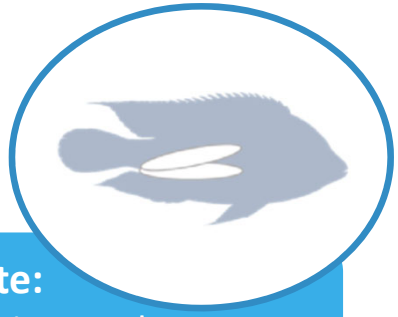
- Potential value in Brazil:
  - + Increase in value of c. **$30m** p.a. to farmers – improved FCR and growth
  - + Increase in value of c. **$230m** p.a. to processors – improved fillet yield
    - * Above figures assume constant prices – no market correction for improved performance

The sterile, monosex donor:

- Genome Editing to block sexual maturation and male or female sex determination;
- Non-functional gonads
- Functional germ cells.

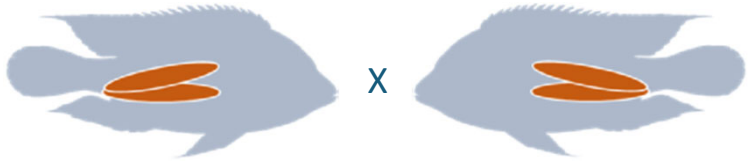


MAKING STERILITY WORK...



The sterile surrogate:

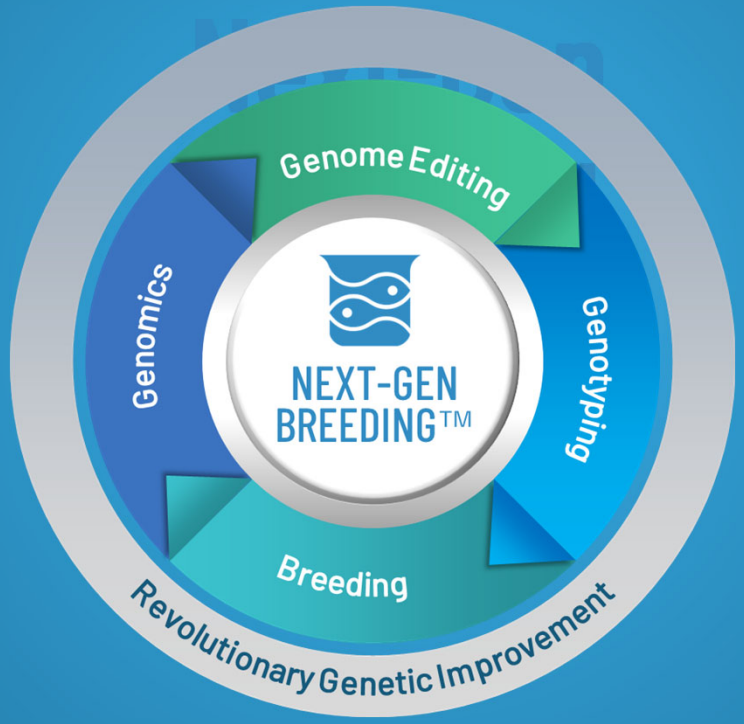
- Agametic fish with functional somatic gonads;
- No germ cells;
- Capable of propagating donor germ cells.



The transplanted surrogate:

- Mature males and females are fertile;
- Mass production of sterile, monosex, offspring.

Delivering revolutionary genetic improvement to aquaculture.



Next-Gen Breeding™ is a cutting-edge strategy that combines Genotyping, Breeding, Genomics, and Genome Editing to enhance productivity, protect genetic assets, and support environmental sustainability.