Benchmark Genetics

Gene Editing – a European Aquaculture Perspective.

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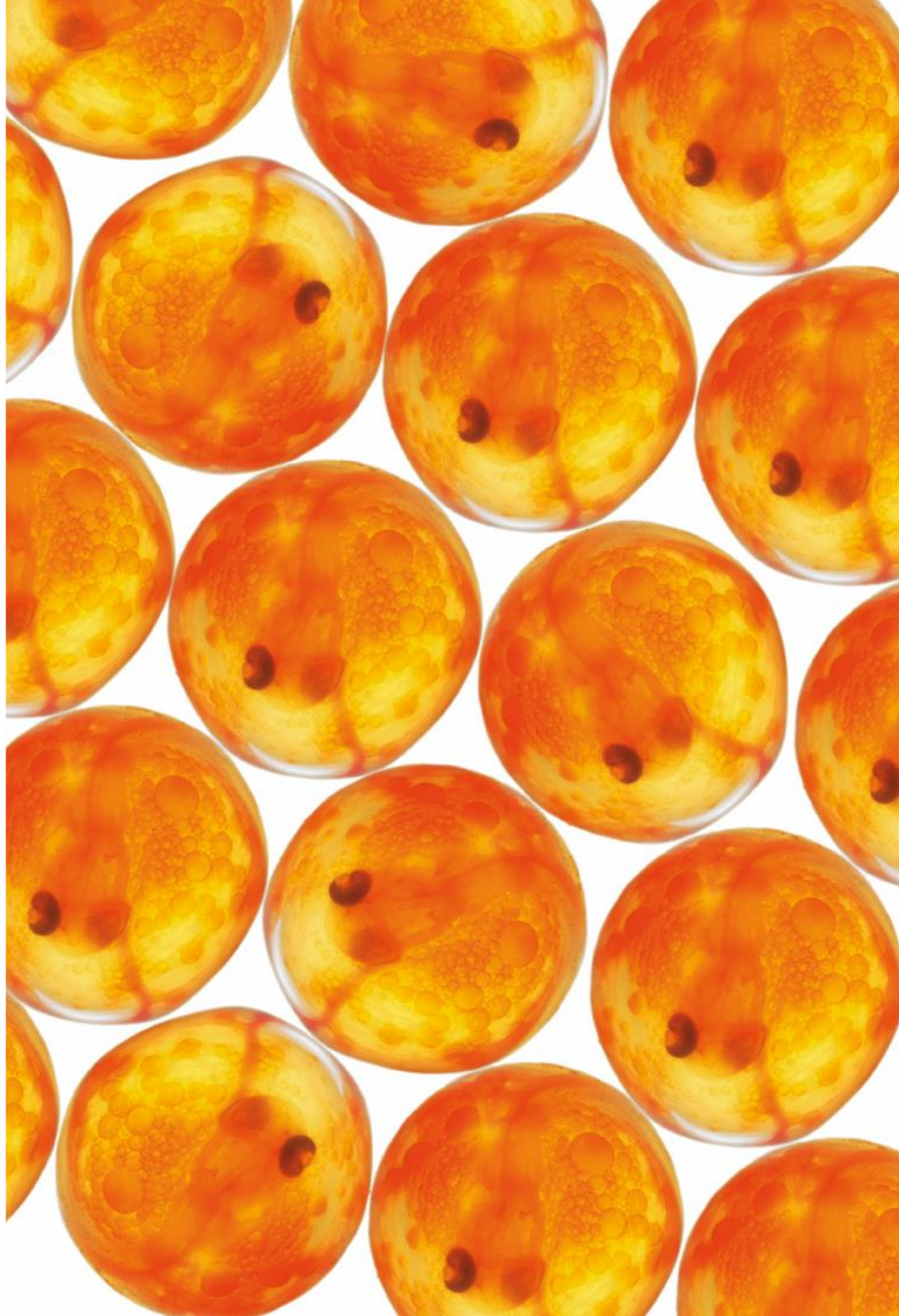
Our mission

Our mission is to enable aquaculture producers to improve their sustainability and profitability.

We deliver genetics, advanced nutrition and health products which improve yield, quality and animal welfare.

Our aim is to be the leading aquaculture biotechnology company driving sustainability



Three core and synergistic divisions

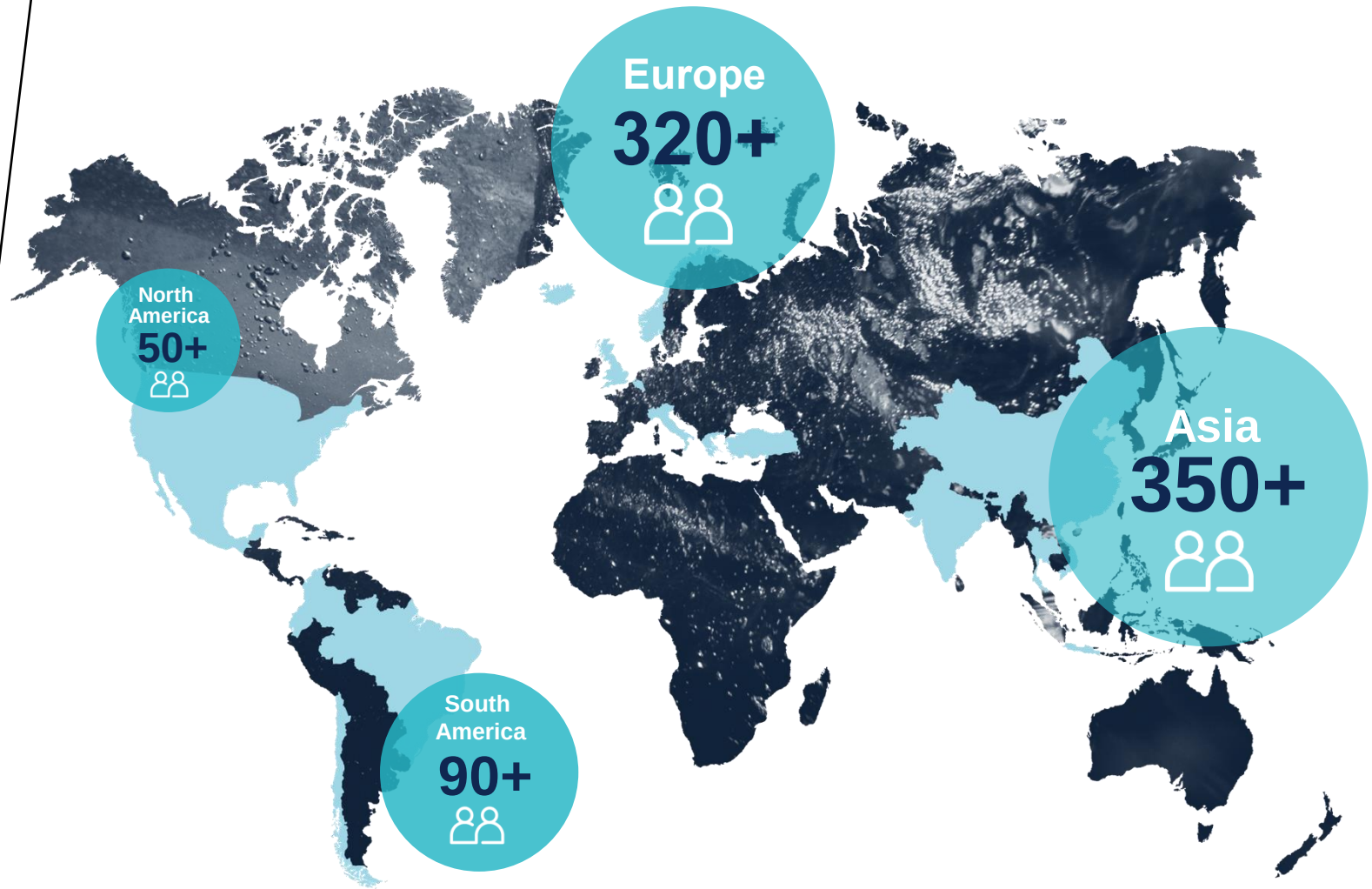
Improved genetics provide a crucial starting point for production efficiencies and health resilience

High performance nutritional solutions for shrimp and marine fin fish enhancing fish health and production efficiency

Solutions for some of the most persistent disease and fish welfare challenges

Benchmark at a glance

We are present in every major aquaculture market and species
Focusing on three main species: salmon, shrimp, bass/bream



Group Revenue (FY19)*

£127.3m

* continuing operations

Large scale production

6 countries

Commercial and R&D operations

20 countries

Genetics

Delivering crucial starting point for production efficiencies and health resilience.

PRODUCTS

- Salmon eggs with improved disease resistance
- SPR shrimp broodstock
- Tilapia broodstock
- Lumpfish
- Genetics services for 10+ species

Global footprint

GENETICS

Capacity (year operational for BMK)

Shrimp, USA
- 60M PL / 52K breeders (2018)

Shrimp, Thailand
- 40K breeders (2020)

Salmon, Norway — 2 sites
- 150M eggs / 300T broodfish (2020)
- 350 families / 0.5m smolt (2015)

Shrimp, Colombia
- 20M PL/month
  250 families & 20K breeders (2016)

Tilapia, USA
- 200 families / 2M fingerlings (2015)

Salmon, Chile — 2 sites
- 50M eggs / 200 families (2017)
- 15K smolt / 2M 25g juveniles (2020)

Salmon, Iceland — 4 sites
- 220M eggs & 600T broodfish
  200 families / 80K smolt (2014)

Benchmark's position on Gene Editing

Benchmark's mission is to be a global leader in driving sustainable solutions in the food chain and proposes a clear, principled approach to gene editing, ensuring that the Company remains at the cutting edge of this technology whilst establishing a position to improve health, welfare and economics of aquaculture and agriculture. Our position statement will be reviewed as the science and regulation develops.

- Benchmark considers gene editing of crops and animals to be a separate technology to transgenesis (moving genes between species), which should be *considered as different from those methods included in the original GMO regulations*. Editing of genes with naturally occurring genetic variation represents a much lower risk to animal welfare and environment.
- Benchmark considers gene editing of microorganisms and cell lines as a *valuable tool* for production of novel biotechnology products, and for understanding the how genes work at a fundamental level and in producing a phenotype.
- Benchmark recognises gene editing as a *potential tool for breeding livestock with improved health, animal welfare and performance*, and will research and investigate possible applications that do not constitute a risk to the genetic integrity of the individual, population or to the environment, or involve transfer of genetic material between species boundaries.
- Benchmark will consider possible applications of gene editing *on a case by case basis* under the 3E framework. Benchmark will take into consideration the potential *ethical, economic and environmental impacts* associated with the application of gene editing for the animal itself, the production system, the producer, potential consequences on agricultural practices, food systems and downstream effects on the environment.
- Benchmark recognises that gene editing may be *one of many useful tools* for improving health and welfare of farmed animals along with conventional breeding, nutrition, vaccination, health management and husbandry.
- Benchmark will implement this technology where it proves to be *socially and legally acceptable* and when it can be shown to *improve the efficiency, health and welfare* of our animals.

https://salmobreed.no/en/research-and-development/

Breeding and Gene Editing

- Benchmark acts responsibly as the guardian of its animals to develop high performance strains without compromising health and welfare;
- Animal and plant breeders have always relied on genetic variation caused by natural mutations to develop strains;
- Gene Editing is a novel technology that breeders can use to make new genotypes;

Why is GE different from GMO?

- Genetically Modified Organism (GMO) is an organism in which the genome has been altered in a way that could not have occurred naturally by mating and/or natural recombination.
- Transgenesis is the creation of a GMO by transfer of a gene from one species to another. Common in crops but only one licenced example in farmed animals – AquaAdvantage salmon.
- Benchmark does not use transgenesis in genetic improvement of products.

- Gene Editing is different from transgenesis since there is no incorporation of foreign DNA, only cutting and repair at a precise, specific position.
- Such alterations could occur naturally and are indistinguishable from natural mutations.

How can GE benefit aquatic breeding programmes?

- Health and animal welfare: by editing genes that control disease resistance.
- Sustainability: control of sterility to prevent genetic contamination of wild populations and reduce precocious maturation
- Faster and more precise improvement: incorporation of a new genotype in many families at once, without involving other genes.

When will Benchmark start using Gene Editing?

- Clear application route to market with profitable sales;
- GE when socially and legally acceptable, for health and welfare traits;

In the meantime:

- Functional genomics – find the genes;
- Collaboration with centres of excellence to identify and assess gene variants for health and welfare traits;
- Constructive discussions on regulatory systems for GE animals.

“Socially and Legally Acceptable”

European Environment

Genetically Modified Organisms (Contained use) European Regulations, 2000:
“genetic modification in relation to “an organism in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination.”

- “natural” methods of food production, eg organic;
- precautionary principle;
- Suspicious of science, experts and big Ag;
- Can control imports if not produced to acceptable standards;

Natural Farming Methods

- What is natural?;
- Focuses on method, not product quality eg organic;
- Subjective view of good and bad methods;
- Anti-innovation.

Precautionary Principle

- Prevent harm before a hazard has come into existence;
- Assume dangerous until proved safe.
- Suspicious of science, experts and big Ag;

- But looks at process in addition to endpoint: important for sustanability

Credit: AIER

Production and Imports

- Europe can control production and importation of goods produced using unacceptable technology;

Credit: Baltic Times

Credit: AIER

“Socially and Legally Acceptable”

Global Environment

- COVID-19 – are we looking for science based solutions?
- Anti-vax – influential groups communicate conspiracy theories about vaccines

- Large parts of the world may accept GE based on benefits to food production.

Consider other invasive, biotech solutions

Vaccination

- What if we had just discovered vaccination?

- How would we inform consumers of the benefits to food production?
- How would we regulate vaccination in farm animals?

What do we need?

Regulation of new breeding techniques

- Constructive, science-based, can-do approach;
- Based on outcome, not method;
- Fair and realistic evaluation of livestock farming and breeding methods, in comparison to historic methods;
- Evaluates technology in relation to sustainability;
- Distinction between Transgenics – GM and Gene Editing;
- Facilitate approval of new technology which allows development of strains with improved health, welfare and sustainability.

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