WP1 - Sustainable breeding of important European aquaculture species
MAIA webinar 21.11.2023

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WP1: Sustainable breeding

To **assess**, **validate** and **demonstrate** the level of the ability of the current breeding programs, their breeding goals and methodologies in four of the main European aquaculture species to answer the future challenges of:

1. Increased need for utilization of alternative feed sources in aquaculture feeds.
2. Need for resilience in the face of climate change.
3. Maintained and increased animal welfare through robustness and disease resistance.

Nofima, Avramar (previously Nireus), Benchmark Genetics Norway, Hellenic Centre for Marine Research, Osland Stamfisk

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Motivation: climate resilience

- Climate change brings upon several climatic elements:
  - Rise in temperatures, and sea-level
  - Ocean acidification
  - Increased risk of diseases, parasites and harmful algal blooms
  - Changes in rainfall patterns and sea-surface salinity
  - Uncertainty of external input supplies
  - Severe climate events
- Many fish species are poikilothermic
- Rise in temperature may
  - Affect production traits
  - Thermal stress → more susceptible to diseases
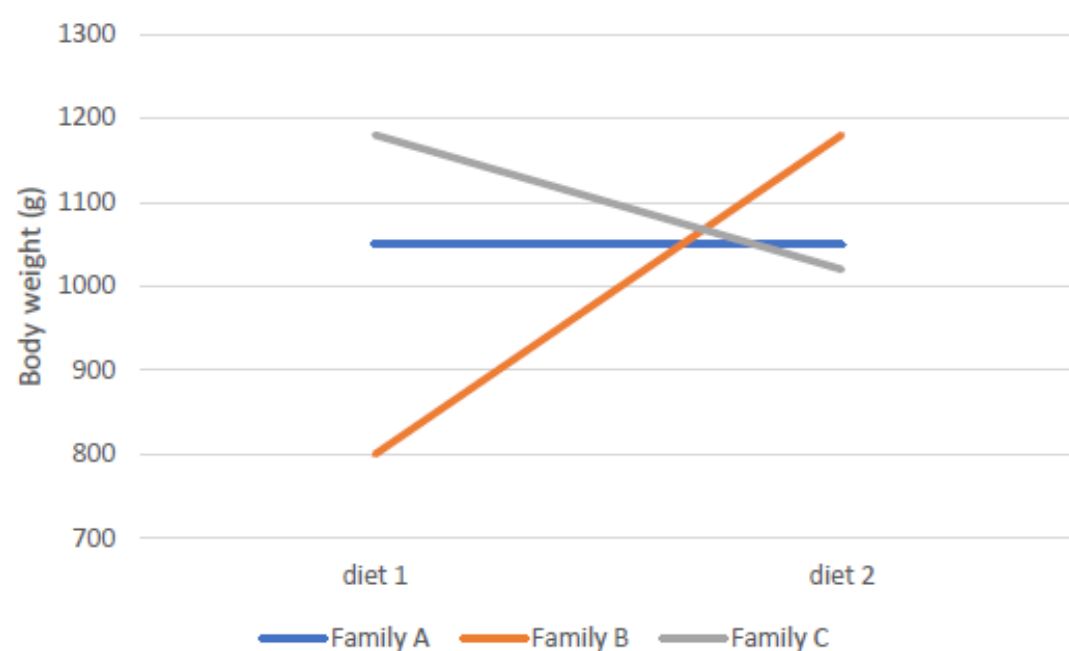 - Increased risk for more opportunistic disease outbreaks

Genotype x Environment

Scaling

Re-ranking

Studying of GxE, will provide valuable information on how aquaculture breeding can prepare up front to future challenges.
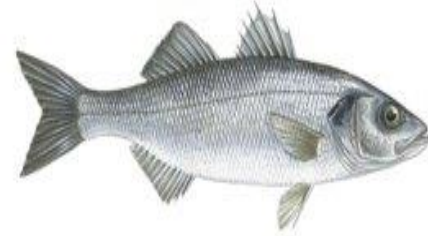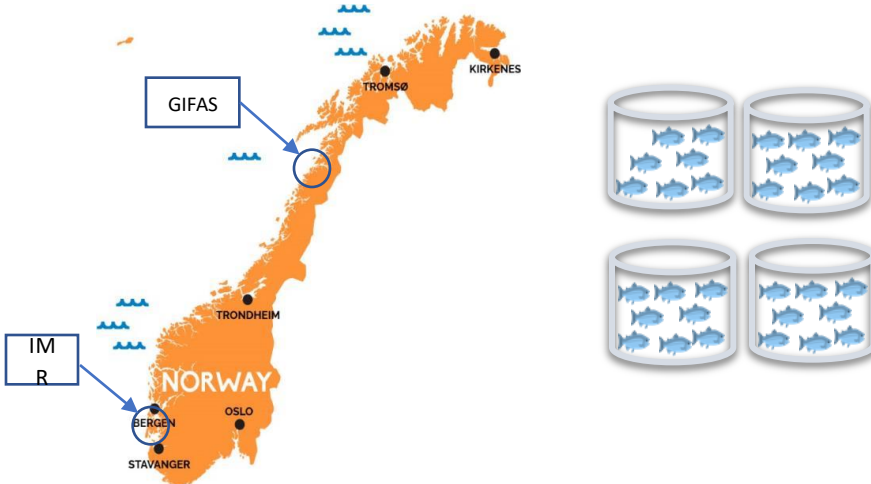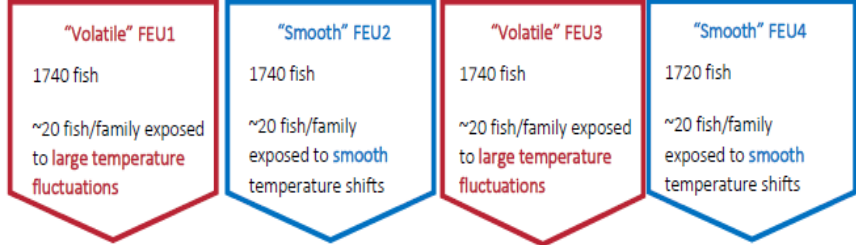
Genotype by Climate

67 Families (BGN)
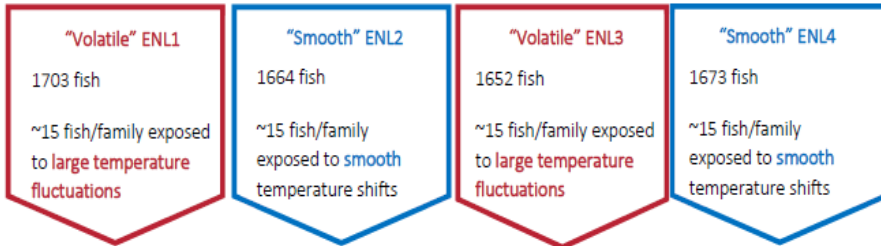N=~3231

88 Families (AVRAMAR)
N=~6960

114 Families (AVRAMAR)
N=~6829

GIFAS

IMR

NORWAY

KIRKENES
TROMSØ
TRONDHEIM
BERGEN
OSLO
STAVANGER

"Volatile" FEU1	"Smooth" FEU2	"Volatile" FEU3	"Smooth" FEU4
1740 fish	1740 fish	1740 fish	1720 fish
~20 fish/family exposed to large temperature fluctuations	~20 fish/family exposed to smooth temperature shifts	~20 fish/family exposed to large temperature fluctuations	~20 fish/family exposed to smooth temperature shifts

| "Volatile" ENL1	"Smooth" ENL2	"Volatile" ENL3	"Smooth" ENL4
1703 fish	1664 fish	1652 fish	1673 fish
~15 fish/family exposed to large temperature fluctuations	~15 fish/family exposed to smooth temperature shifts	~15 fish/family exposed to large temperature fluctuations	~15 fish/family exposed to smooth temperature shifts

GxE in Atlantic salmon

Genotype-by-climate

- SOUTH 969 g, NORTH 1590 g (conv.diet only) due to different grow-out period length
- Moderate to high heritability for growth
- High genetic correlation between growth traits across environments → no significant GxE
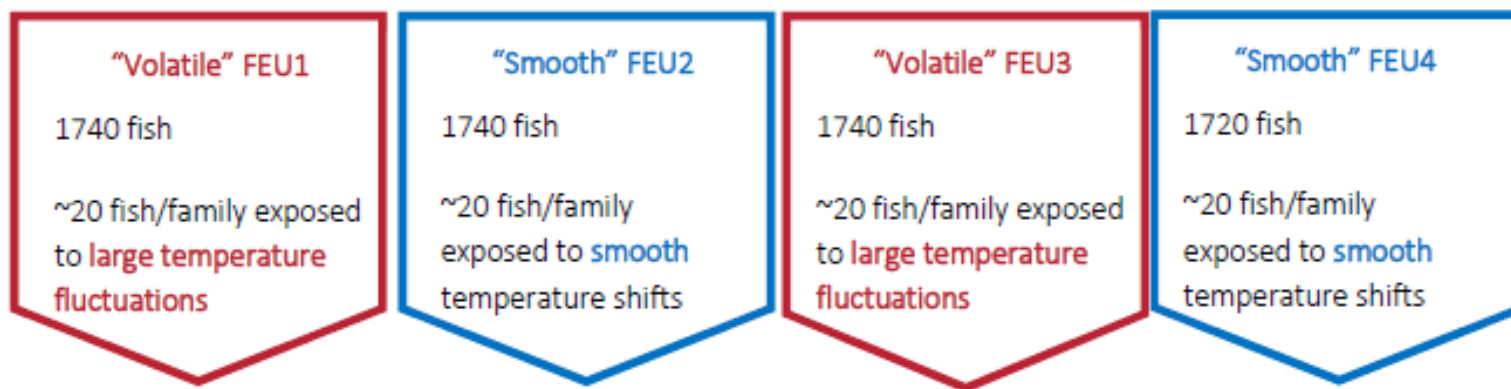
Traits	End weight		TGC	
	SOUTH	NORTH	SOUTH	NORTH
SOUTH	**0.58±0.03**		**0.56±0.04**	
NORTH	0.93±0.06	**0.46±0.02**	0.94±0.08	**0.44±0.03**

Daily average temperature
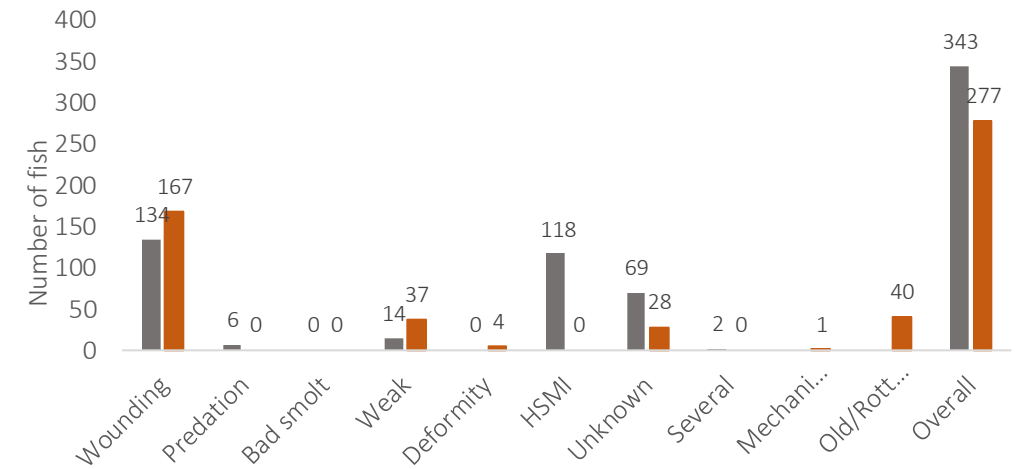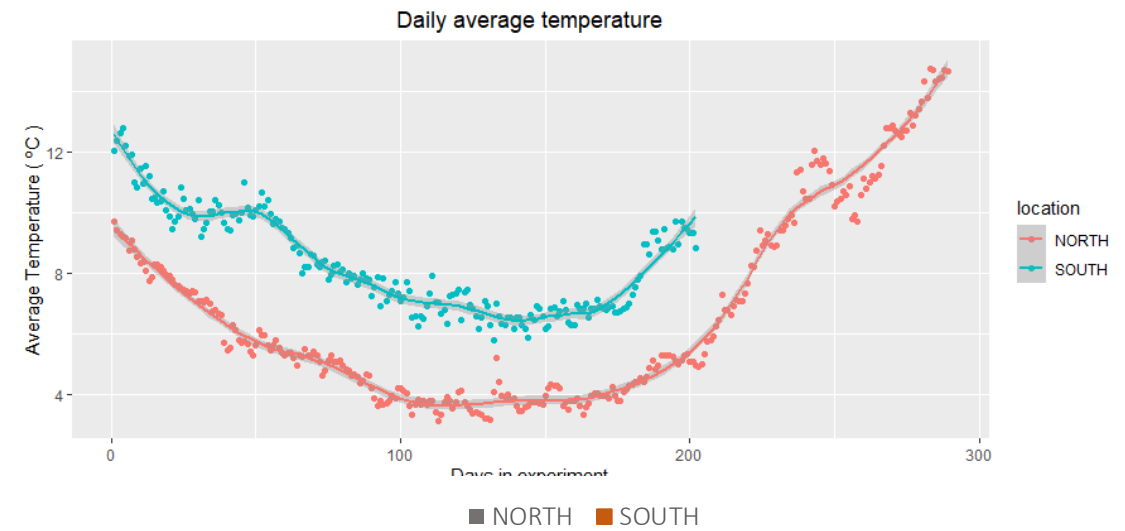
- QTL-study; no statistically significant associations for any of the growth traits were found → support for polygenic inheritance
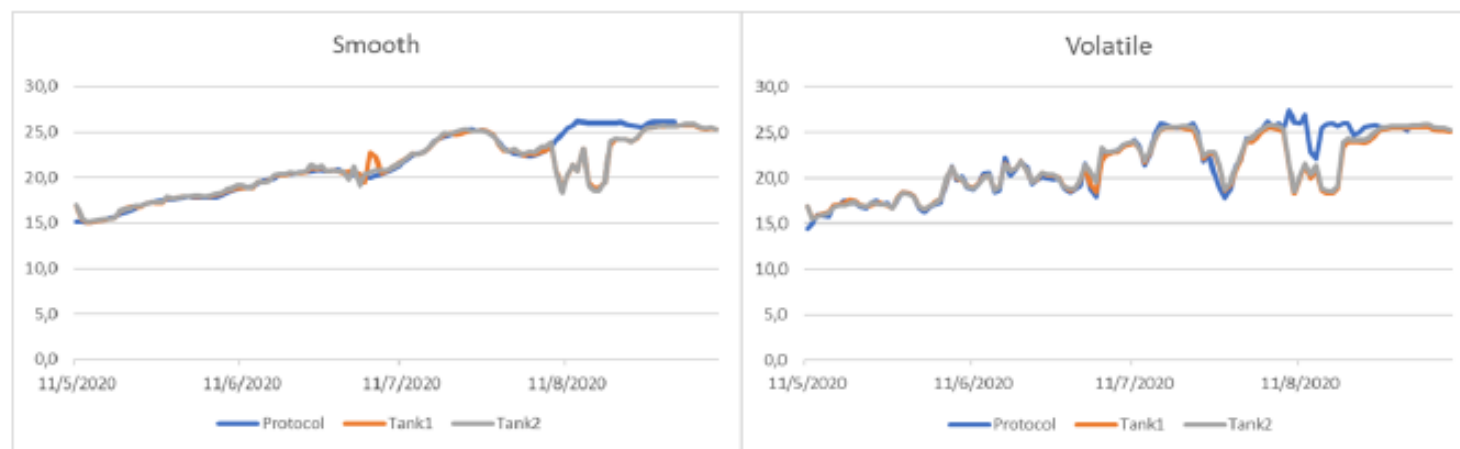
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Experiment: European sea bass

"Volatile" FEU1

1740 fish

~20 fish/family exposed to large temperature fluctuations

"Smooth" FEU2

1740 fish

~20 fish/family exposed to smooth temperature shifts

"Volatile" FEU3

1740 fish

~20 fish/family exposed to large temperature fluctuations

"Smooth" FEU4

1720 fish

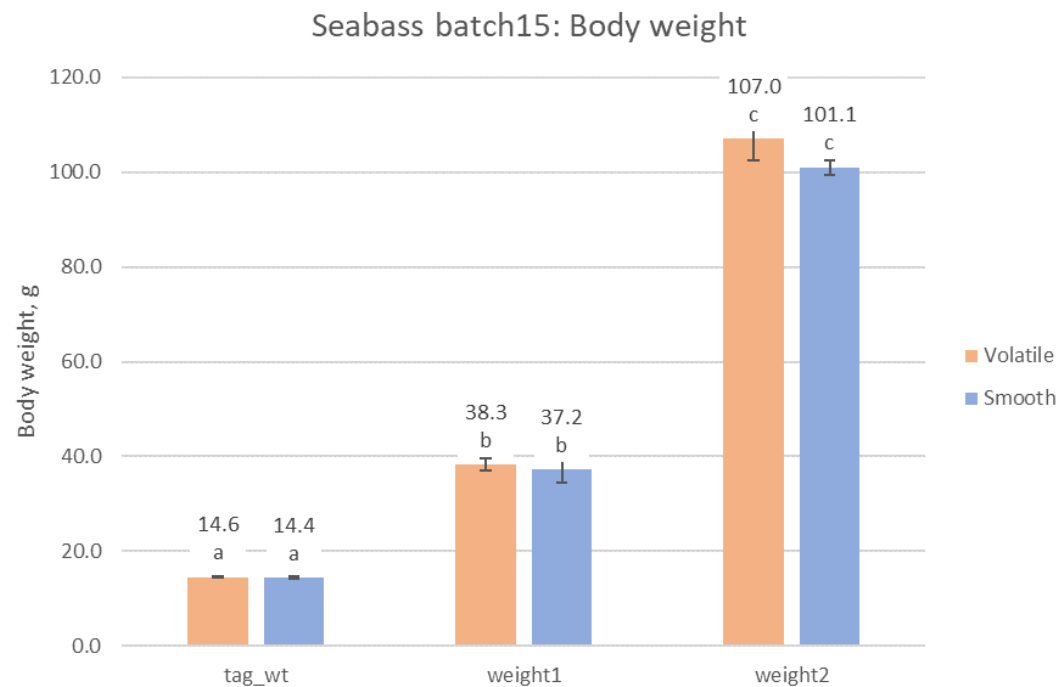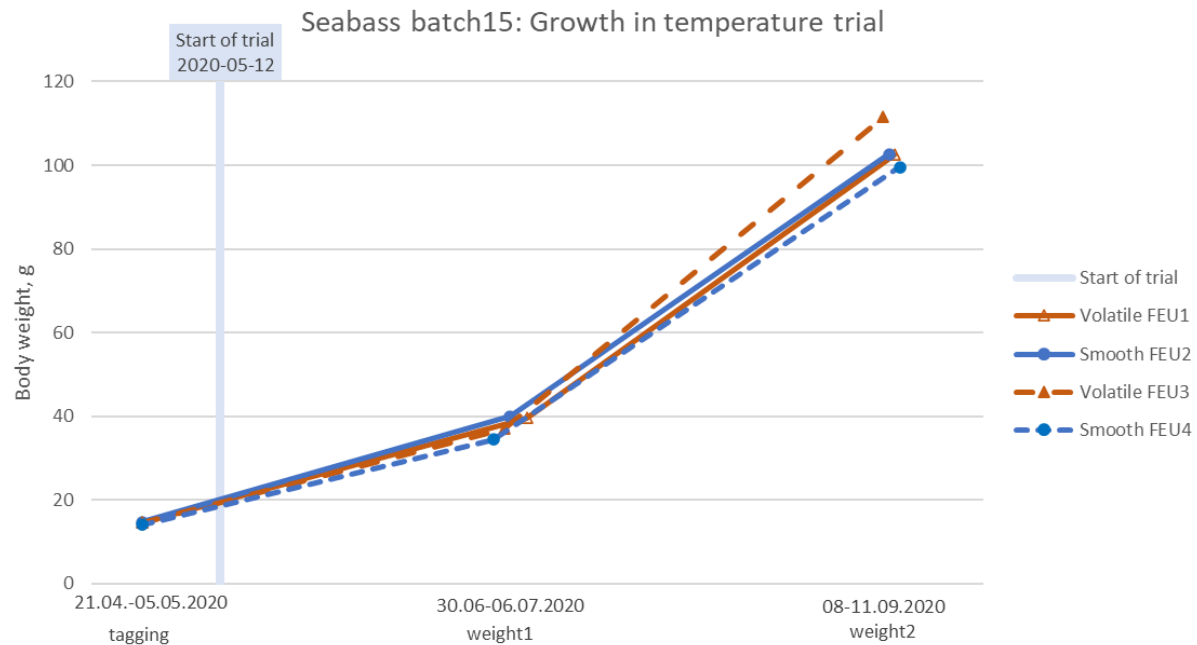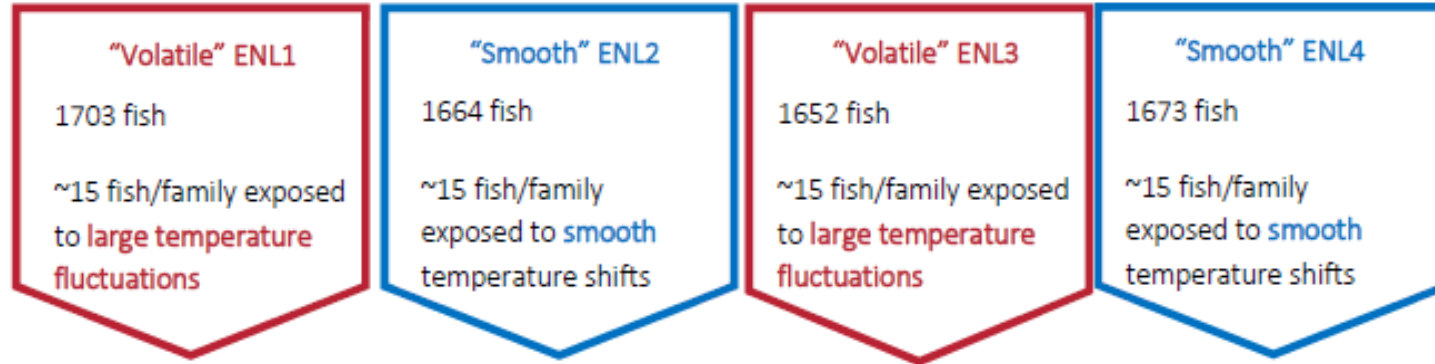~20 fish/family exposed to smooth temperature shifts

G-by-climate

- N=6904, 88 families

- 4-month trial:
  - May-September 2020

GxE in European sea bass

Seabass batch15: Growth in temperature trial

Seabass batch15: Body weight

Experiment: Gilthead sea bream

"Volatile" ENL1	"Smooth" ENL2	"Volatile" ENL3	"Smooth" ENL4
1703 fish	1664 fish	1652 fish	1673 fish
~15 fish/family exposed to large temperature fluctuations	~15 fish/family exposed to smooth temperature shifts	~15 fish/family exposed to large temperature fluctuations	~15 fish/family exposed to smooth temperature shifts

G-by-climate

- N=6692, 114 families
- 3-month trial
  - November 2021-February 2022

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GxE in sea bream

Seabream batch19: Growth in temperature trial

Seabream batch19: Body weight
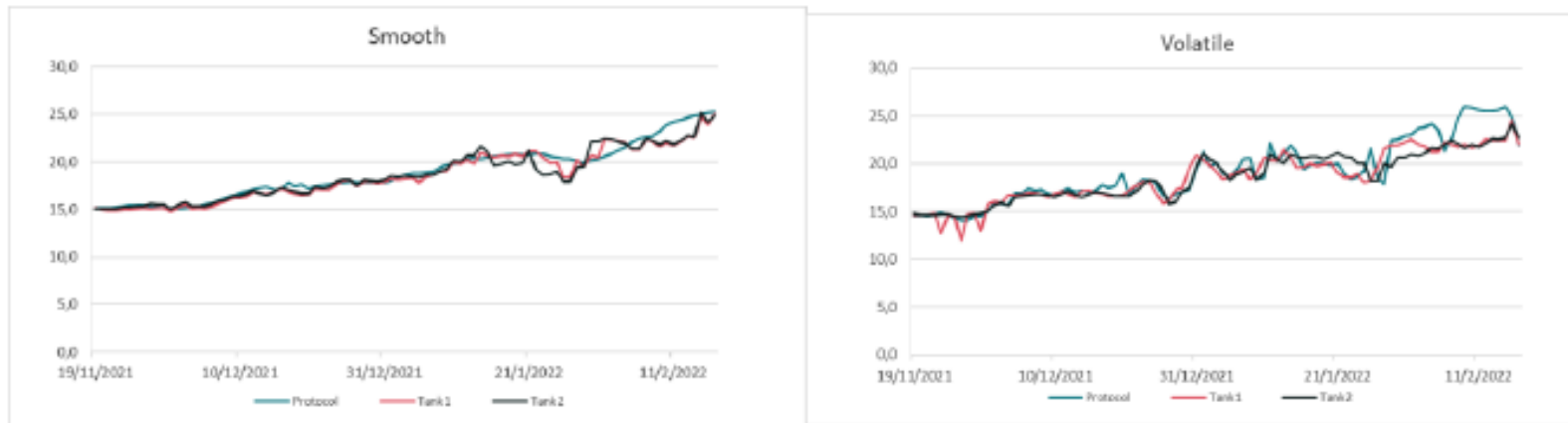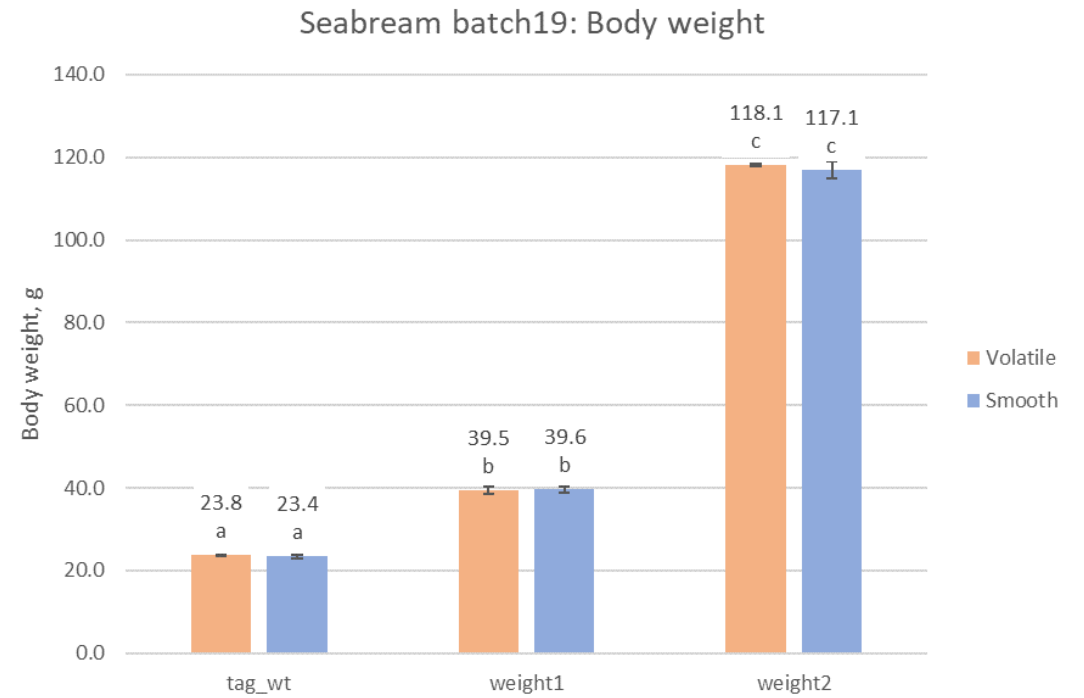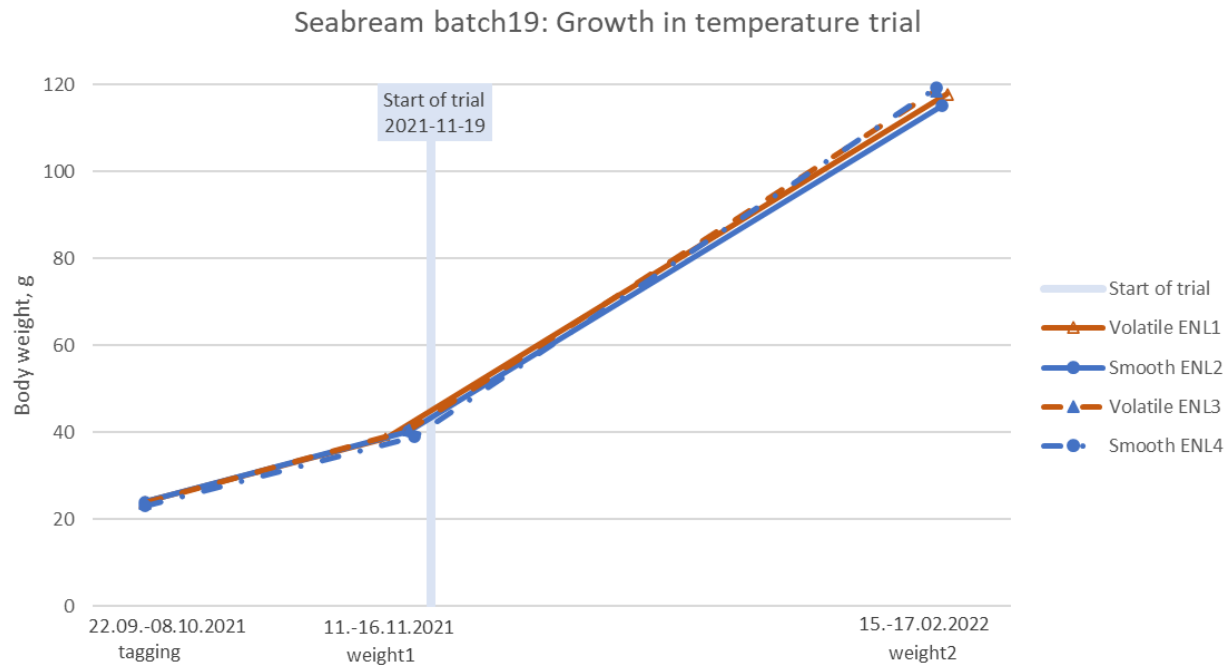
GxE climate in bass and bream

SEA BASS	Weight volatile	Weight smooth
Weight volatile	0.21 ± 0.09	
Weight smooth	0.99 ± 0.04	0.23 ± 0.09

SEA BREAM	Weight volatile	Weight smooth
Weight volatile	0.32 ± 0.10	
Weight smooth	1.01 ± 0.03	0.32 ± 0.09

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Main conclusions

- High genetic correlations between growth traits across climates/temperature regimes indicate non-significant genotype-by-environment interactions in Atlantic salmon, European sea bass and Gilthead sea bream.

- Independent from the environment growth can be genetically improved by selective breeding in the three species.

Relevance to implementation

- Growth selection in breeding nucleus in the current environmental conditions will be also effective in the changing environment.

- Breeding companies can serve large markets using genetic material from a single breeding program.

- Fish farmers will experience that the expected genetic gain from the nucleus will realize in their production environment.

- Overall resilience regarding climate change and novel feeds is expected to help in resource optimization, and to promote predictable and sustainable aquaculture production, and increased animal welfare in the important European aquaculture species.

Thank you!

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