# Harnessing Efficient Genetic Improvement to Maximize Economic Return

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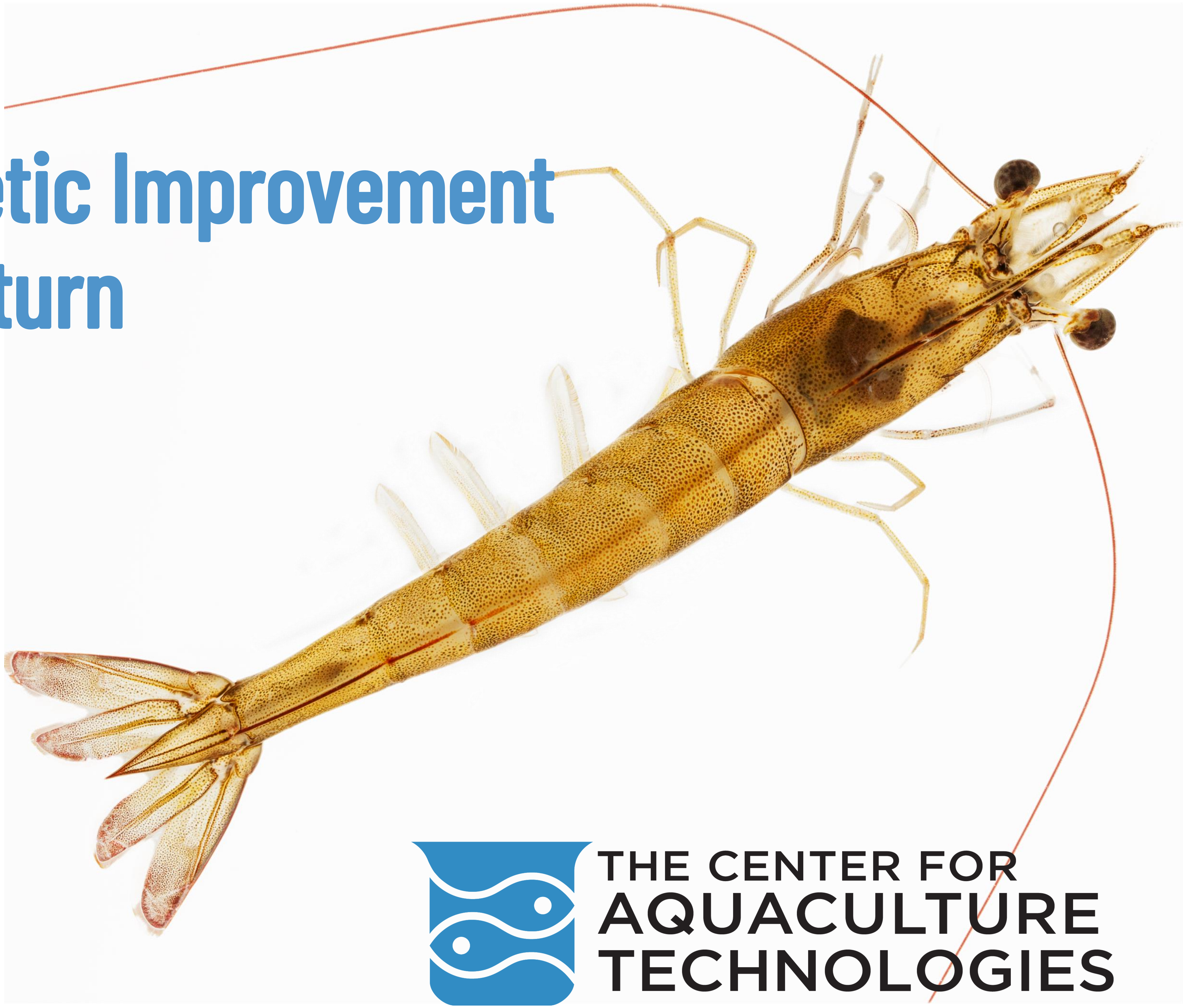


THE CENTER FOR AQUACULTURE TECHNOLOGIES

# SERVICES

Our 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

101001

## BREEDING

## GENOME EDITING

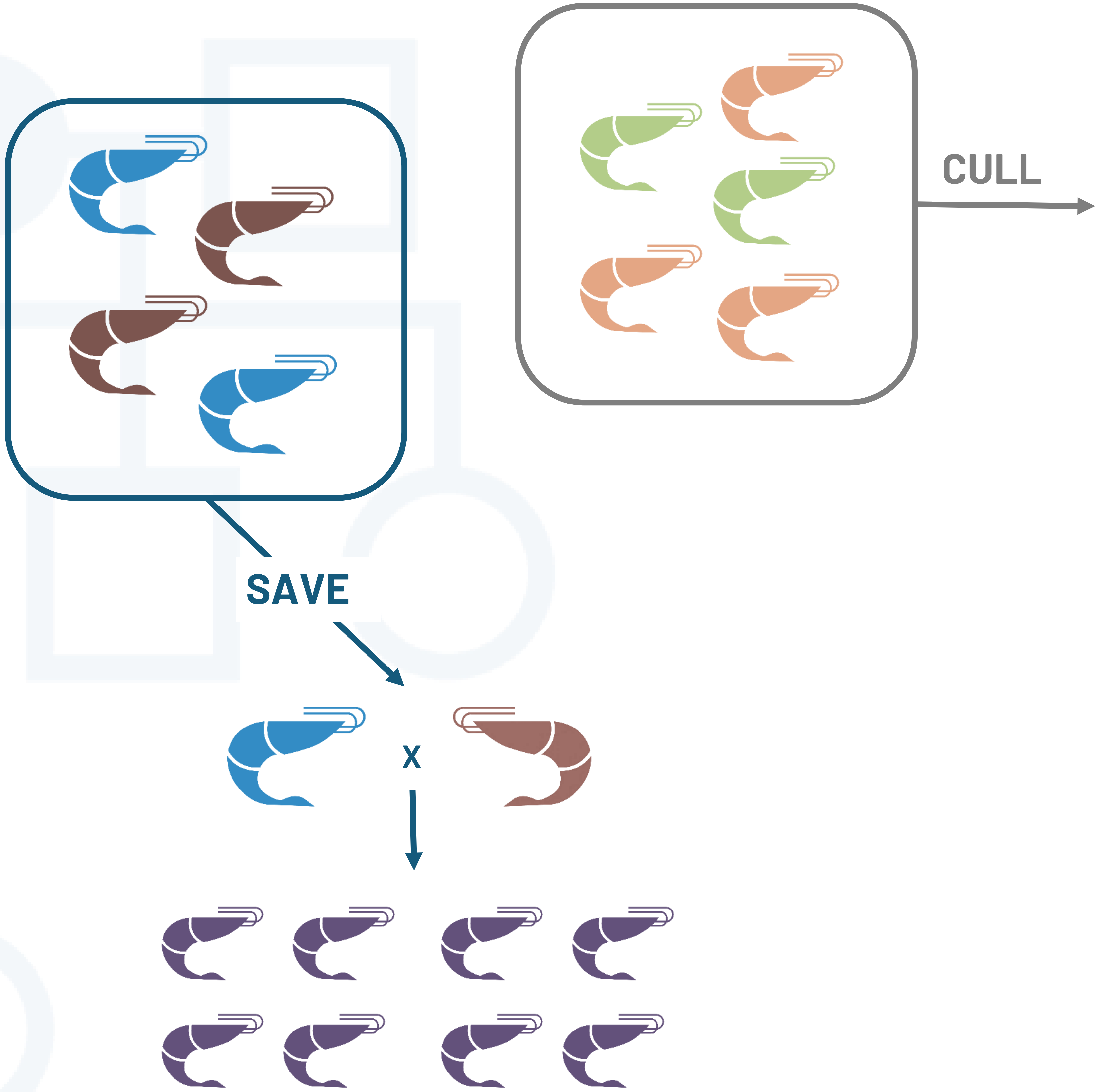
# Main questions that producers have about genetics:

- What can I do to improve my genetics?
- How much will it cost?
- Is it worth it?

# Breeding designs – from simple to complex

# WHAT IS SELECTIVE BREEDING?

The process of improving one or more desirable traits of a cultured species through the selection of superior parents.

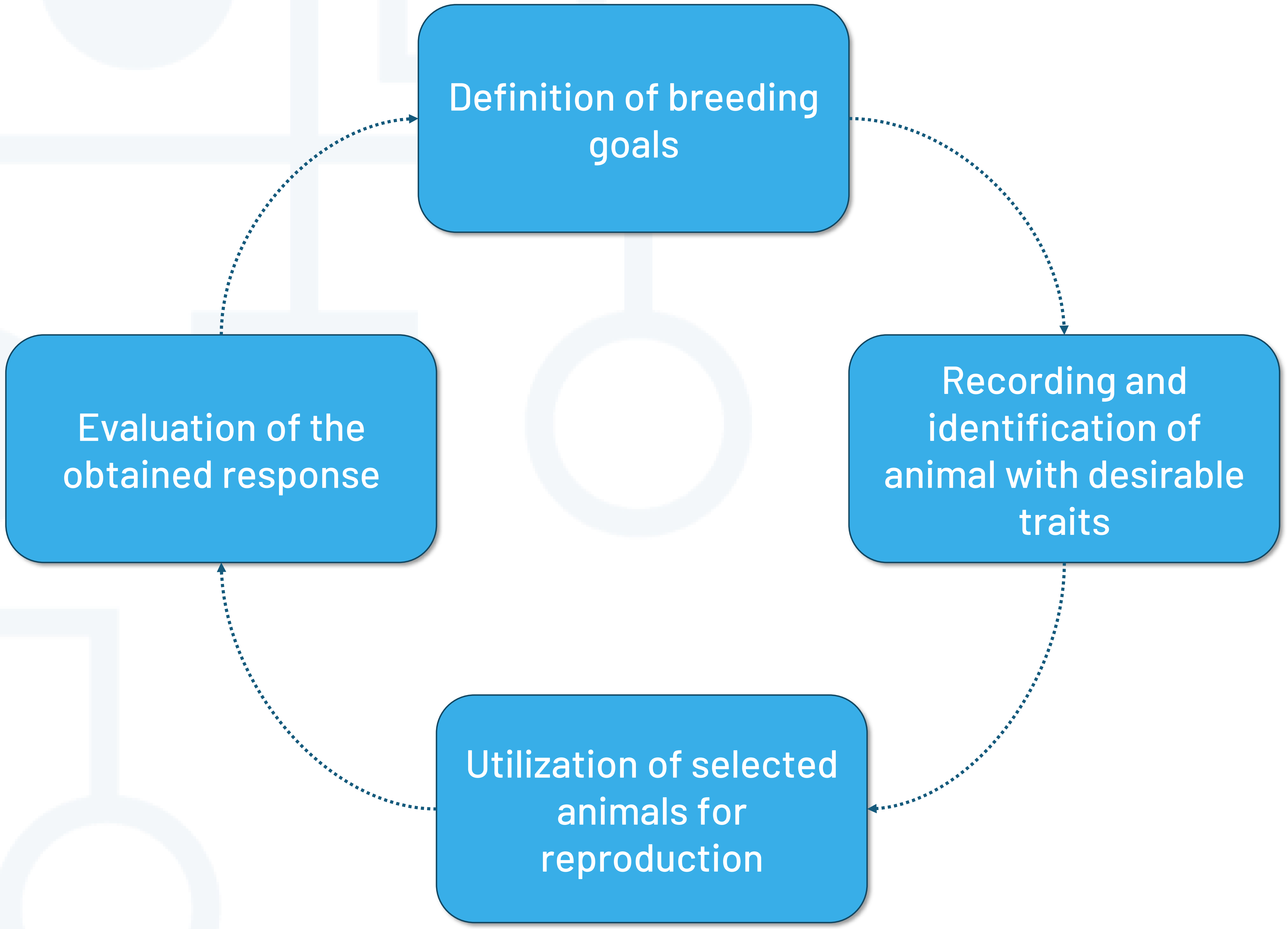


# Selective Breeding Programs

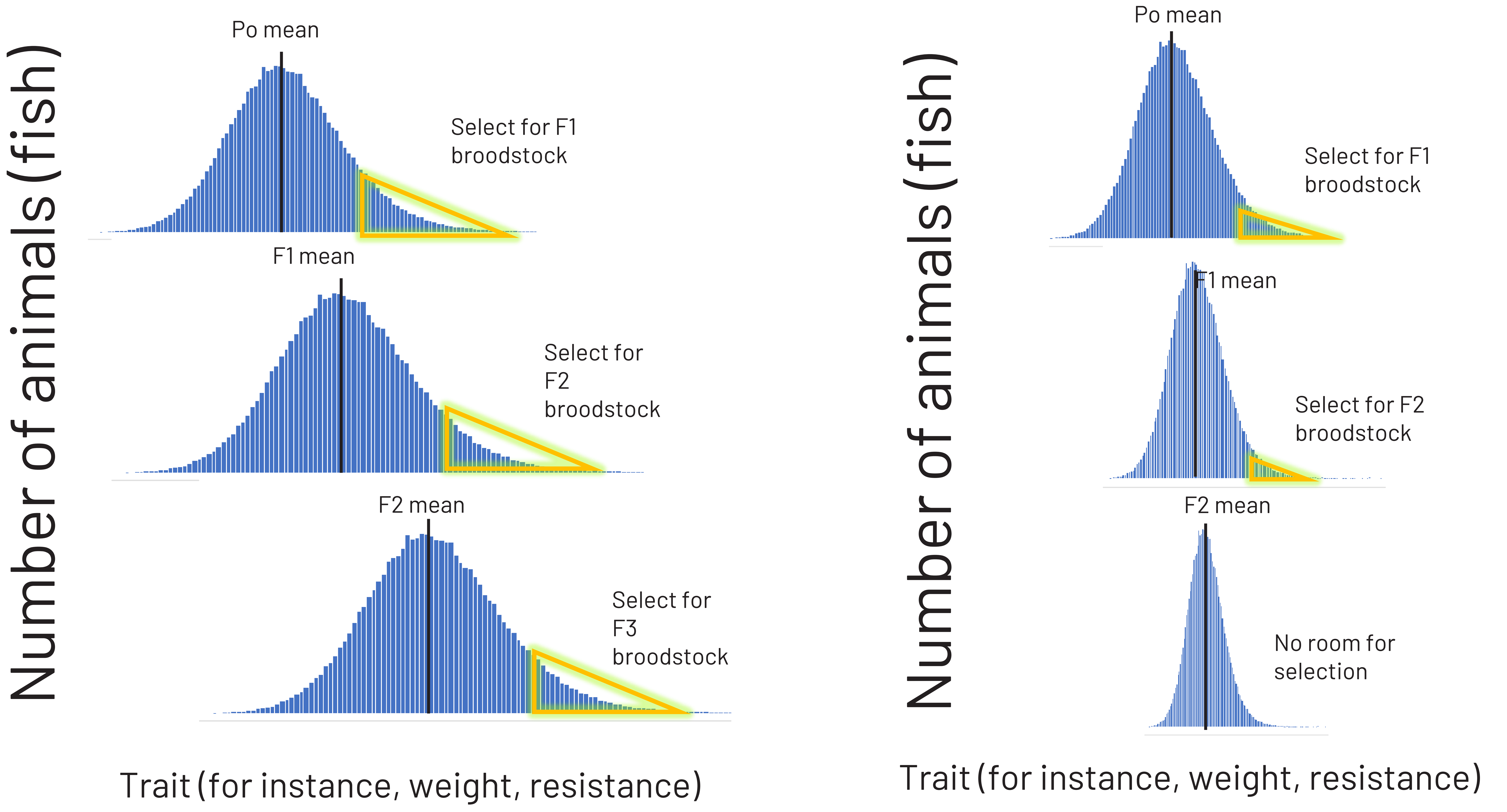
A breeding program is the implementation of a selective breeding strategy and associated tools.

Typically designed to maximize economic productivity for a commercial aquaculture producer.

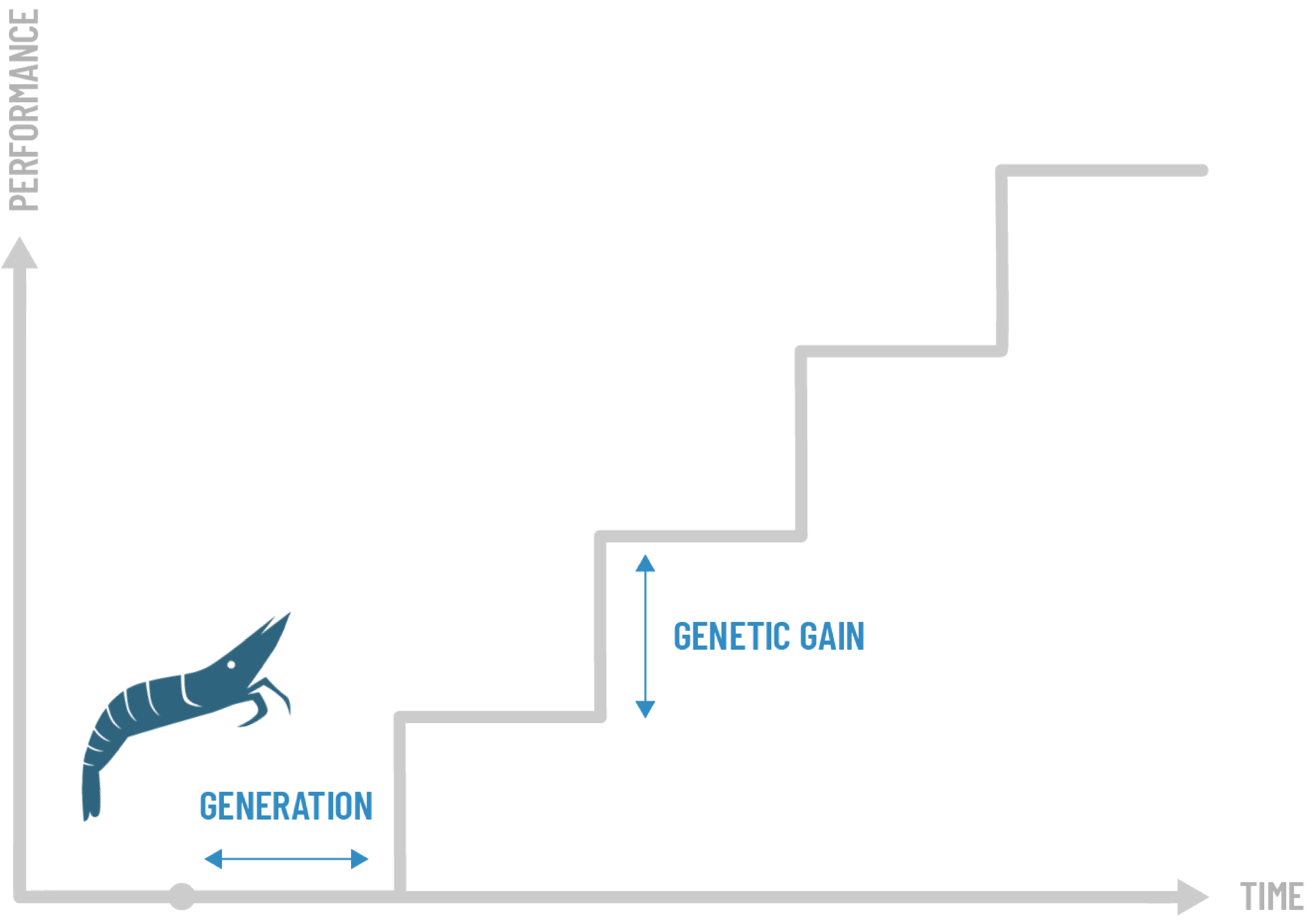
**The cycle of a breeding program**



# Benefits of a good genetic foundation and good diversity



# Benefits of a Breeding Program




- Competitiveness
- Production improvements
- Economic gains
- Compounding benefits
- Routine component of a mature agribusiness

$$\Delta G = \frac{intensity \ * accuracy \ * heritable\ proportion}{\boldsymbol{Generation\ time}}$$

# HOW GENOTYPING SUPPORTS BREEDING PROGRAMS

**Genotyping can support all breeding strategies**

SNPs (Single Nucleotide Polymorphisms) are a type of genetic marker

Genotyping tools look at varying numbers of SNP's (their 'density')

Different breeding strategies require different densities of genotyping tools

AQUAARRAY

**LD**

Up to 1,000 SNPs

- parentage assignment
- genetic diversity assessment
- broodstock population structure
- inbreeding monitoring

AQUAARRAY

**MD**

Up to 10,000 SNPs

- includes LD applications
- traceability management
- imputation to HD dataset

AQUAARRAY

**HD**

10,000 to Millions of SNPs

- LD & MD applications
- genomic selection
- marker-assisted selection
- marker discovery

## Low Density; 192 SNPs

## High Density; 50,0000 SNPs

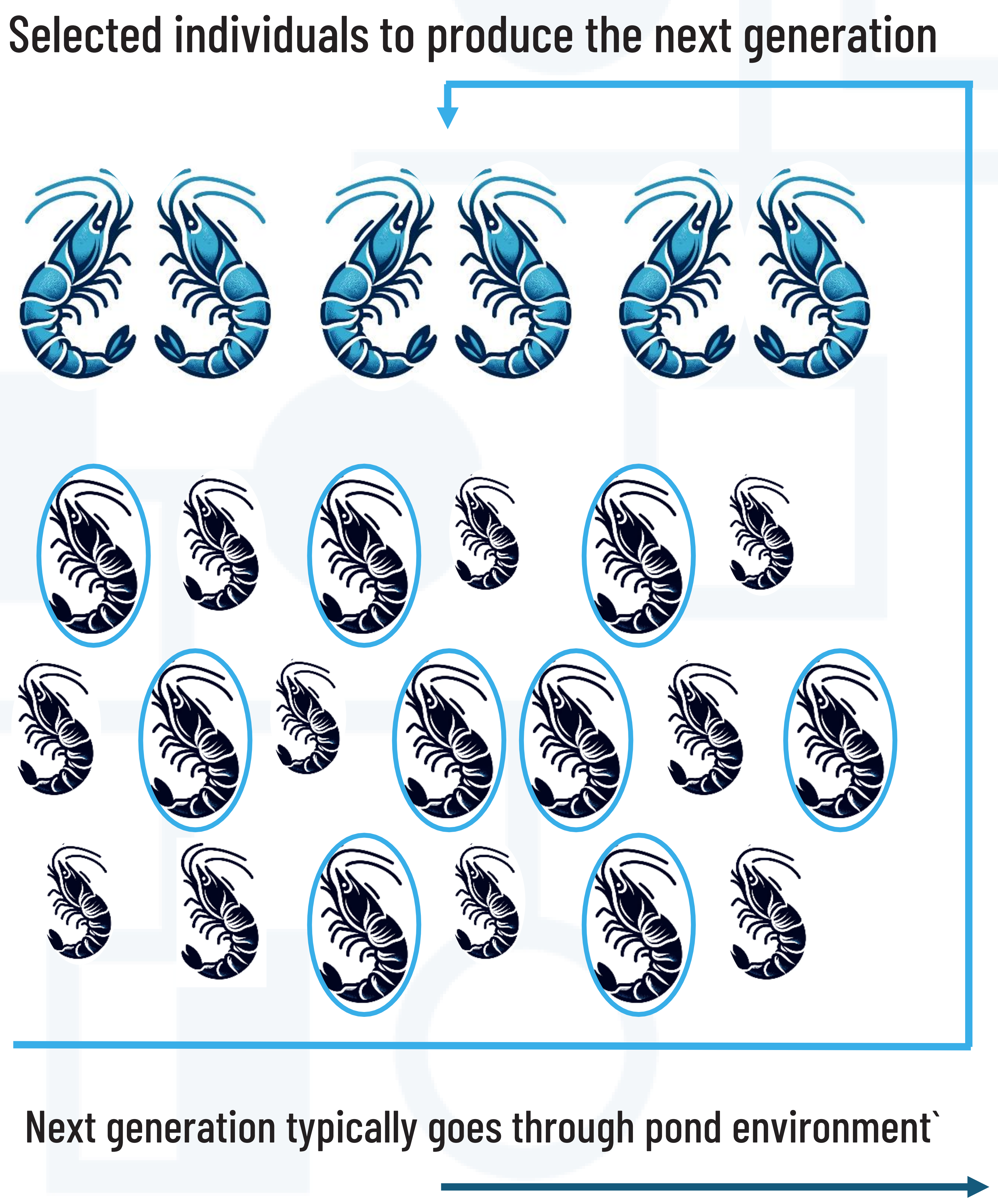


## Whole genome sequencing; millions of SNPs

# Types of Breeding Programs Mass Selection (Growth)

- Easy to implement
- Very low investment
- Molecular markers can help manage the inbreeding/variability

- Inbreeding and loss of diversity risk
- Can only be implemented in traits measured directly on the candidates
- In most cases it can only be implemented for one trait




**"Ecuadorian model"**

1. Mass Spawning
2. Evaluation for Growth and "Survival"
3. Selection of Best Individuals based on phenotype
4. Must manage inbreeding
5. Can have very high intensity

# Types of Breeding Programs Mass Selection (Disease)

- Easy to implement
- Very low investment
- Molecular markers can help manage the inbreeding/variability

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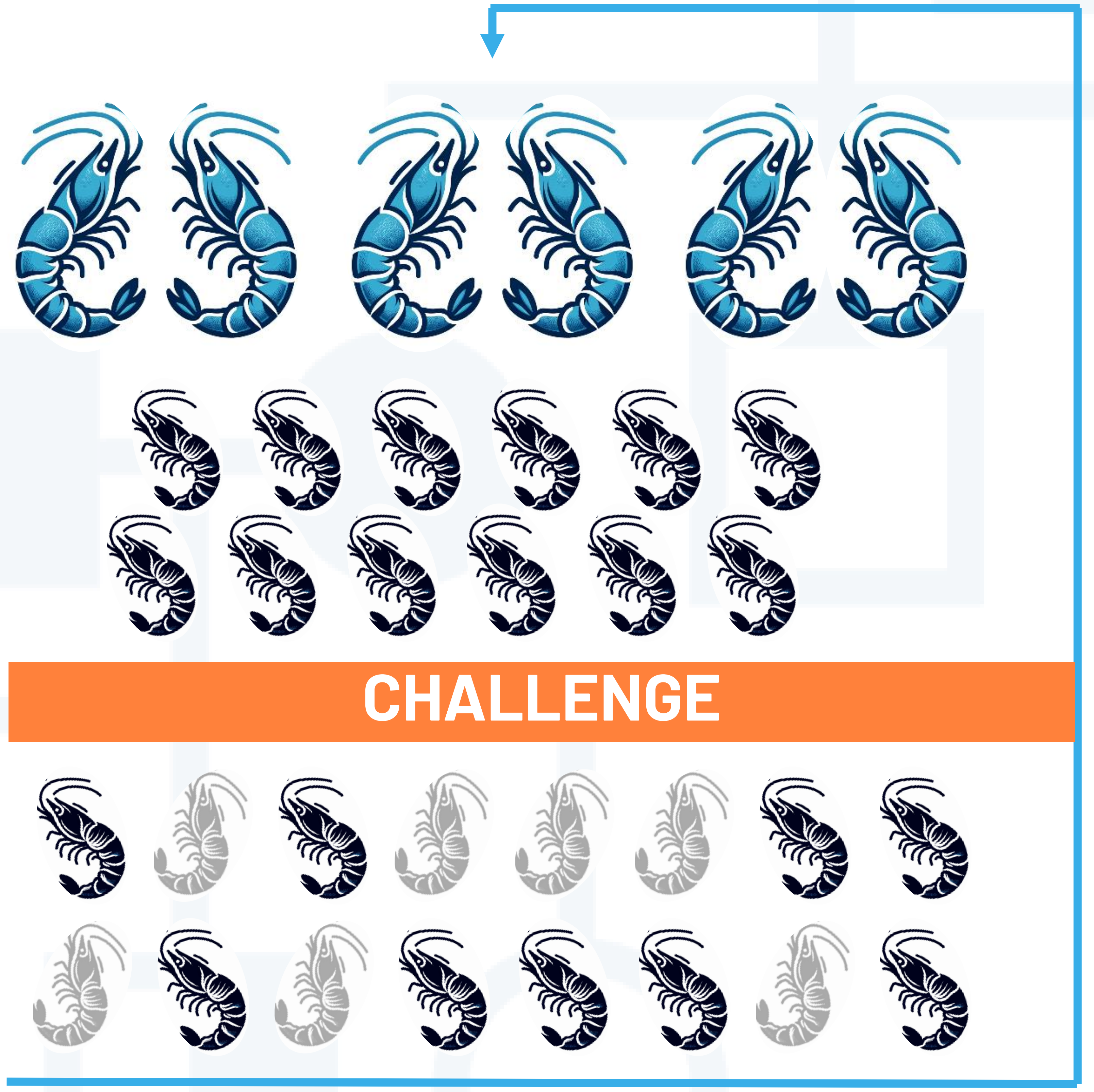
Selected individuals to produce the next generation




Next generation typically goes through pond environment`

**“Ecuadorian model”**

1. Mass Spawning
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5. Can have very high intensity

# Types of Breeding Programs: Family Selection (Growth)

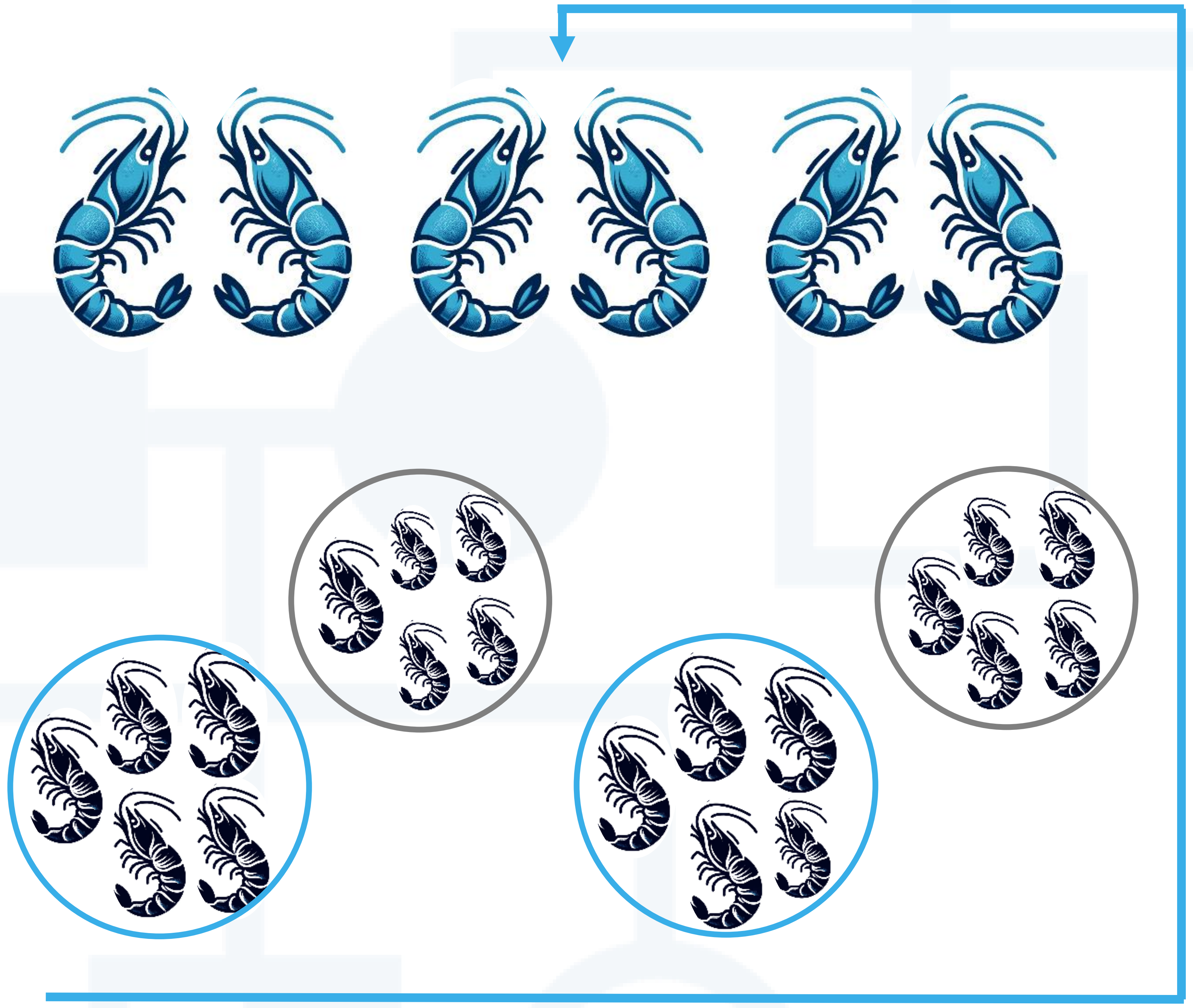
- Improvement of traits is very efficient
- Several traits can be improved at the same time
- Traits can be measured indirectly to subsets of family members without exposing NBC to disease

- Requires significant amount of infrastructure/investment
- Data management and analysis is critical for the best results
- Large number of families are needed for best management of inbreeding/variability

No environmental exposure

**"Biosecure family nucleus"**

**Best families mated to produce the next generation**



**Families typically selected based on performance in breeding nucleus, or in performance of siblings in disease trials**

1. Controlled mating to produce Families
2. Evaluation of Families for key traits
3. Selection of best Families
4. Can't select within Families for commercial growth outside nucleus
5. Can select within family for growth inside nucleus

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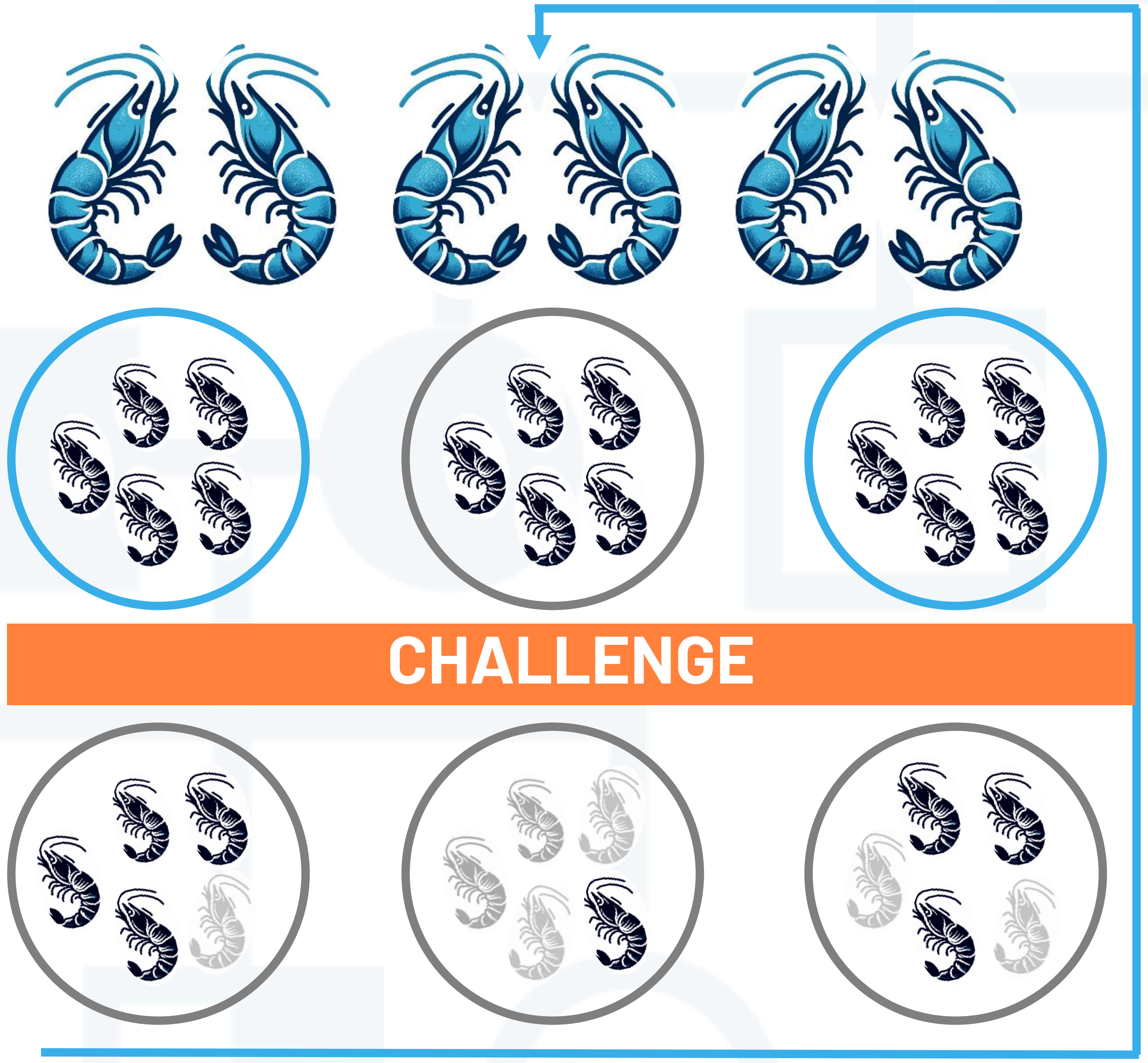


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# Types of Breeding Programs: Genomic Selection (Growth)

- Improvement of traits is the fastest, with the best ROI
- Several traits can be improved at the same time
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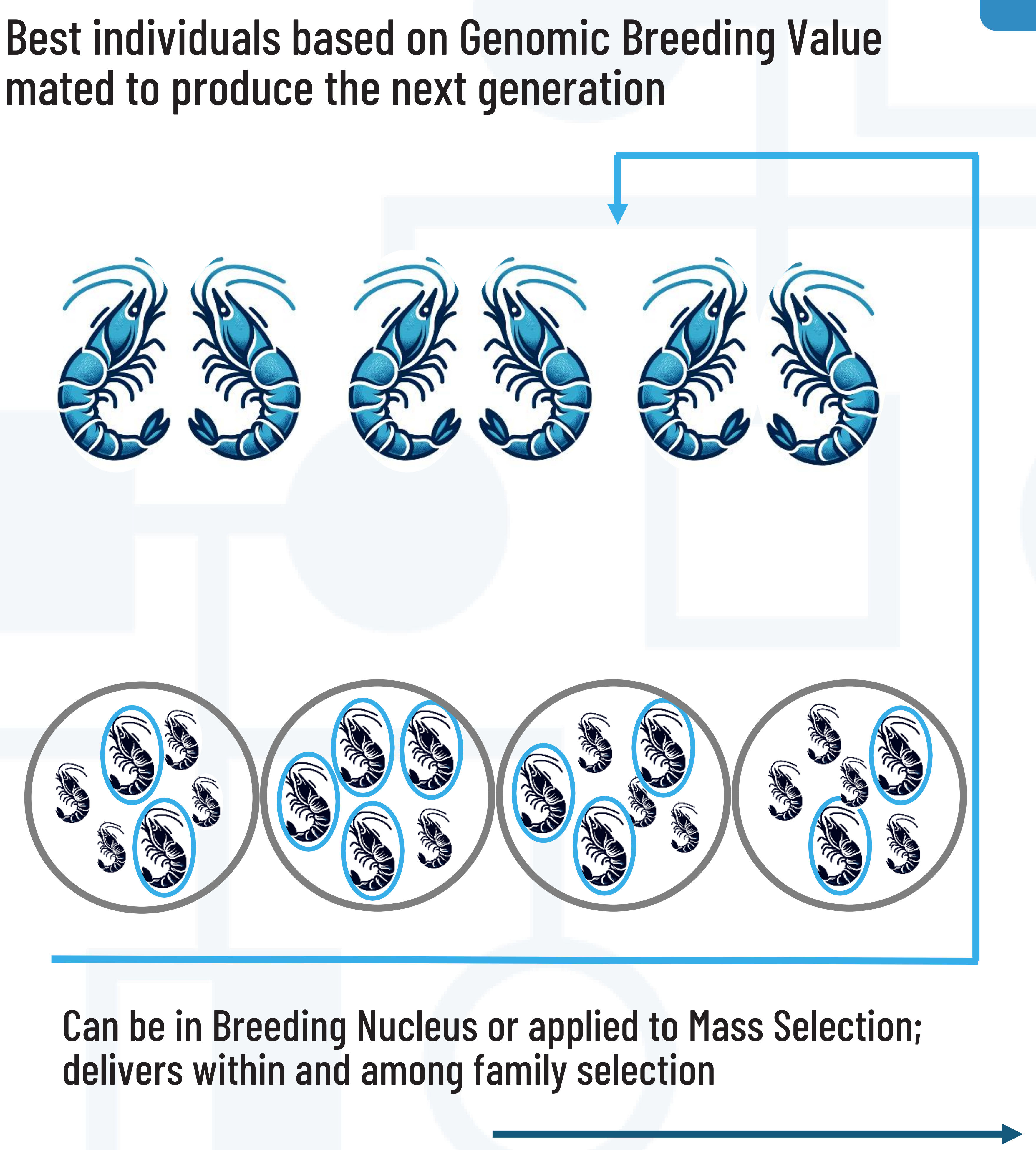
- Has the highest cost to implement
- Requires management of large data sets and complex analysis
- Cost for genotyping at high density of molecular markers; ROI must be clear




## Genomic Selection

1. Mass Spawning or controlled mating
2. Evaluation for key traits
3. Selection of best Individuals
4. Control of inbreeding and diversity
5. Very accurate and can scale intensity

# Types of Breeding Programs: Genomic Selection (Disease)

- (+) Improvement of traits is the fastest, with the best ROI
- (+) Several traits can be improved at the same time
- (+) Traits can be measured indirectly to subsets of family members without exposing NBC to disease

- (−) Has the highest cost to implement
- (−) Requires management of large data sets and complex analysis
- (−) Cost for genotyping at high density of molecular markers; ROI must be clear

**Best individuals based on Genomic Breeding Value mated to produce the next generation**


**Can be in Breeding Nucleus or applied to Mass Selection; delivers within and among family selection**

## Genomic Selection

1. Mass Spawning or controlled mating
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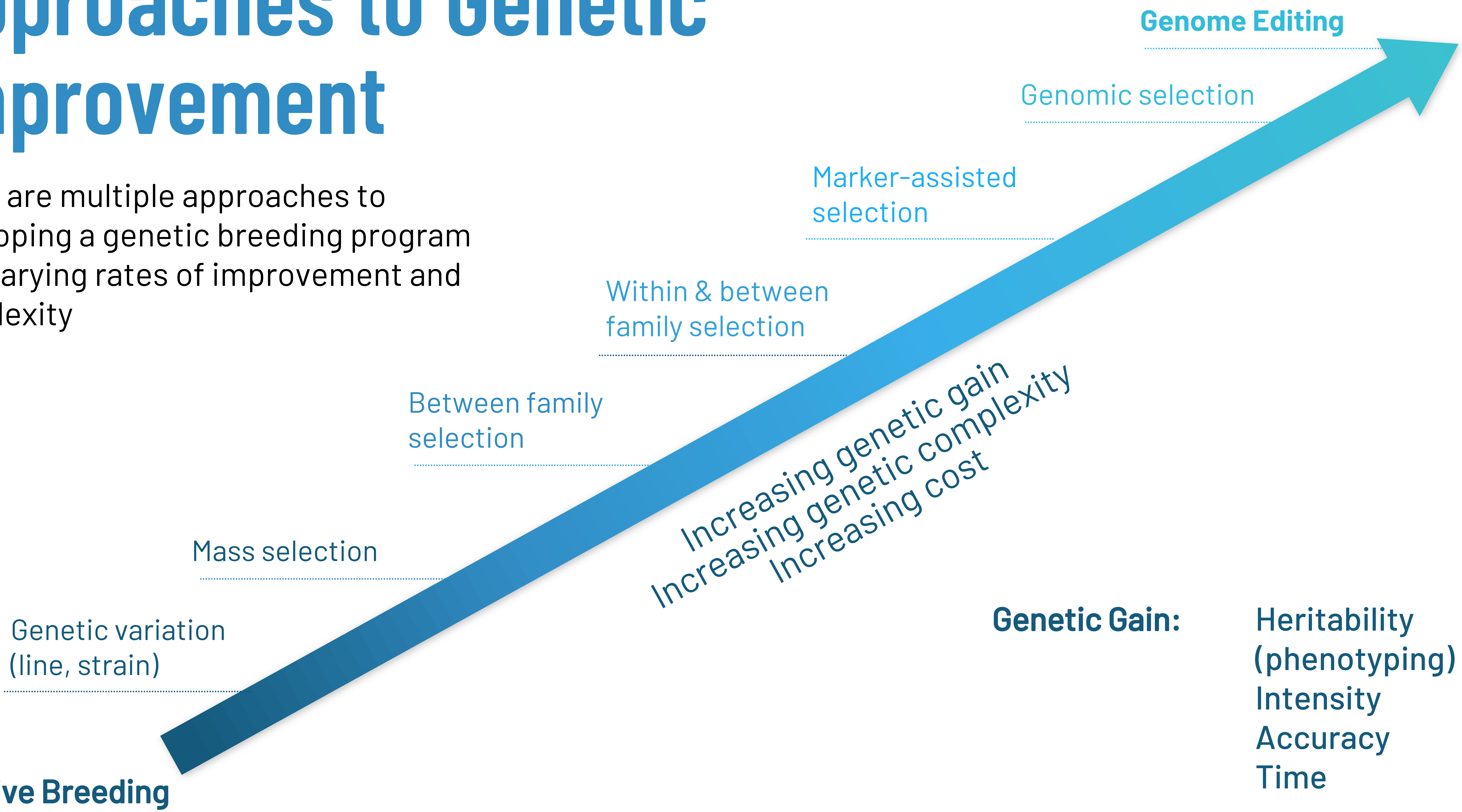
# Approaches to Genetic Improvement

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

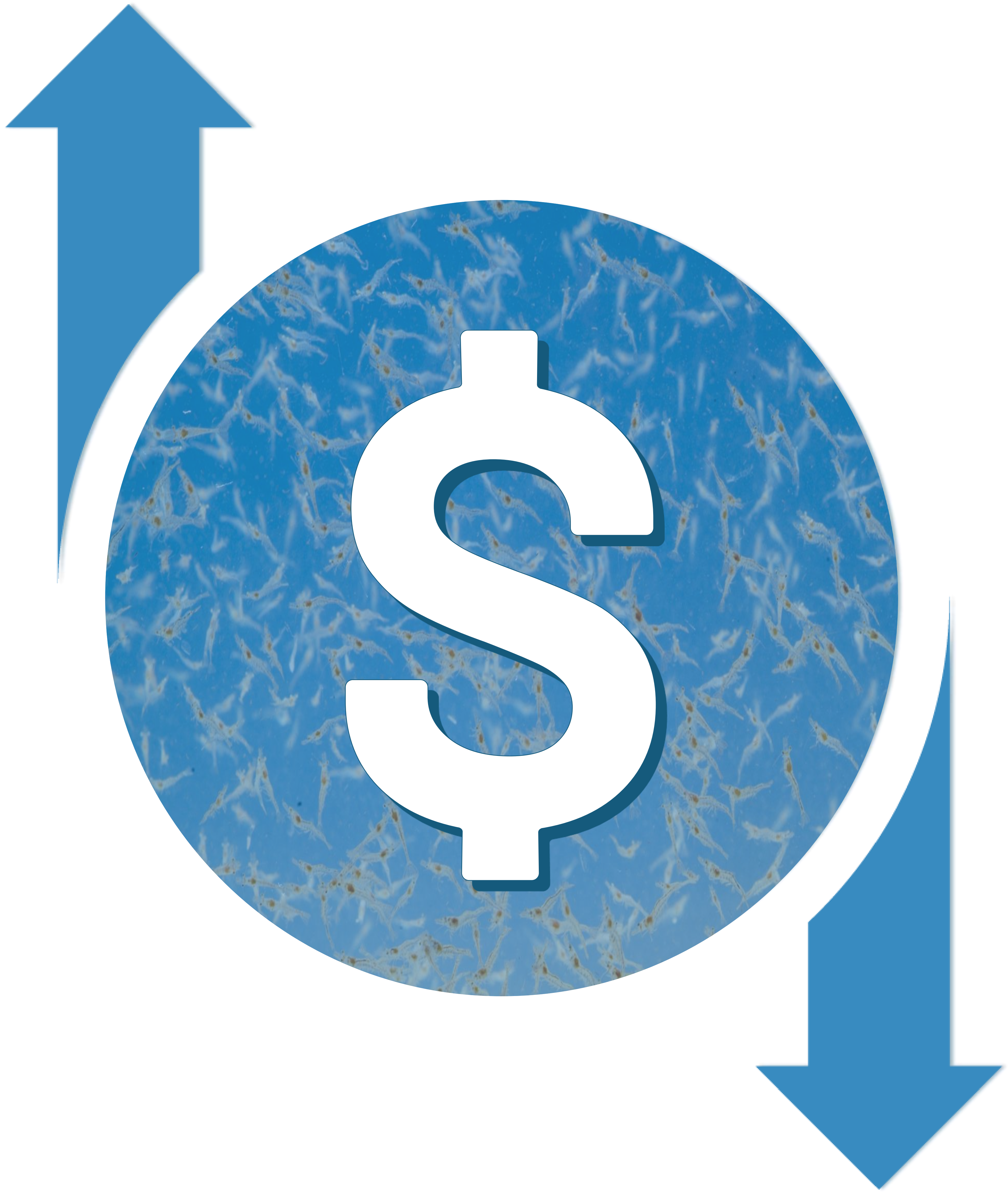



**Genetic Gain:**

Heritability (phenotyping)
Intensity
Accuracy
Time

# Thinking about the return on investment in genetic improvement

Improving your genetics needs investment in technology, people and infrastructure



In simple terms – will enough returns be generated to justify this investment?

# Considerations

Deciding whether to undertake a new project

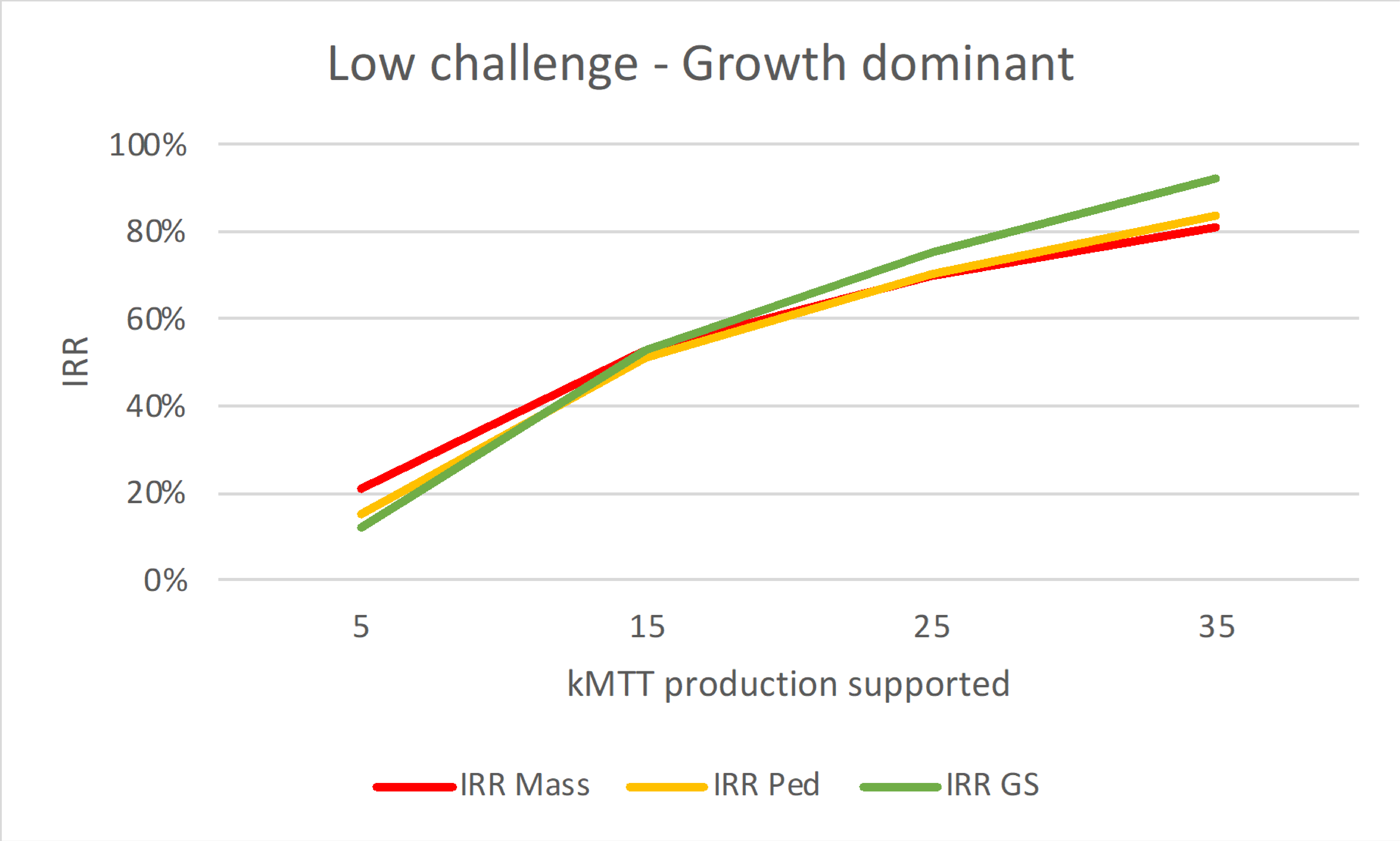
Choosing between different options for a project

Understanding potential return on investment and how to measure this

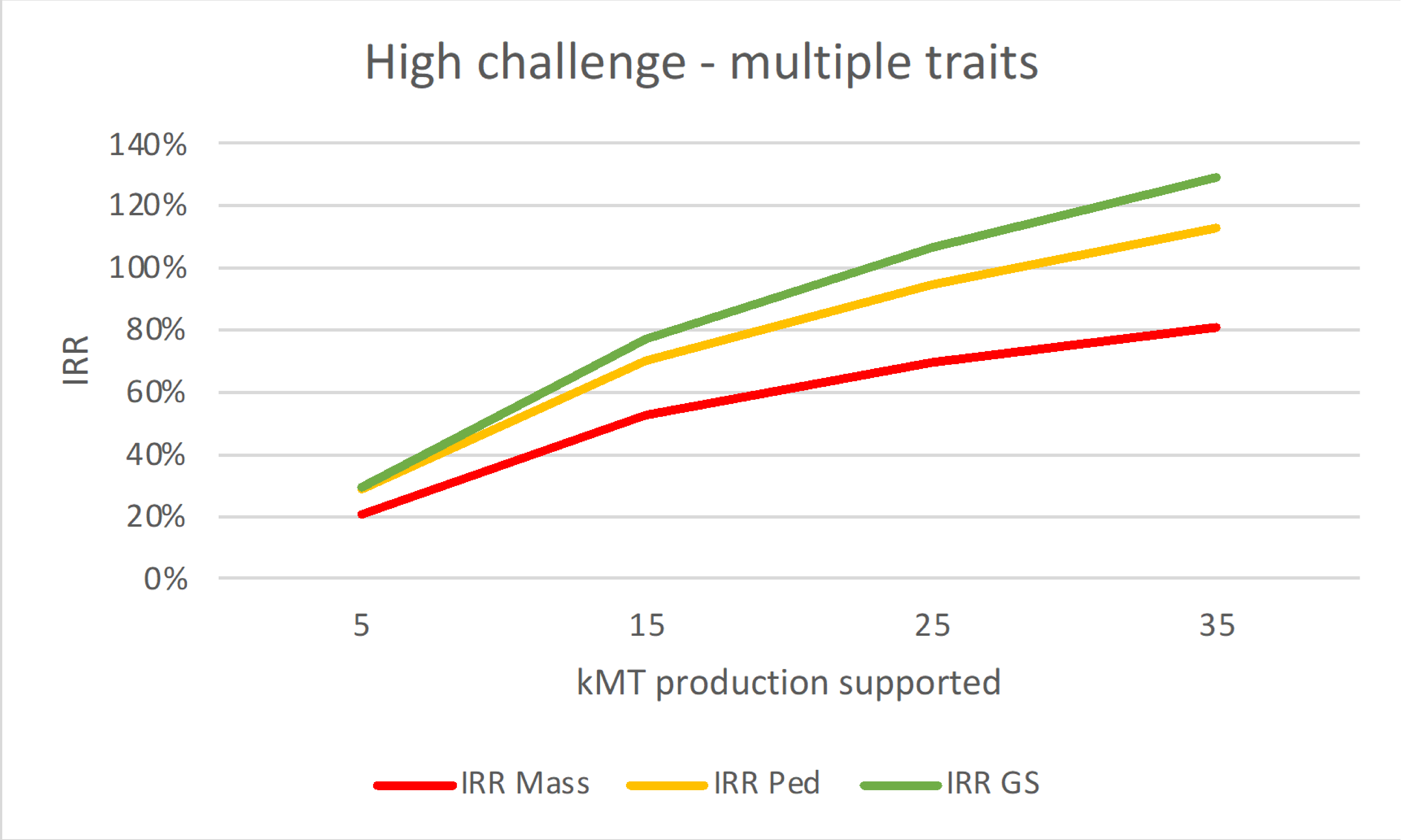
Understanding the impact of investments on business value

## *Internal Rate of Return (IRR)*

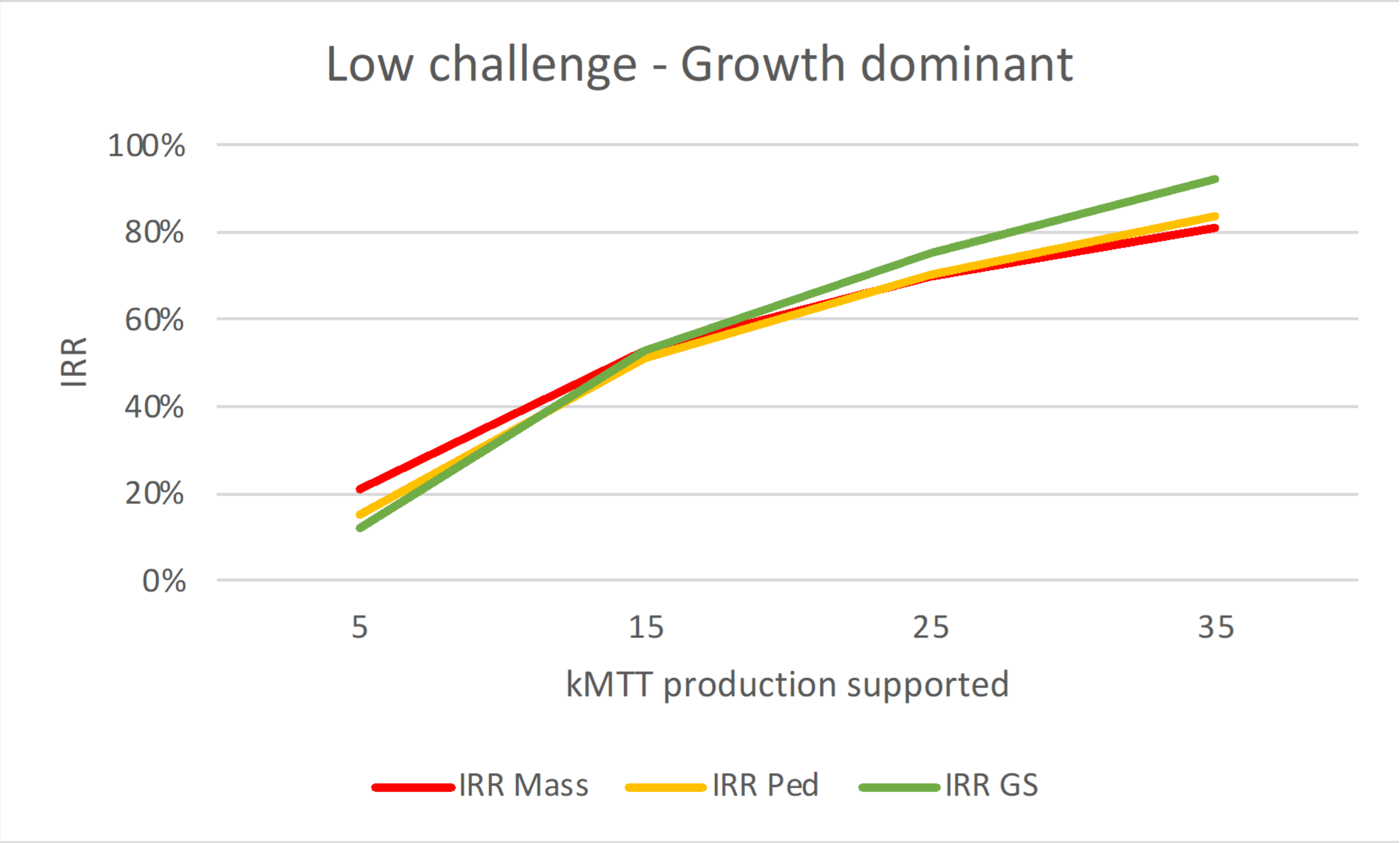
- The rate of growth that an investment is expected to generate annually
- Takes into account initial investment, cash flows, and time cost of money
- Value can be thought of as the amount of return an investment can generate
- Based on assumptions of performance, so return is not discounted for risk

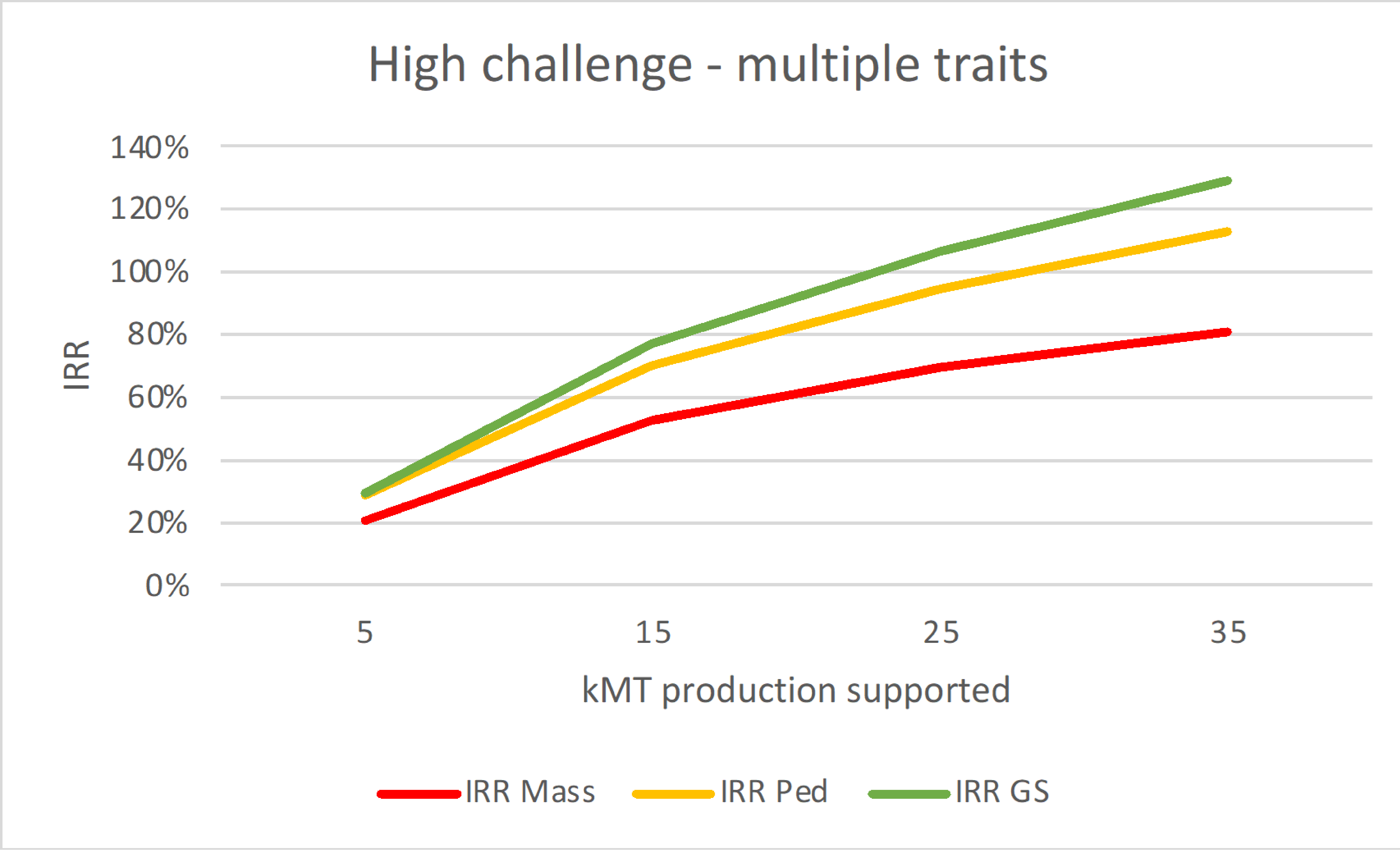



Mass selection gives higher returns at small volumes but Genomic programs were more profitable for medium and large breeding programs.




GS is preferred strategy even at smaller scales when looking at challenging environments. Returns are higher at each production point compared to low challenge scenario.




Mass selection gave higher returns at small volumes but Genomic programs were more profitable for medium and large breeding programs.

GS is preferred strategy even at smaller scales when looking at challenging environments. Returns are higher at each production point compared to low challenge scenario.

**Economic analysis indicates that the cost of not implementing Genomic Selection is often much higher than choosing a Genomic Selection strategy**

# Summary

- A selective breeding program is worth the investment
- Benefits compound over time; there is a cost to not acting
- Mass selection is a good strategy when only selecting for growth
- Selection for indirect or multiple traits is significantly more economical when using a genomic approach
- Genomic Selection strategies will become more and more common (as tools become available)
- The economic return on genetic improvement is significant when the right approach is applied in the right environment

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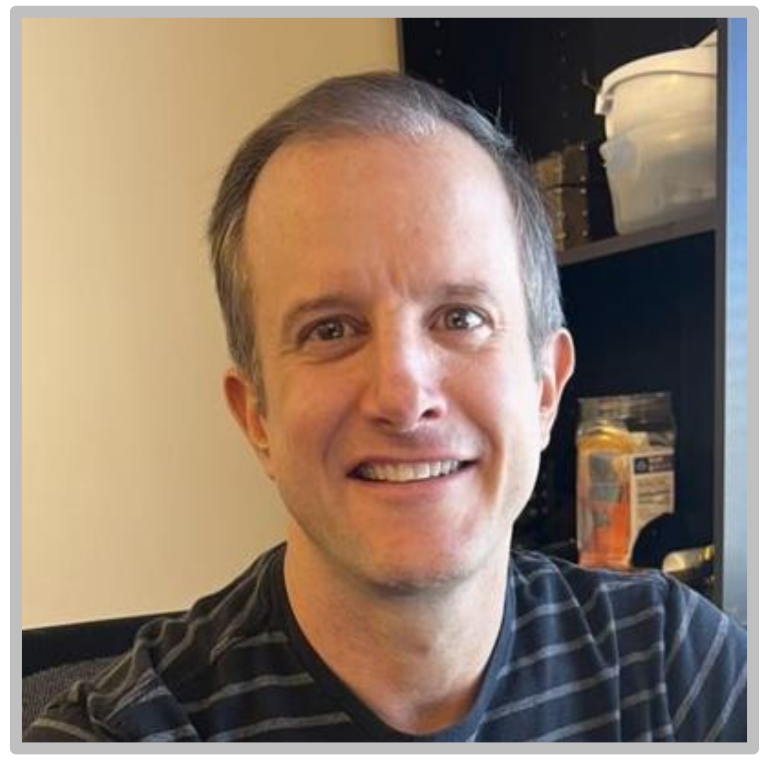
# Thank you!











TIENE MÁS PREGUNTAS? **NO DUDE EN CONTACTARME**

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PARA SABER MÁS DE CAT Y DE LOS SERVICIOS QUE OFRECEMOS >

DR. ADRIANA ARTILES
**BD MANAGER**

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# ENTREGANDO **RESULTADOS** ÚTILES.

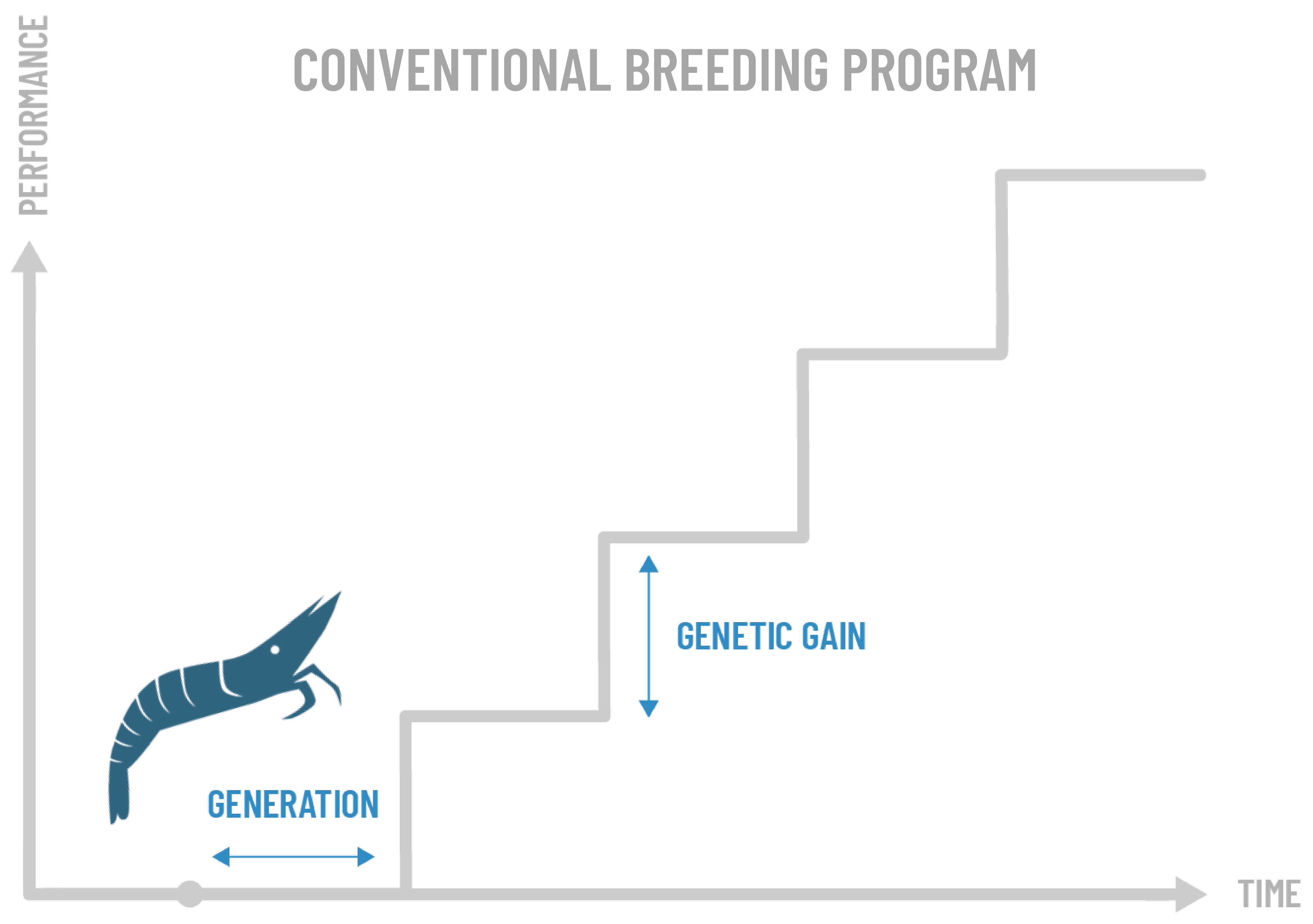
# Thanks

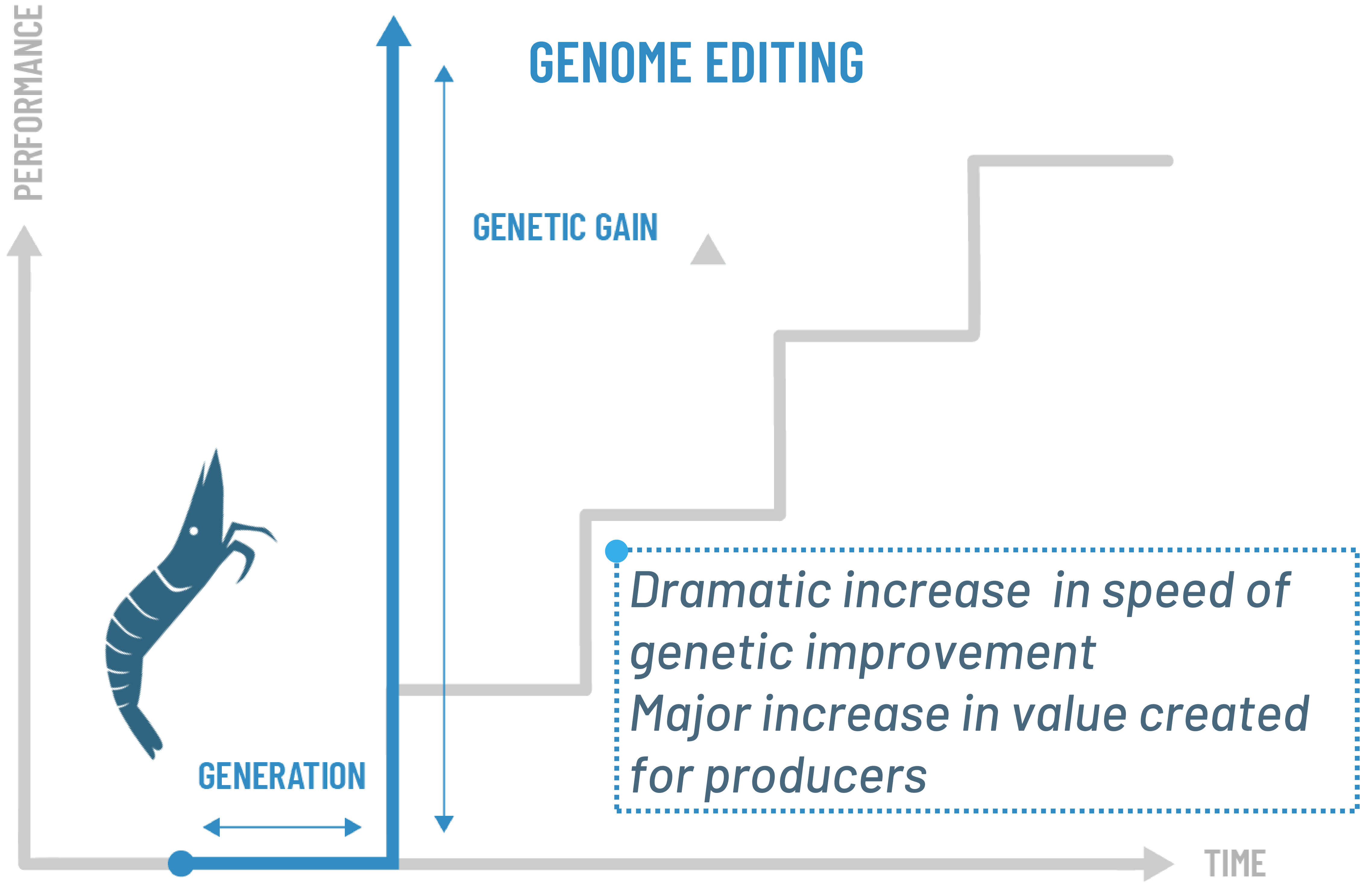
# GENOME EDITING: A LEAP IN GENETIC IMPROVEMENT

## Sterility+™

- + Sterility
- + Growth
- + Yield
- + Reduced environmental impact
- + Feed efficiency
- + Sex control: Monosex

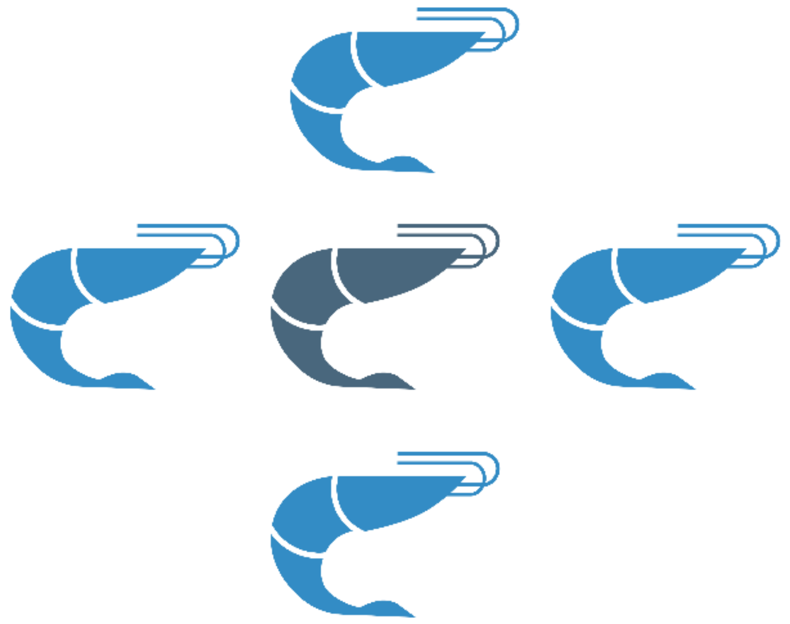
- Disease resistance
- Survivability
- Reproduction
- Environmental tolerance
- Product quality
- Nutritional benefit

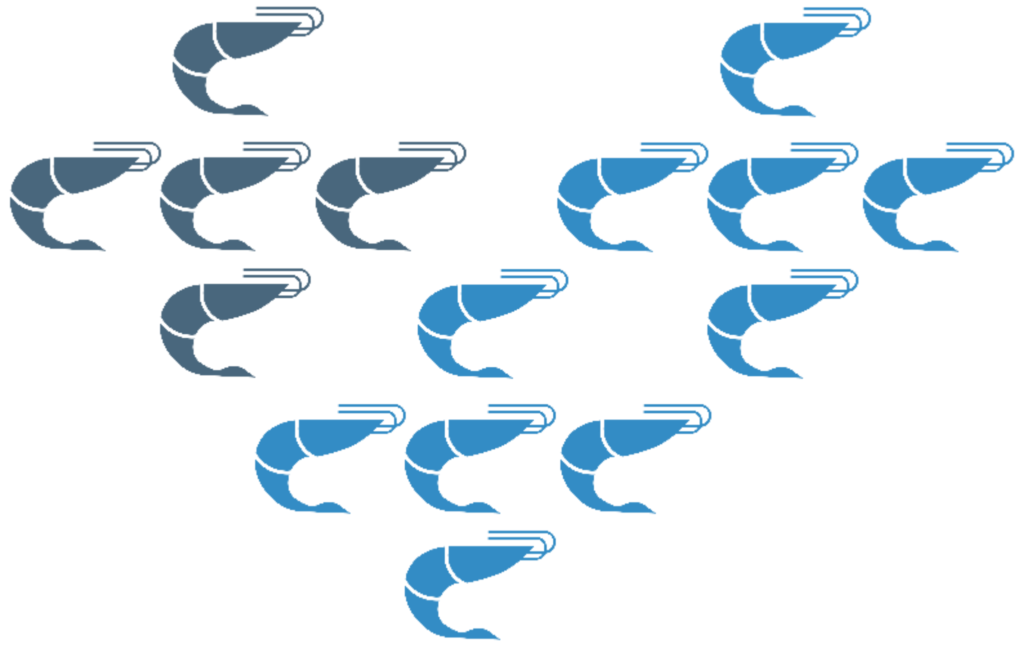


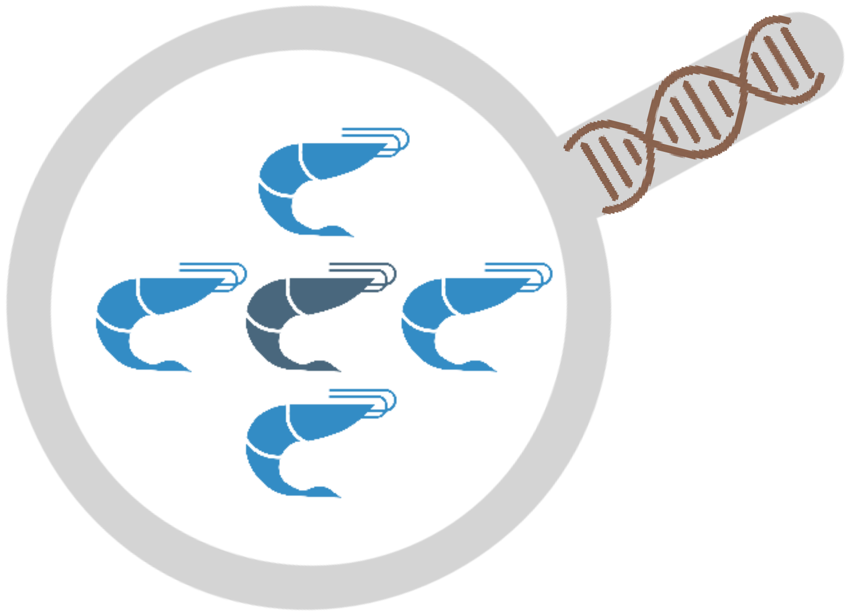



# General concepts – Investment Returns

# Investment Return Factors for Different Breeding Strategies

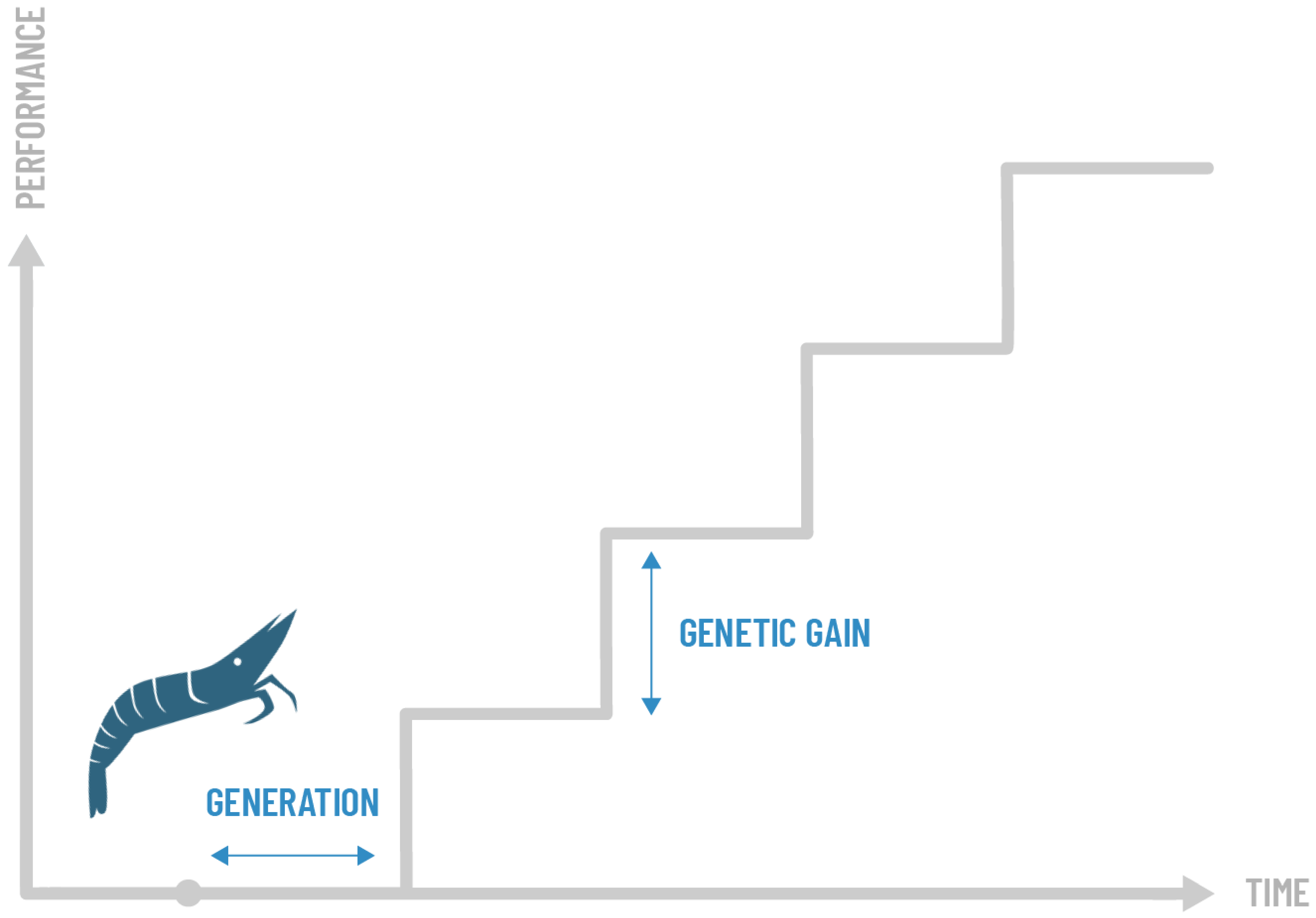






| | Mass selection | Pedigree-based selection | Genomic selection |
|---|---|---|---|
| **Initial investment** | Low level of investment to implement | Higher running costs than Mass selection | Higher genotyping costs but some savings in running costs compared to Pedigree selection |
| **Gains & Losses** | Good | Great | Highest |
| **Investment returns** | Moderate returns for low investment cost. Good where growth is dominant required trait | Improved returns, especially in high challenge or complex environments | Greatest returns, especially in high challenge environments or selecting for multiple traits |

# WHY IMPLEMENT A BREEDING PROGRAM?



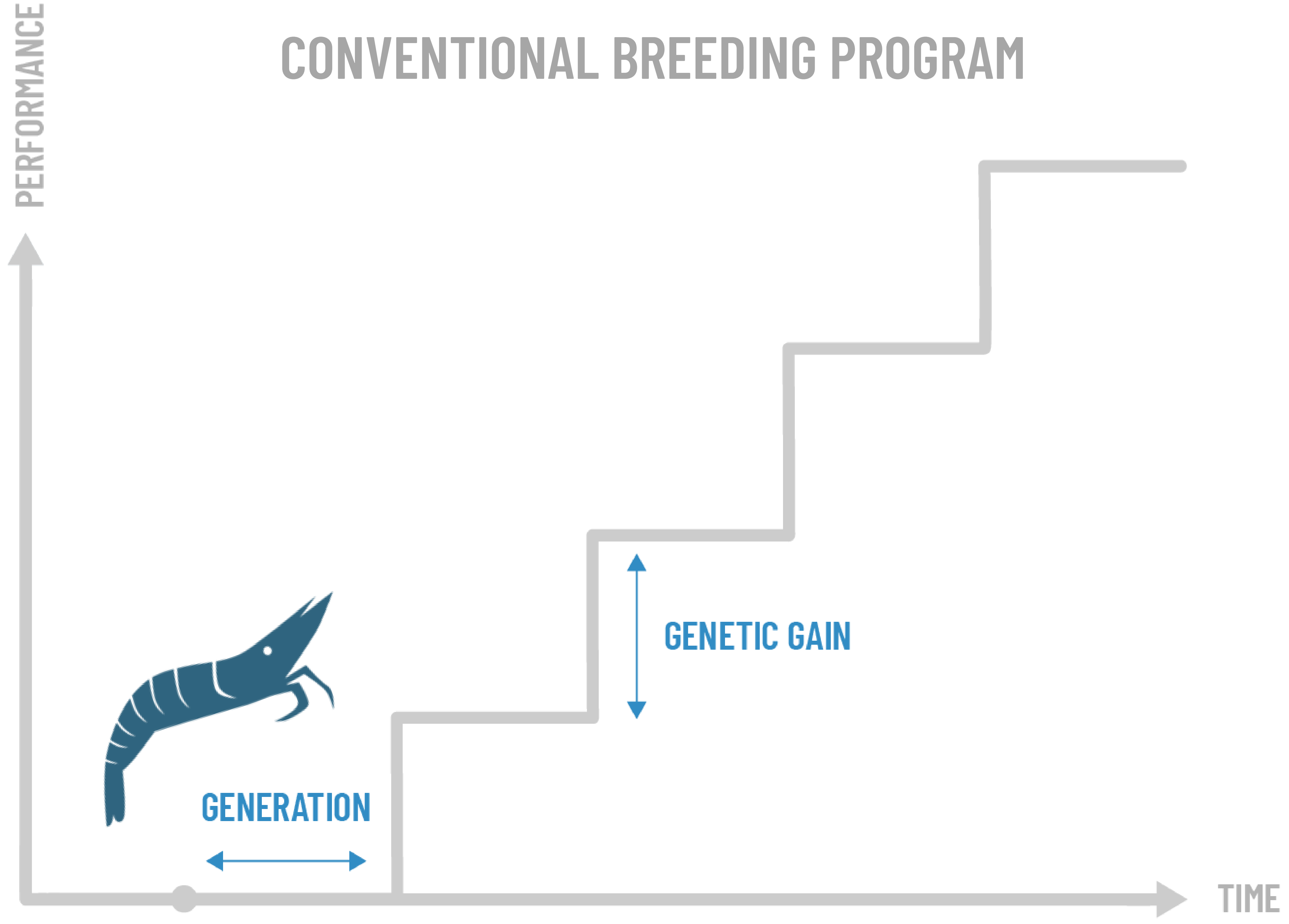

$$\Delta G = \frac{intensity\ * precision\ * heritable\ proportion}{\boldsymbol{Generation\ time}}$$

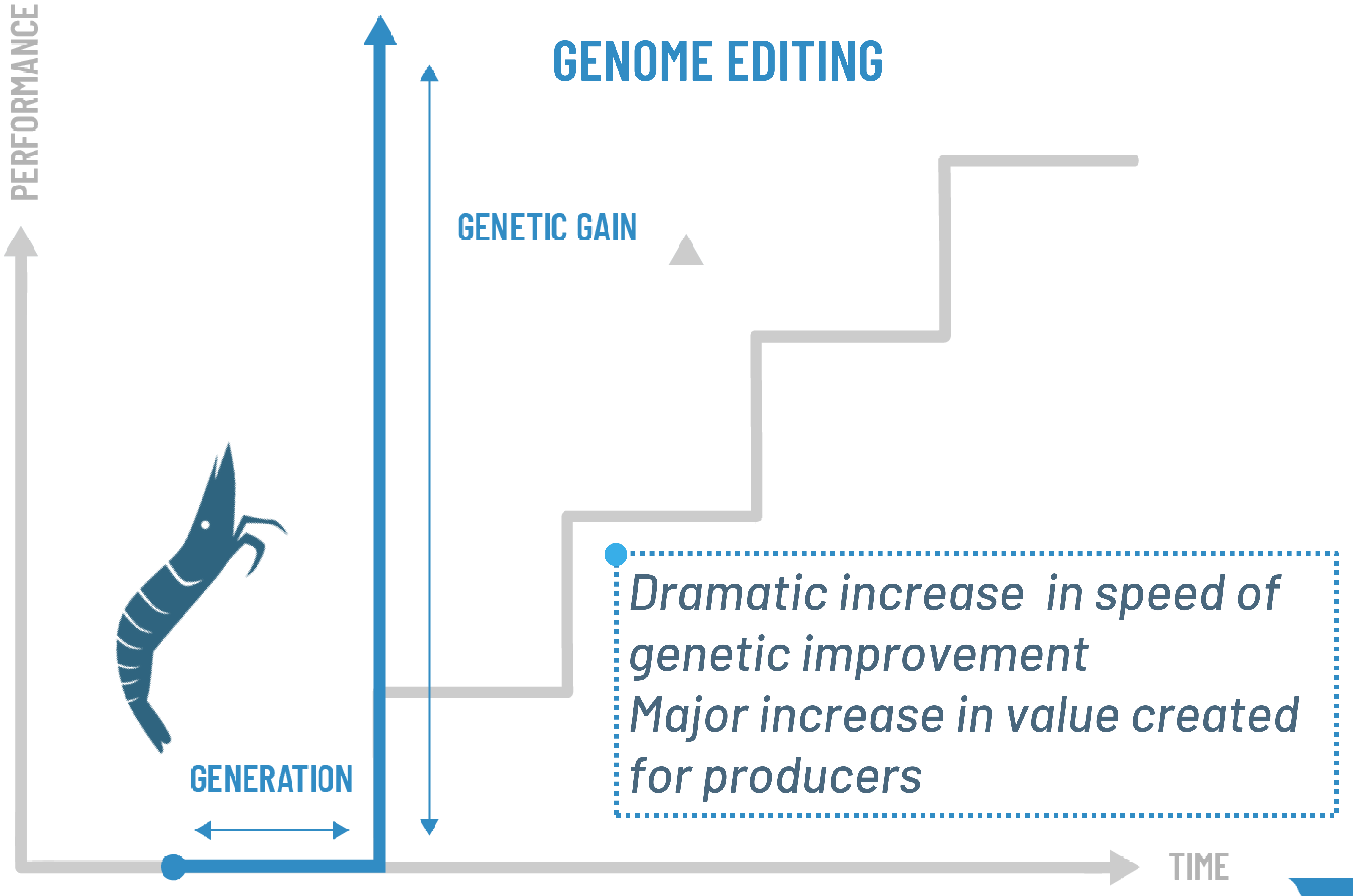
- Maintaining competitiveness
- Production improvements
- Economic gains
- Routine component of a mature agribusiness

# Genome Editing: Step Change in Desirable Traits

## Sterility+

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



# Low Density; 192 SNPs

# The future of genotyping for genetic improvement applications

Can see causative variants

Whole genome sequencing; millions of SNPs