RIVERENCE

THOUGHTS FOR THE FUTURE OF LAND-BASED AQUACULTURE

Jesse Trushenski, Director of Science

RIVERENCE

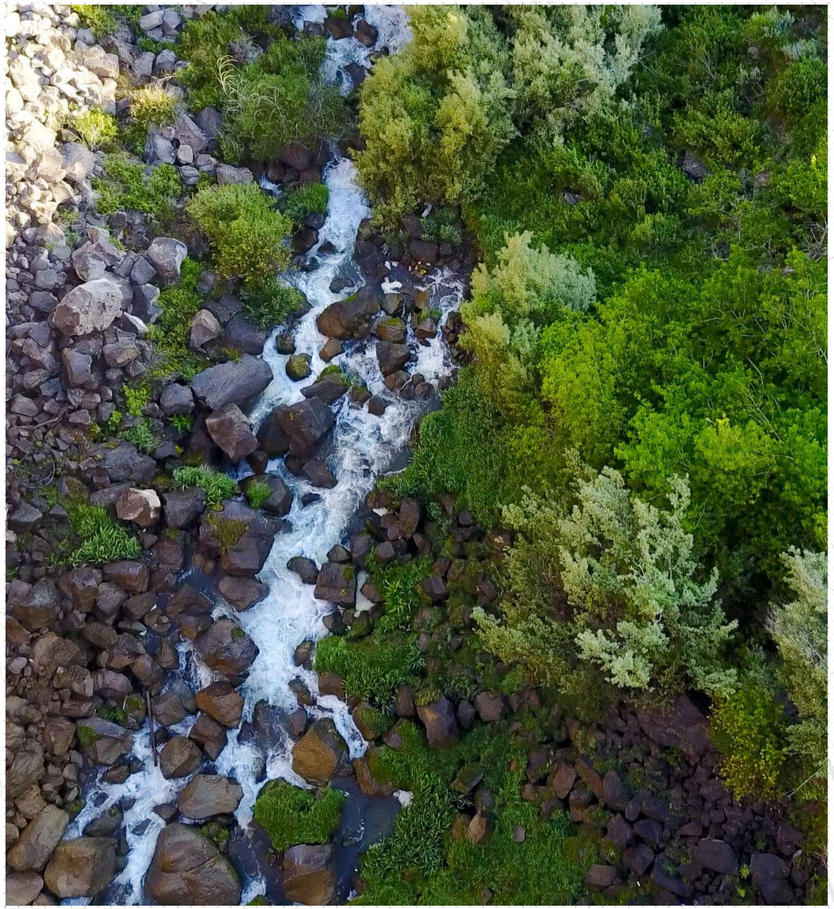
OUR STORY

WHO WE ARE & WHAT WE DO

Salmon and trout feed us—body and soul—and are part of the biological and cultural legacy we will leave to future generations

Riverence is the shared vision of a life-long, passionate fisherman and a 4th generation, conservation-minded rancher to protect wild fish while producing delicious seafood

Through mindful breeding, sustainable land-based seafood production, efficient distribution, and the development of industry-leading technologies, we are committed to satisfying demand for wholesome seafood while stewarding the environment



STATE OF PLAY

NEEDS IN THE AQUACULTURE INDUSTRY

Most farms operate—more or less—the same way that they always have

- Biomass estimation, size grading/sorting and distribution
- ‘Mainline’, single-trait breeding, limited reproductive technologies
- Rudimentary slaughter technologies
- Innovation in feeds and feeding, but minor compared to terrestrial agriculture

Aquaculture industry needs to rethink how we approach all aspects of production with performance, animal welfare, and consumer expectations in mind

RAS and land-based aquaculture are examples of this type of innovation—they may enable other novel approaches, but also present unique operational challenges

CURRENT AND EMERGING NEEDS

A SOLUTIONS-ORIENTED RESEARCH PORTFOLIO

Rigorous scientific inquiry allows for informed decision-making—it is what gives us the power to know better and do better

Our scientific portfolio emphasizes applied science and is intended to help shape the future of aquaculture, industry-wide, and support our vision

Projects are developed to address breeding, nutrition, health, efficiency, product quality and welfare priorities—the work must inform our approach or offer short- or long-term improvements in operations

Science initiatives are supported by our own research capacity and key collaborations

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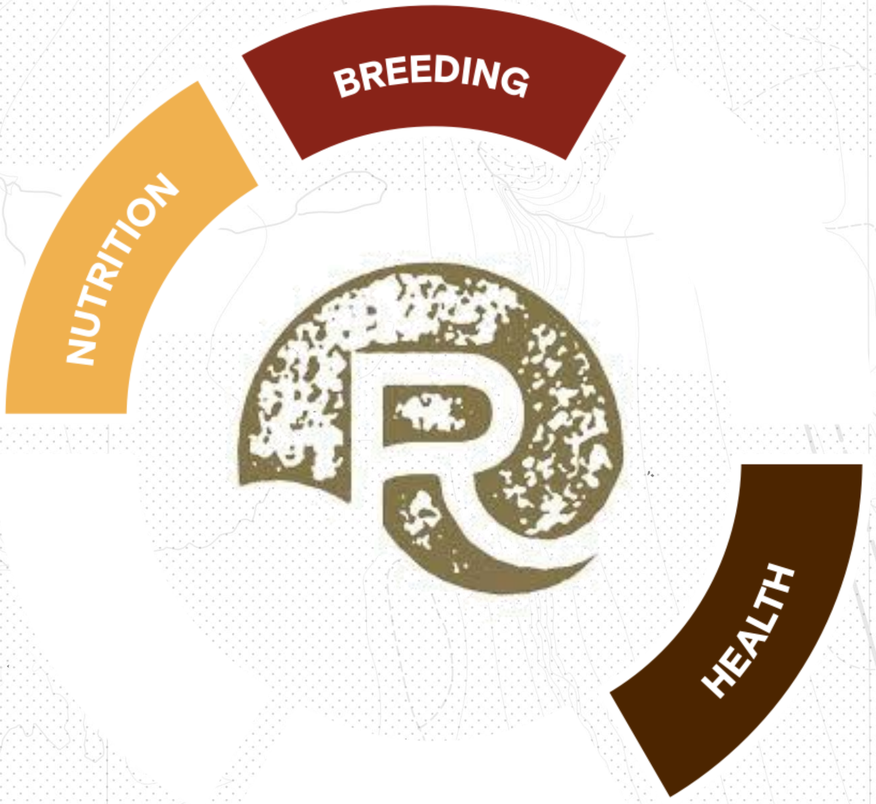


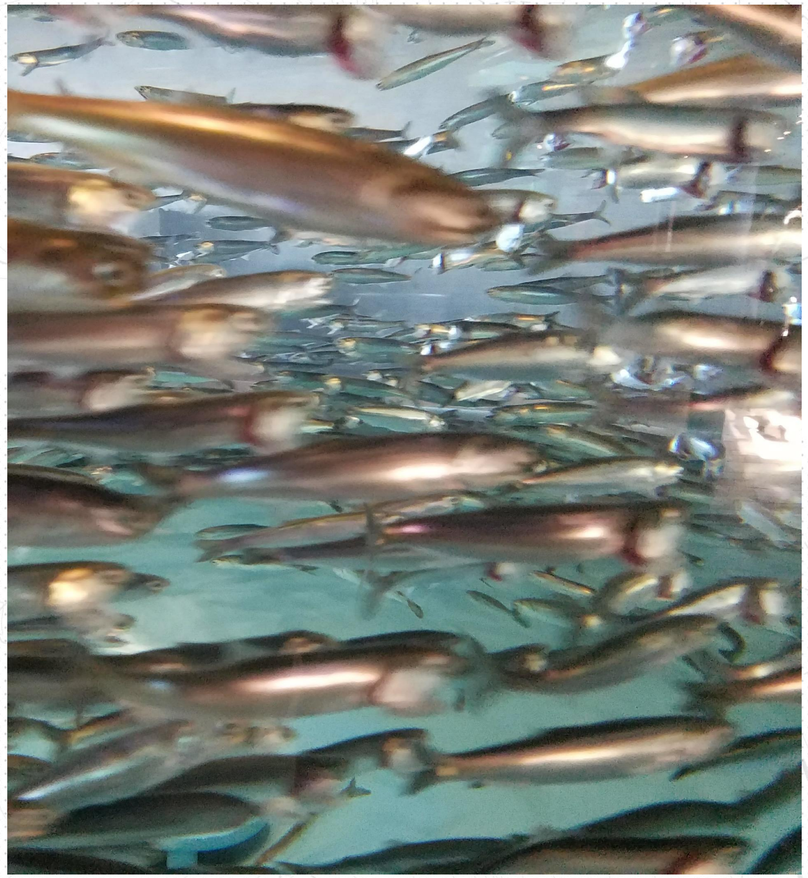
JUDICIOUS USE OF NATURAL RESOURCES

DEFINING SUSTAINABILITY IN THE AQUAFEED SECTOR

Fish meal and oil are highly valuable feed resources that are used more efficiently in aquaculture than other sectors

We believe judicious use of fish meal and oil in aquafeeds is a sustainable practice, but current usage patterns will not support a thriving industry at the necessary scale

Aquaculture must be both economically and ecologically sustainable



THE CHALLENGE

WHAT ALTERNATIVE INGREDIENTS MUST DELIVER

Our goal is to reduce fish meal and oil use in our feeds, but ingredients used to spare marine resources must…

- Support rapid and efficient growth
- Provide nutrients needed to maintain robust, resilient, vigorous livestock
- Yield products that meet consumers' expectations regarding taste, long-chain omega-3 fatty acids and other nutrients, etc.

Cost-effective feeds are needed to put superior seafood within everyone's reach

PROMISING PATHWAYS

WHERE WE SEE POTENTIAL IN ALTERNATIVE INGREDIENTS

Least-cost feed formulation requires a portfolio of ingredients with certain compositional and logistical attributes

- Known nutrient profiles and digestibilities
- Consistent composition or predictable variation
- Sizable product volumes and no gaps in availability
- No contaminants or antinutritional factors
- Do not negatively affect nutrient retention, effluents, or ability to capture wastes
- Competitive pricing

IMAGE COURTESY OF
BRETT GLENCROSS

PROMISING PATHWAYS

WHERE WE SEE POTENTIAL IN ALTERNATIVE INGREDIENTS

Where we see value and possibility

- Improved capture of seafood processing wastes
- Improved processing of traditional commodity protein and lipid sources
- GM grains and/or oilseeds that contain long-chain omega-3 fatty acids or are otherwise better suited to aquafeeds
- Insect and other invertebrate meals

Greater focus on the functional properties and potential synergy between ingredients

IMAGE COURTESY OF BRETT GLENCROSS

FURTHER READING

North American Journal of Aquaculture 81:13–39, 2019
© 2018 American Fisheries Society
ISSN: 1522-2055 print / 1548-8454 online
DOI: 10.1002/naaq.10067

FEATURED PAPER

Thoughts for the Future of Aquaculture Nutrition: Realigning Perspectives to Reflect Contemporary Issues Related to Judicious Use of Marine Resources in Aquafeeds

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https://doi.org/10.1002/naaq.10067

FISH HEALTH MANAGEMENT

ANTICIPATING AND IDENTIFYING THREATS

RAS technology allows for stricter biosecurity protocols, but such practices don’t eliminate all fish health threats

More proactive and comprehensive fish health management strategies are needed

- Anticipation of emerging infectious and other threats to fish health
- Biosecurity and preventative strategies
- Rapid diagnostics and early intervention tools
- Additional therapeutic options for when integrated fish health management fails

MORE TOOLS FOR THE TRADE

STOCKING THE TOOLBOX OF TOMORROW

Surface disinfectants/sanitizers

- Biofilter-safe products, alternatives to formalin

Treatments for systemic bacterial infections and parasites

- Next generation antibiotic or analogous therapeutant

Preventive measures

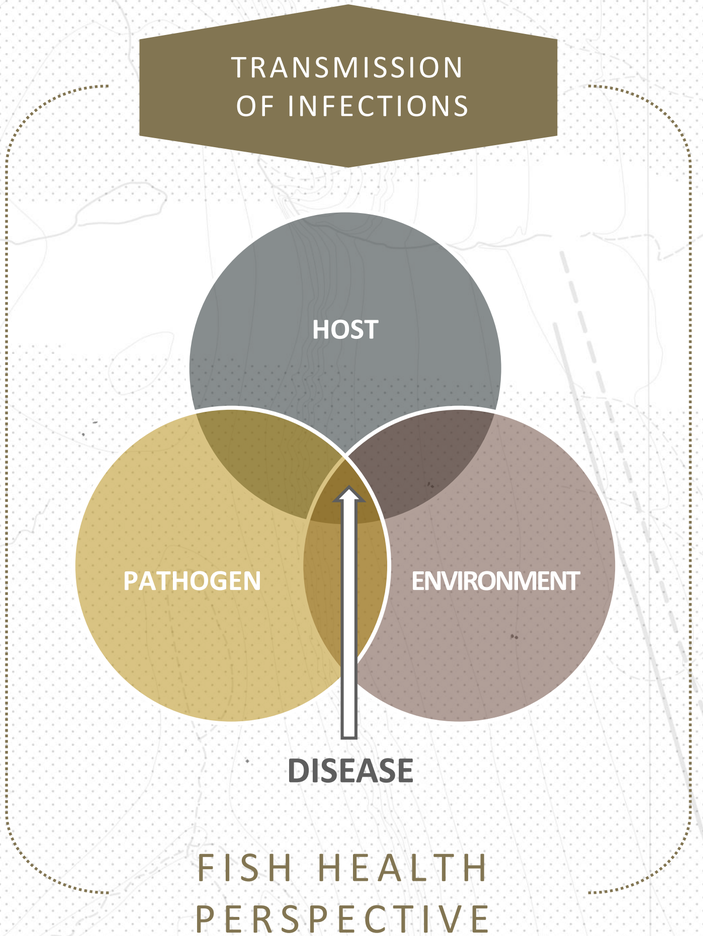
- Biologics, bacteriophages, novel feed ingredients/additives

Sedation

- Zero-withdrawal for transport, handling, rested harvest

Farmer-friendly tools needed to identify pathogens and confirm effectiveness of sanitation protocols

Research to satisfy regulatory requirements should be prioritized



FISH HEALTH PERSPECTIVE

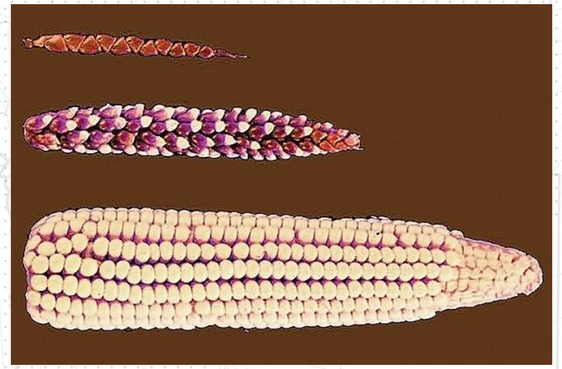
SELECTIVE BREEDING

ARTIFICIAL VS. NATURAL SELECTION

Natural selection favors those traits that increase the likelihood of survival and recruitment

Artificial selection favors traits identified as valuable by the breeder

All modern livestock breeds and crop varieties are—more or less—the result of intentional crosses of ‘like with like’ to increase the occurrence of desired traits



MAIZE BRED FOR LARGE, STARCHY KERNELS

LINCOLN LONGWOOL SHEEP BRED FOR WOOL

CARROTS BRED FOR COLORS AND OTHER TRAITS

ENGLISH LONGHORN BRED FOR DRAFT AND BEEF

LESSONS LEARNED

SUCCESSES & FAILURES OF SELECTIVE BREEDING

Artificial selection is decisive and rapid, leading to dramatic changes in observable traits in just a few generations

Breeders may intentionally select for a single trait, but they are also unintentionally selecting for (or against) many others

Natural selection is slower, but allows for ‘course correction’ and balancing of many traits that influence biological fitness

SELECTION FOR LARGE SIZE AND HEAVY MUSCLING IN BELGIAN BLUE CATTLE HAS MADE CESAREAN DELIVERY NECESSARY FOR ALL BIRTHS

SAMOYED DOGS SELECTED FOR PERFORMANCE IN EXTREMELY COLD WEATHER SUFFER FROM HEREDITARY CATARACTS AND DIABETES

SELECTION FOR EGG YIELD HAS MADE LAYING HEN BREEDS PRONE TO OSTEOPOROSIS, SKELETAL FRACTURES AND DEFORMITIES

SELECTION FOR SIZE AND BREAST YIELD HAS MADE BROAD-BREASTED WHITE TURKEYS INCAPABLE OF BREEDING AND PRONE TO HEALTH PROBLEMS

TRAITS & TRADE-OFFS

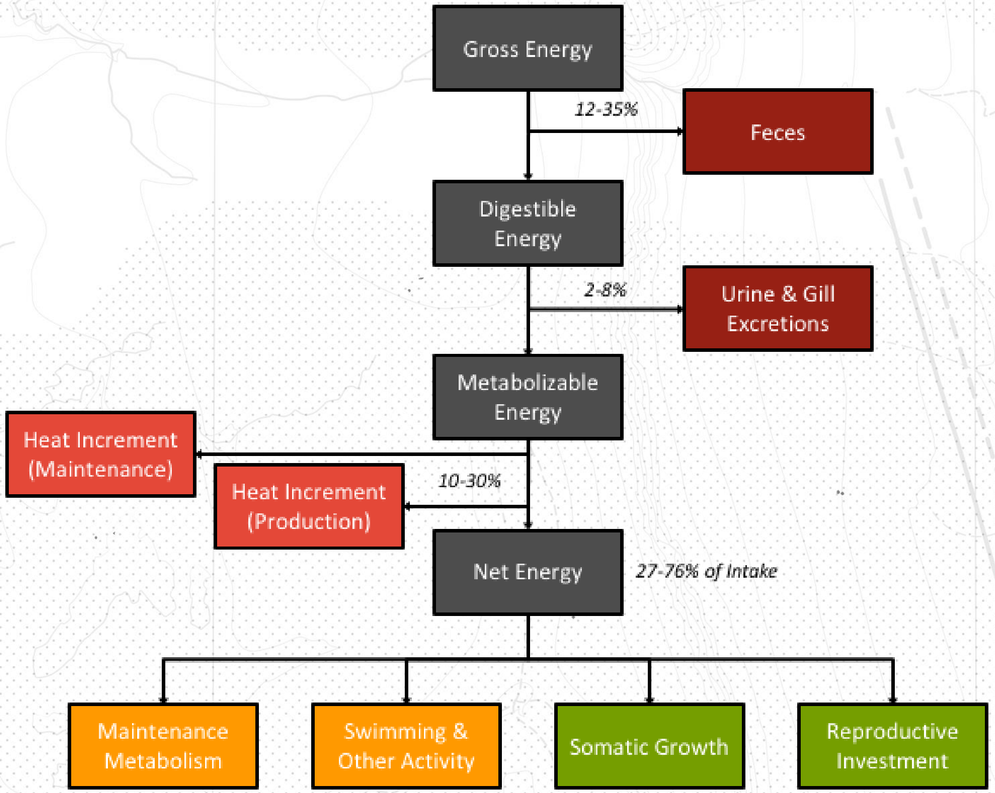
BALANCING THE BIOENERGETIC BUDGET

Everything that an animal does or that occurs within its body requires raw materials and energy—both are provided by the diet and distributed among competing needs based on internal and external cues

Bioenergetic models are ‘budgets’ with mandatory and discretionary line items

Traits are the observable result of how discretionary ‘funds’ are invested

GENERALIZED BIOENERGETIC MODEL FOR FISH



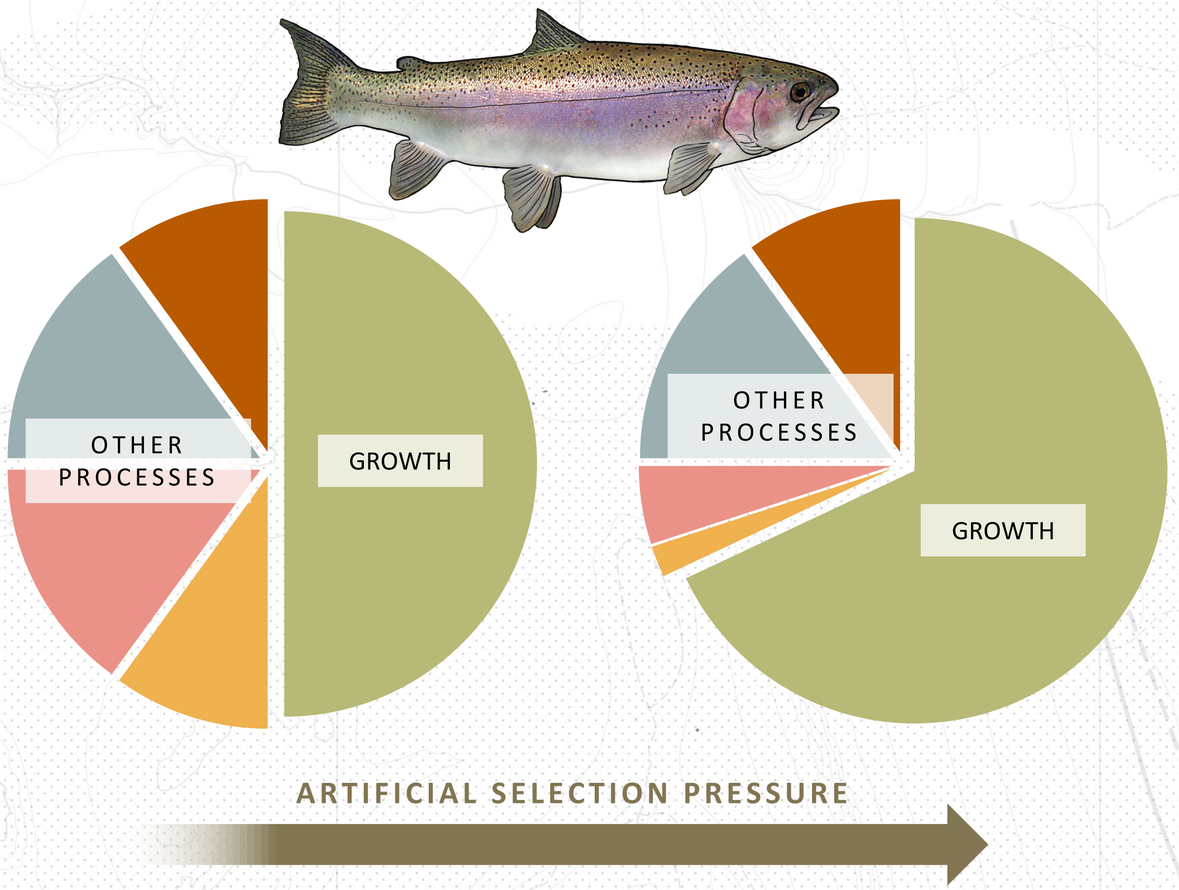
TRAITS & TRADE-OFFS

PARTITIONING AMONG PROCESSES

Consumed energy supports all processes, including those relevant to performance

Greater investment in one area means there will be fewer resources available to support others—this is the essence of artificial selection

Increasing the budget (through nutrition) allows more investments to be made, but there will always be trade-offs



RETHINKING BREEDING

TIME FOR A NEW/OLD APPROACH?

Despite the advances made to-date, single-trait selection is no longer a tenable approach to breeding

The landscape has changed—literally and metaphorically—and breeding must reflect the fact that growth, efficiency, and yield are no longer the only metrics that matter

Vigor and fitness—the driving principles of natural selection—are becoming de rigueur

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PHYSICAL STRENGTHS AND GOOD HEALTH

SYNONYMS

ROBUSTNESS, HEALTHINESS, GOOD HEALTH, HARDINESS, STRENGTH, STAMINA, STURDINESS, FITNESS, GOOD SHAPE, GOOD TRIM, GOOD CONDITION, FINE FETTLE, TOUGHNESS, RUGGEDNESS, MUSCLE, POWER; BLOOM, RADIANCE, SAP; ENERGY, ACTIVITY, LIVELINESS, LIFE, SPRYNESS, SPRIGHTLINESS, VITALITY, VIVACITY, VIVACIOUSNESS, VERVE, ANIMATION, SPIRITEDNESS, SPIRIT, ENTHUSIASM, FIRE, FIERINESS, FERVOR, ARDOR, ZEAL, PASSION, MIGHT, FORCEFULNESS, DETERMINATION, INTENSITY, DYNAMISM, SPARKLE, EFFERVESCENCE, ZEST, DASH, SNAP, SPARK, GUSTO, PEP, BOUNCE, EXUBERANCE, DRIVE, PUSH, ZING, OOMPH, GET-UP-AND-GO…

RETHINKING BREEDING

WHY BREED FOR ROBUSTNESS?

The environment and rearing practices have changed and are still changing

Traits that define efficiency and profitability vary among operations and over time

Animals equipped to thrive perform more efficiently and have fewer welfare concerns

The ‘farm animal of the future’ is biologically suited to life—robust, adapted, and healthy

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RETHINKING BREEDING

INDIRECT APPROACH

Like controlled natural selection, selection is based on performance in common garden-style trials

Selection pressure isn't driven by any one trait, but top performers will possess—more or less—what it takes to be successful

Indirect approach is slower, but lets real-world conditions drive selection and can help identify vigor traits retrospectively

DIRECT APPROACH

Essentially the same as traditional selective breeding, except for the basis of selection

Traits are selected to be broad-based indicators of fitness—traits must reflect attributes that make an animal suited to life

Direct approach is more rapid, but can easily go awry if focused on the wrong traits

RAUW & Gomez-Raya 2018
DOI: 10.3389/FGENE.2015.00310

RIVERENCE BROOD

IT ALL STARTS WITH THE EGG

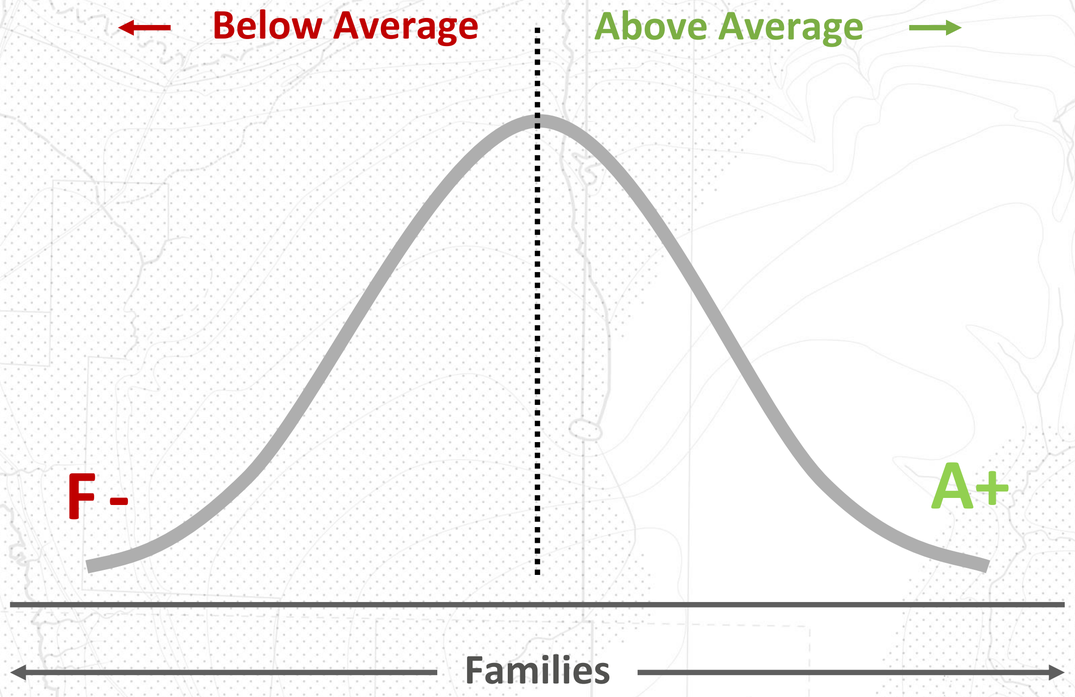
Salmonid breeding company based in Washington State

Rainbow Trout, Atlantic Salmon, and Coho Salmon broodstocks maintained in modern, biosecure partial RAS systems

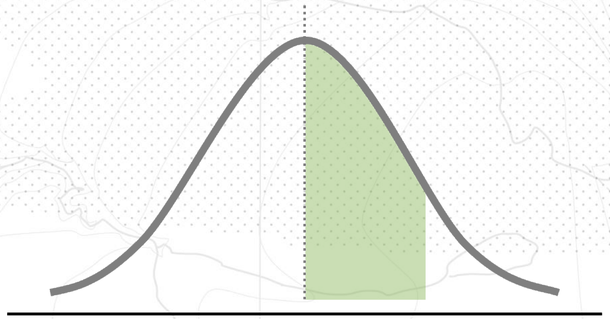
Annual capacity of 100 million eggs

Breeding for vigor, not traits du jour, by harnessing natural selection in range of environments and rearing environments

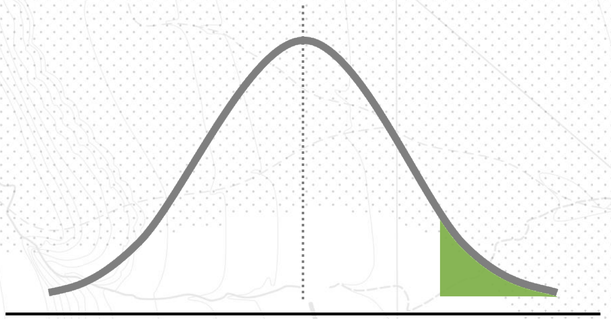
INFORMED BREEDING



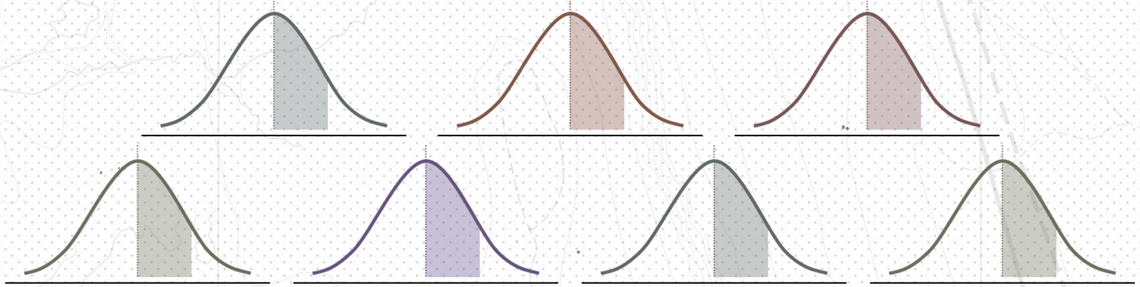
FAMILIES WILL PERFORM DIFFERENTLY WITH RESPECT TO EACH METRIC, RANGING FROM POOR TO EXCELLENT PERFORMANCE



MODERATE SELECTION FOR TRAIT—FACILITATES SELECTION FOR MULTIPLE TRAITS



AGGRESSIVE SELECTION FOR TRAIT—VULNERABLE TO BOTTLENECKS



BREEDING MUST TAKE ALL RELEVANT TRAITS INTO CONSIDERATION

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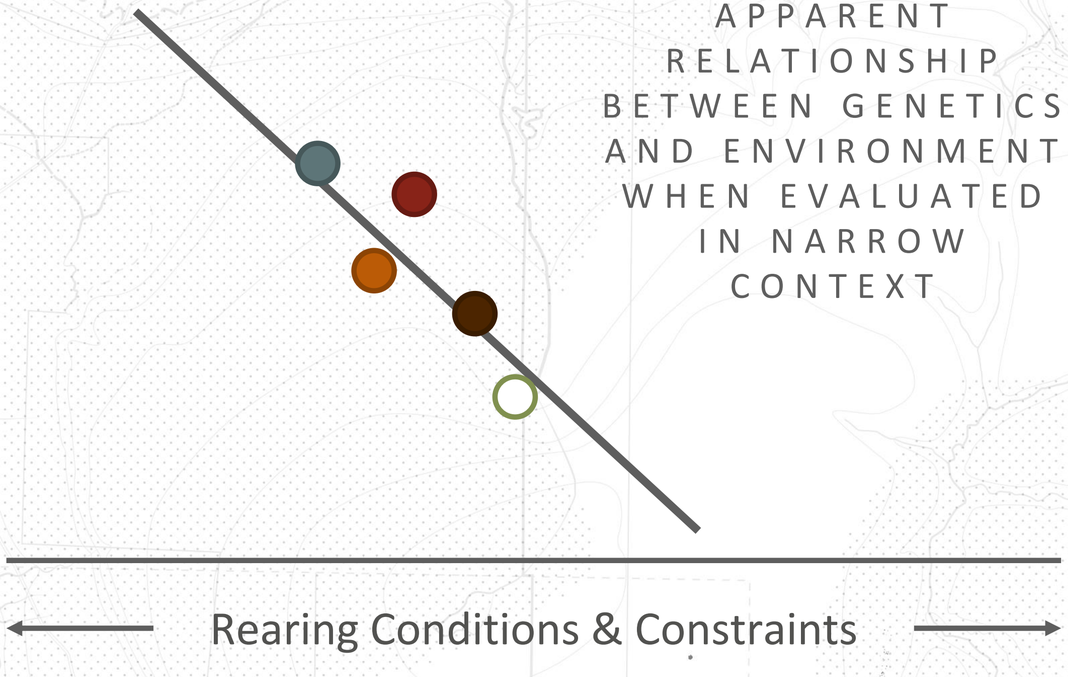
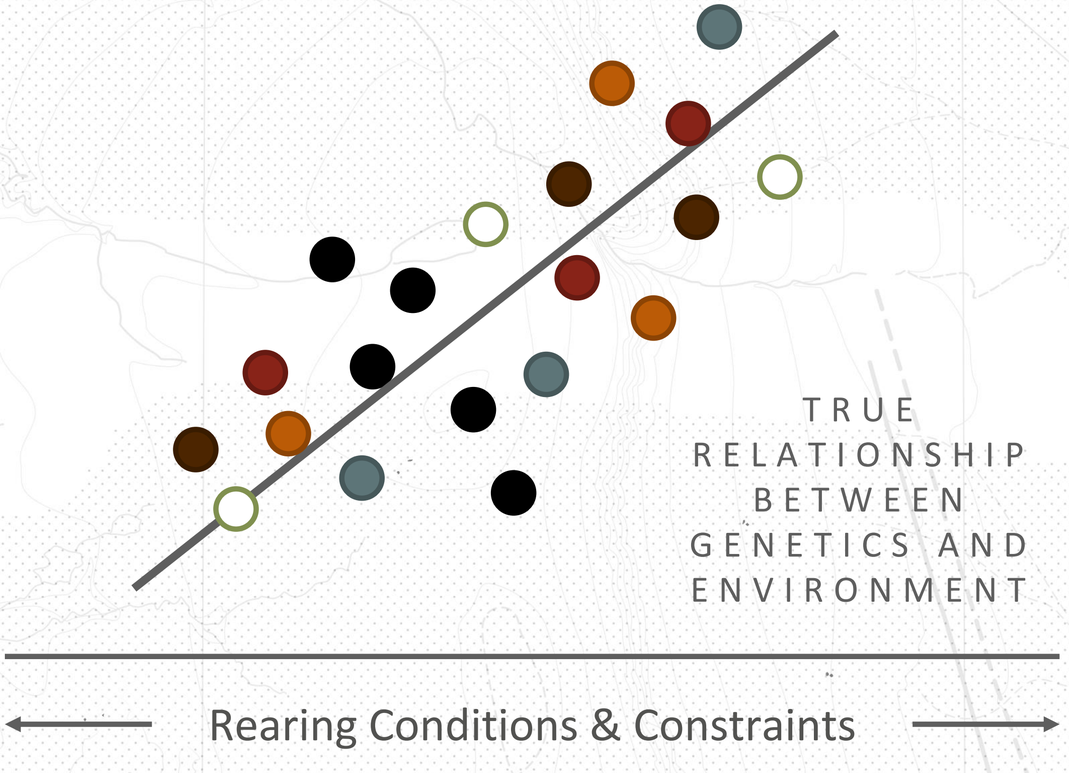
INFORMED BREEDING



APPARENT RELATIONSHIP BETWEEN GENETICS AND ENVIRONMENT WHEN EVALUATED IN NARROW CONTEXT

Rearing Conditions & Constraints



TRUE RELATIONSHIP BETWEEN GENETICS AND ENVIRONMENT

Rearing Conditions & Constraints

REPRESENTATIVE ASSESSMENTS UNDER DIFFERENCE REARING SCENARIOS ARE ESSENTIAL

RIVERENCE

RIVERENCE FARMS

THE WAY STEELHEAD AND TROUT ARE SUPPOSED TO TASTE

2nd largest producer of Rainbow Trout and Steelhead in the USA

Collection of farms and processing facilities located in Idaho

Annual target of 10 million pounds

Routine operational statistics and performance of sentinel groups deployed here are used to benchmark Riverence genetics and make vigor-based breeding decisions

LOOKING AHEAD

THE ONLY CERTAINTY IS CHANGE

Matters related to seafood demand, resource availability, efficiency, and the social license to operate will likely intensify

New issues will emerge and further change the state of play

Artificial selection is a powerful tool, but the future lies in retaining vigor while shaping the attributes of salmonids to meet the demands of modern aquaculture

FRESHWATER AVAILABILITY AND ENVIRONMENTAL PREDICTABILITY WILL CONTINUE TO DECLINE

INGREDIENT AVAILABILITY, AQUAFEED COMPOSITION, AND MANUFACTURING WILL REMAIN IN FLUX

SEAFOOD DEMAND WILL CONTINUE TO GROW, MEANING AQUACULTURE MUST CONTINUE TO DO MORE WITH LESS

ENVIRONMENTAL AND WELFARE CONCERNS WILL INTENSIFY

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OTHER THOUGHTS

PUBLIC DATA-GENERATING PARTNERS

The domestic aquaculture research community is smaller now than in the past and funding is even more restricted.

Who will take responsibility for research needs in the future and how can new partners secure funding for needed work? Where will studies, especially GLP studies, be conducted?

REALIGNING RESEARCH PRIORITIES

Federal research planning exercises solicit industry input, but the resulting priorities rarely reflect immediate needs or approval activities. Outreach and technology transfer efforts are largely restricted to technical publications and presentations.

How can regulatory science be incentivized within the federal system?

WORKFORCE READINESS

The aquaculture research community has experienced substantial turnover in recent years, and the number of educational program has contracted.

How will institutional knowledge be replaced and new researchers be brought up to speed? Where will the next generation of fish farmers come from?

FINDING COMMON GROUND

Many of the solutions needed in aquaculture may exist be developed in other sectors.

How do we communicate our needs to other industries or research communities? How do we encourage collaborative research across disciplines?