

# Delivering *Innovative Solutions* for Aquaculture...



# Genetic Improvement of Farmed Fish using Biotechnology

Alan Tinch  
12<sup>th</sup> Sept 2022.





# About us

The Center for Aquaculture Technologies (CAT) is focused on the application of technologies to improve productivity, efficiency, and sustainability in the aquaculture industry.

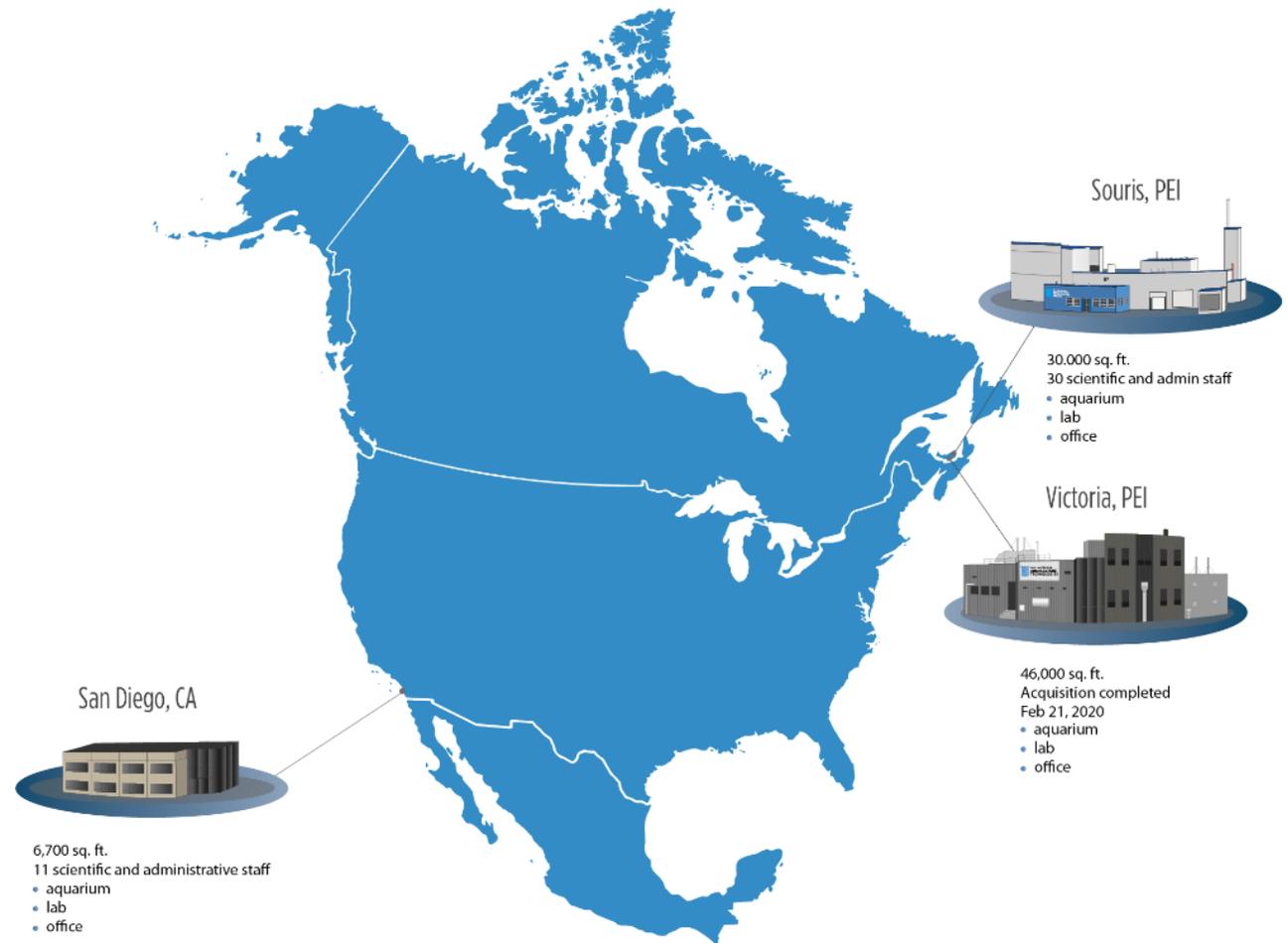
Our world-class research teams and state-of-art facilities are equipped to support a diverse range of projects from discovery through final product development and testing.

Founded in 2012, facilities in San Diego and Prince Edward Island with team members in Australia, Canada and the US

**Experienced**, focused, team of more than 50 aquaculture professionals and technical experts in the fields of health, nutrition and genetic improvement

**Client-focused** service provider facilitating the delivery of new products to market faster

**Leader** in the application of genome editing to aquaculture





# Why us?

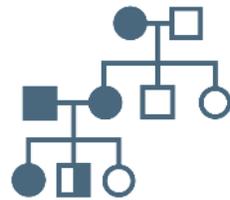
## ALL SERVICES UNDER ONE ROOF



HEALTH



NUTRITION



BREEDING  
&  
GENOMICS



GENOME  
EDITING



GENOTYPING

CAT is home to a unique combination of world-class scientists bringing together complementary expertise in health, nutrition, and genetics working in state-of-the-art facilities to deliver innovative, tailor-made solutions for organizations in the sector.



# Complete scope for innovation in breeding and genetics

## Applied Breeding Team

## Genomics Team

## Analysis Team

## Genome Editing Team

## Genotyping Team

- Breeding program design
- Breeding strategy
- Practical understanding of commercial production
- Consideration of economics and best practices
- Implementation of genomic technologies
- Implementation of genome editing in commercial breeding

- Design new genotyping tools
- Implement new technologies
- Data handling and summarization
- Novel genomic approaches, pipelines for analysis
- Identify targets for genome editing

- Quantitative genetics
- Genomic prediction
- Marker association
- Biostats
- Novel analysis methods
- Database maintenance

- Creation of genome edits
- High throughput methods
- Multispecies
- Innovation in supporting technologies for GE
- Driving innovation
- Sterility for responsible use of genome editing

- Scale to deliver cost-effective genotypes
- Integration with customization for breeding clients
- Support for novel genotyping solutions for breeding problems
- Methods to track genome edits in breeding populations



# What is Aquaculture?



**"In the past 10,000 years we have learned to irrigate, fertilize, and develop hardy breeds of grain and stock. An acre of land, scientifically farmed, is far more useful in human terms than an agriculturally idle one. Yet thousands of years after we abandoned hunting on land as an efficient method of obtaining food, we continue to pursue the creatures of the sea with the attitudes of cavemen.**

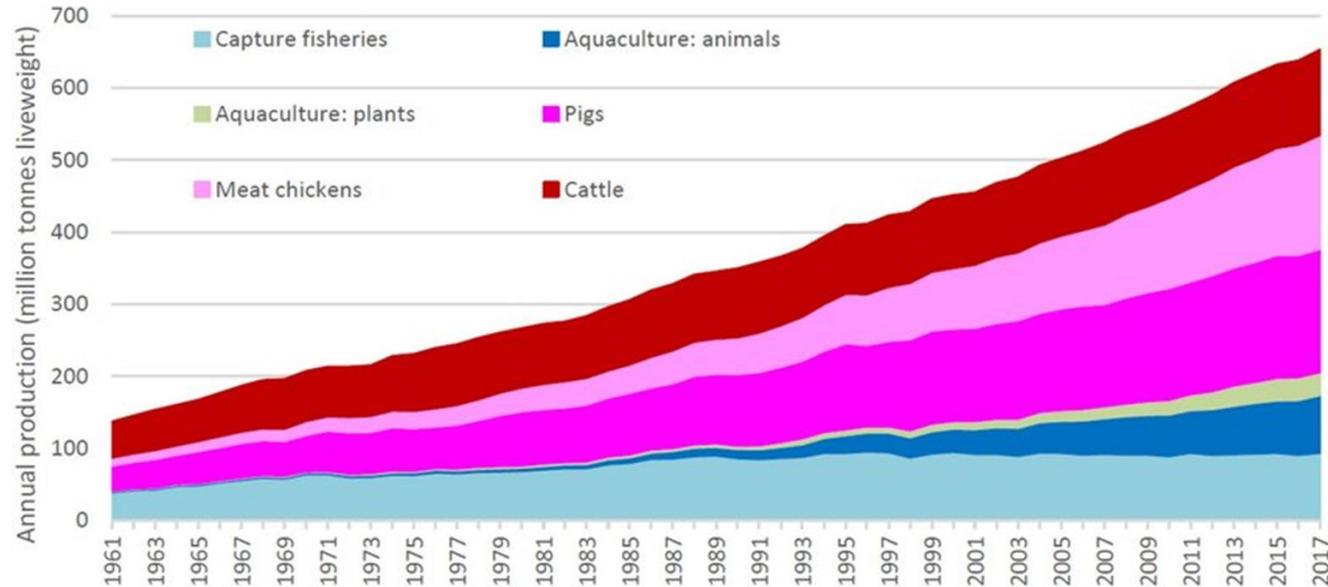
**Ocean farming – mariculture – can protect the natural stock in the sea as well as vastly supplement our food supply."**

**Jacques Cousteau, 1979**

**"Farming not hunting..."**

**Alan Tinch, 2022.**

## Where are we now, and Where are we going?



↑ JC quote...

***Aquatic breeding programmes need to be efficient and learn from terrestrial species...***

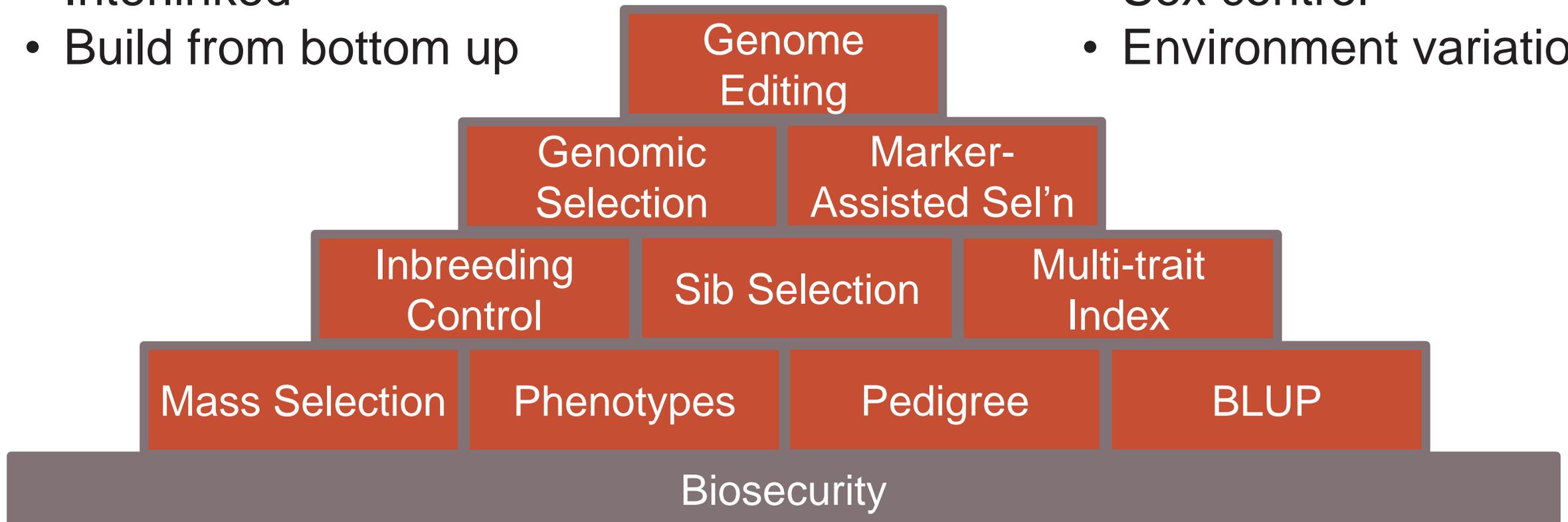
- Cattle, Chickens and Pigs are each 1 species
- Aquatic animals are many species, at least 20.



# How to build a breeding program...

- Strong foundation
- Cumulative added value
- Interlinked
- Build from bottom up

- Biology
- Ploidy – sterility
- Sex control
- Environment variation





## Why?

**We can improve the difficult traits that we couldn't change before!**

- **Sterility**

*Because we don't want our GE animals to reproduce in production or in the wild...*

**Sustainable** - Minimum effect on environment.

- **Sex**

*Because sometimes we only need males or females...*

- **Disease Resistance**

**Animal Welfare** - *Because it's wrong to let animals suffer with disease, and with gene editing we can give natural selection a little boost...*

**Sustainable** - Antibiotic Resistance and Parasite treatments

- **Environment**

*Because improving **sustainability** helps feed people and protect the planet*

- **Economics**

*Because improved growth, efficiency and yield increase **sustainability***



# Genome Editing – Operating Environment

- Gene edits are indistinguishable from natural mutations;
  - Legislative, not scientific issue;
  - Breeders have systems to monitor individuals and populations.
- Breeders will make variants that adapt animals to farm environments;
  - Animal breeders will adapt animals to the farming environment;
  - GE is a tool to increase speed and range of adaptations.
- Wild animals are adapted to native environment by natural selection;
  - Fish farming generally occurs in an open environment;
  - Interbreeding of wild and farmed fish will decrease the fitness of wild populations.



## Concerns:

- Fish farming takes place in the wild environment
- Breeders will GE to deliver big effects on phenotype
- Introduction of novel species for biocontrol often has unintended consequences.
- Escapees could outcompete or interbreed with wild counterparts
- Genes interact with other genes – effects can be unpredictable in different backgrounds and environments.



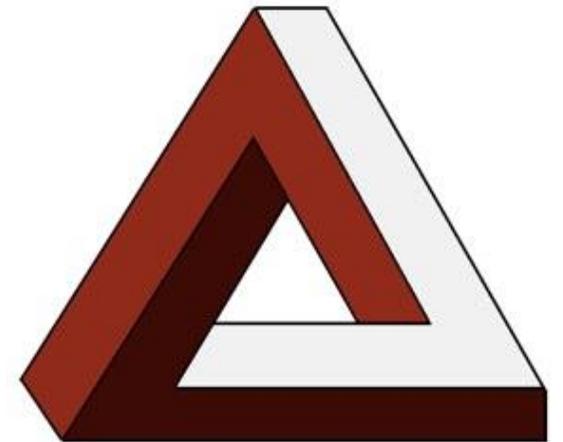
***Gene edited farm animals should be sterile...***



# The Infertility Paradox

1. Animal breeders breed for improved performance. They need many **fertile** animals.
2. Producers want many high-performance, **infertile** animals.
3. But an animal can't be **fertile** and **infertile** at the same time...

**How can we breed for infertility?**

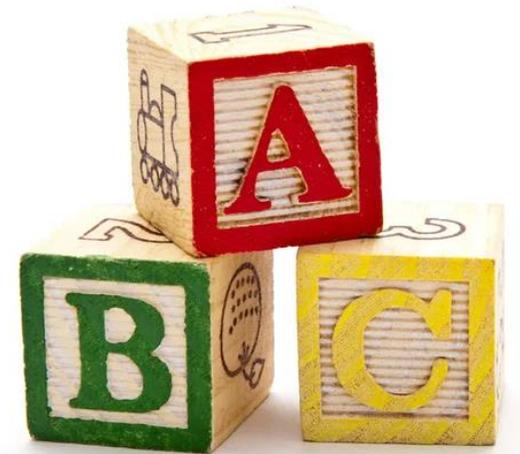


Escher



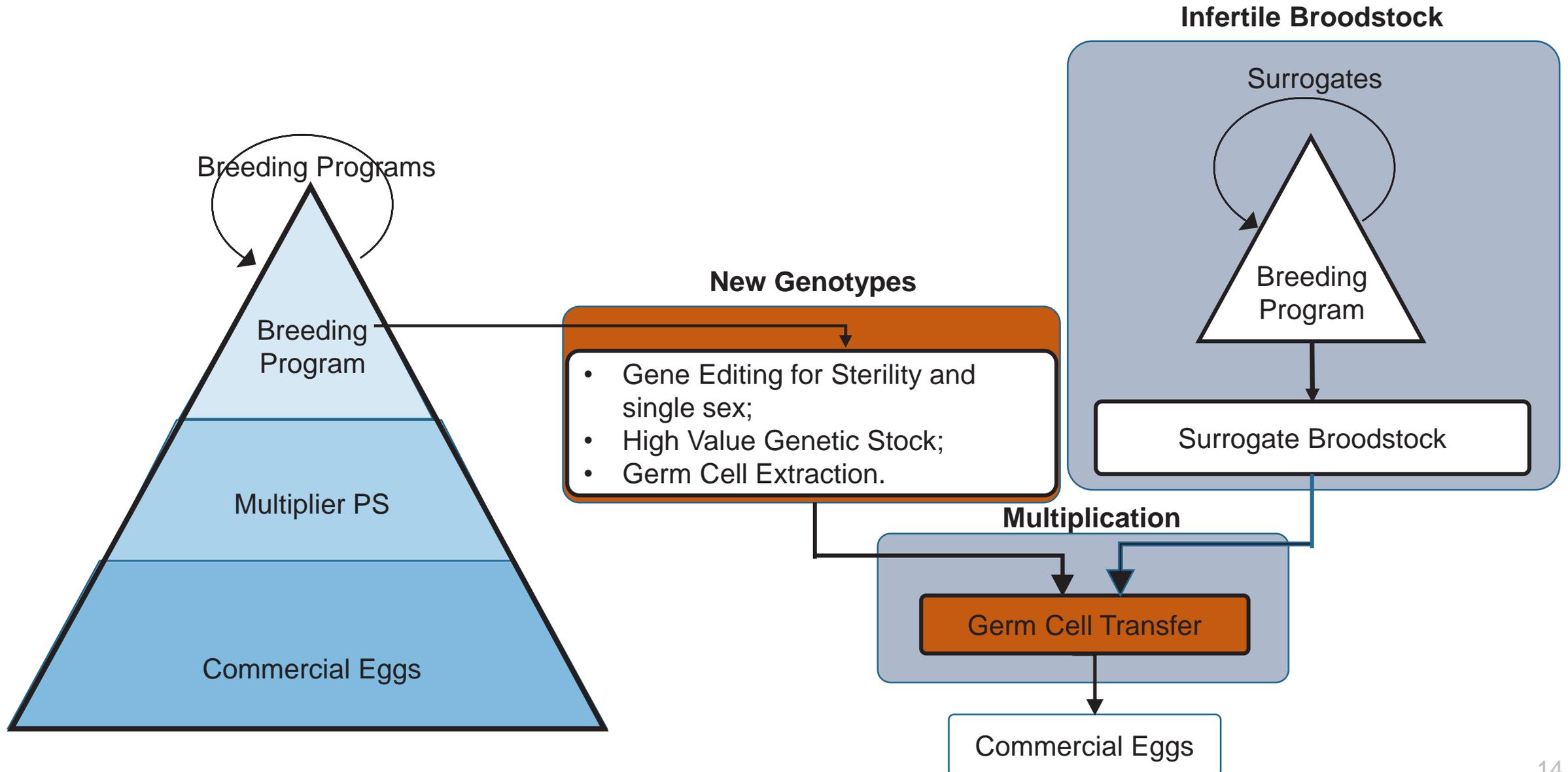
# The Infertility Paradox – resolved.

- A. Develop desirable strains, and make infertile using gene editing;
- B. Transfer germ cells to fertile, surrogate broodstock;
- C. Breed surrogate broodstock to produce many infertile offspring...





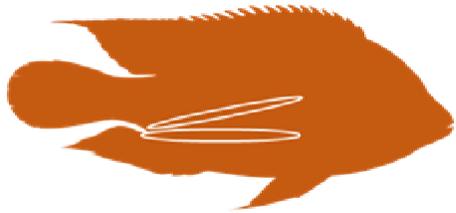
# Making it work...



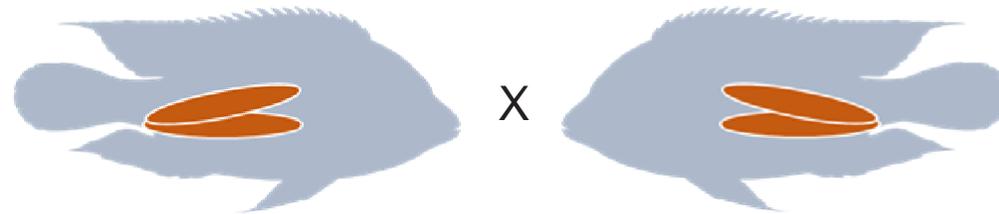
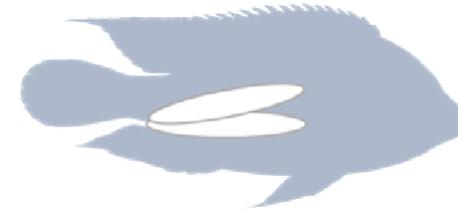


# Making it work...

- **The infertile monosex donor:**
- GE to block male or female sex determination and sexual maturation.
- Inactivated genes only affect the somatic cells of the gonad.



- **The sterile surrogate:**
- Agametic fish with intact somatic gonads.
- Capable of nursing donor germ cells.



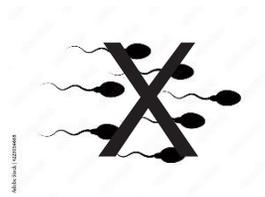
- **The transplanted surrogate:**
- mass production of monosex, infertile offspring



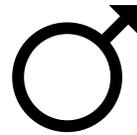
# Results you can use.

- At CAT we have in finfish:

- GE for Sterility



- GE for Sex control



or



- GE for Functional Traits



- Collaboration with breeders and producers to deploy the technology



# Context – “The sea has fish for ~~every man~~ everybody”

- Aquaculture is many species
  - Fin-fish, Crustaceans and Shellfish
- Conventional technology:
  - Ploidy, monosex / sex reversal, protoandric/gynic hermaphrodites
- GMO is already in market
  - AquAdvantage salmon
- GE reported in many fish species, with licences in several countries
- Genome Editing:
  - Knock-out and knock-in
  - Knock-down

***Regulation needs to embrace the range  
of current and future technologies***

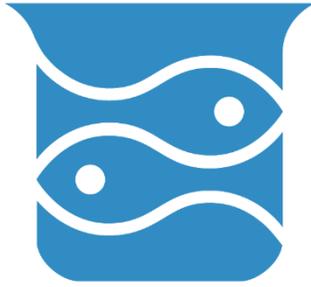


# How do we get there?

- Genome editing – indistinguishable from natural mutation;
- Sustainable improvements in performance – especially with sterile animals;
- Unethical not to use technology if it can be used to improve health, welfare and sustainability of farming animals.

***We understand from experience that scientific advances can be deployed to deliver a range of outcomes.***

***We should assess and deploy new technology to improve systems, not dismiss it because there are potential negative consequences...***



**THE CENTER FOR  
AQUACULTURE  
TECHNOLOGIES**

**Thank You**

**HAVE MORE QUESTIONS? REACH  
OUT TO US DIRECTLY:**

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