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AN INDIVIDUAL-BASED BIOENERGETIC GROWTH MODEL OF RAINBOW TROUT *Oncorhynchus mykiss*

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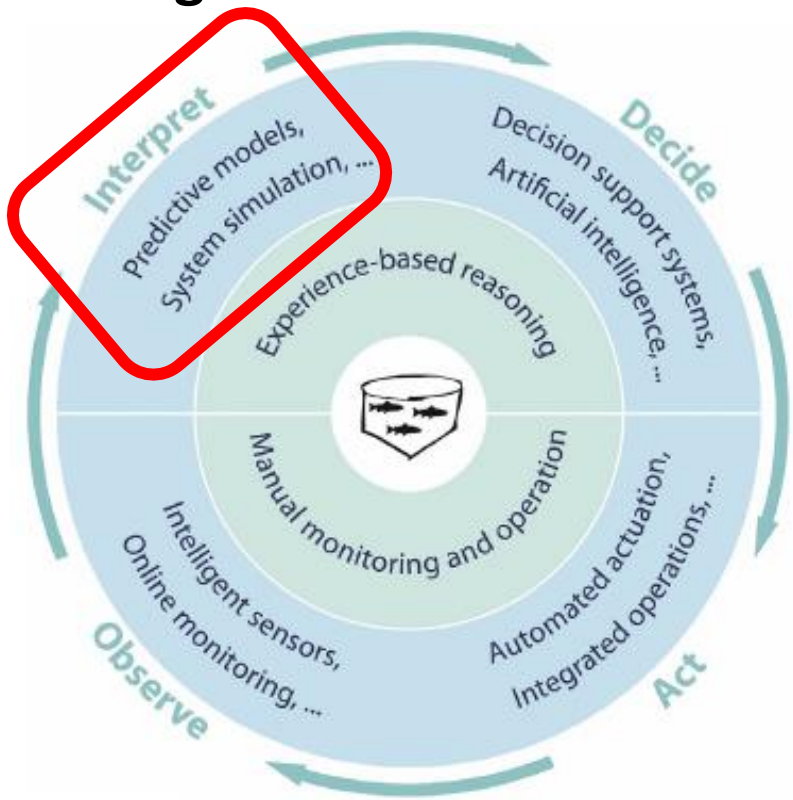
MOTIVATION OF THE PROJECT

The fast development of the computer science sector together with the reduction of costs of sensors makes possible the implementation of **Precision Fish Farming**

The **GOAL** of this study is to develop a growht model of rainbow trout, which:

- Provides **RELIABLE** weight predictions according to **FEEDING REGIME** and **WATER TEMPERATURE**
- **SIMPLE** for the further implementation of Data Asisimilation methods to optimize other husbandary practices



GAIN
Green Aquaculture Intensification

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Green Aquacuture INtensification in Europe

GAIN aims to support the **ECOLOGICAL INTENSIFICATION** of the sector of aquaculture in Europe by incresing **COMPETITIVENESS** of the industry, boost production and reducing losses, while ensuring **ENVIRONMENTAL SUSTAINABILITY** and compliance with EU legislation.

Ca' Foscari University of Venice
UNIVERSITY of STIRLING
AWI
IBM
CSIC
LONGLINE ENVIRONMENT
sparos I&D nutrition in aquaculture
Salten Havbrukspark
WAGENINGEN UNIVERSITY & RESEARCH
THÜNEN
lebeche grupo cumarex
afbi Agri-Food and Biosciences Institute
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie
ANFACO CECOPESCA
MULTIVECTOR
GIFAS
Sagremarisco
FONDAZIONE EDMUND MACH
DALHOUSIE UNIVERSITY 1818 2018
NOAA
South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

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GAIN – Pilot Sites

➢ **Cage culture**

Atlantic Salmon

Rossøya Nord – Norway

Carness Bay, Orkney-Scotland (UK)

McNutt'S Island, Shelburne - Nova Scotia, Canada

Seabass/Seabream

Gorguel – Spain

➢ **Land based - raceway**

Rainbow trout

Preore, Trentino Alto Adige – Italy

➢ **Pond – semi-intensive**

Common carp

NOWE CZARNOWO - POLAND

➢ **Pond – semi-intensive**

Shrimp

Guangzhou - China

➢ **Shellfish**

Pacific oyster/Blue mussels

Dundrum bay – Northern Ireland

Mediterranean mussels

Sagres – SW of Portugal

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GAIN Italy – Case of study

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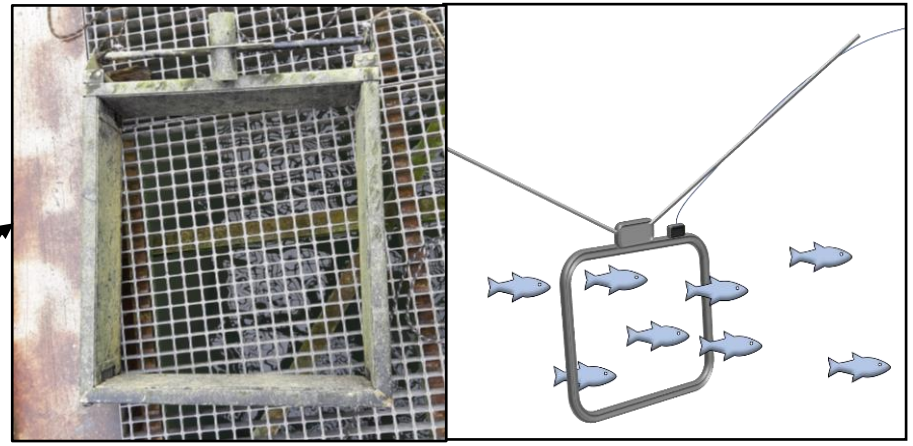
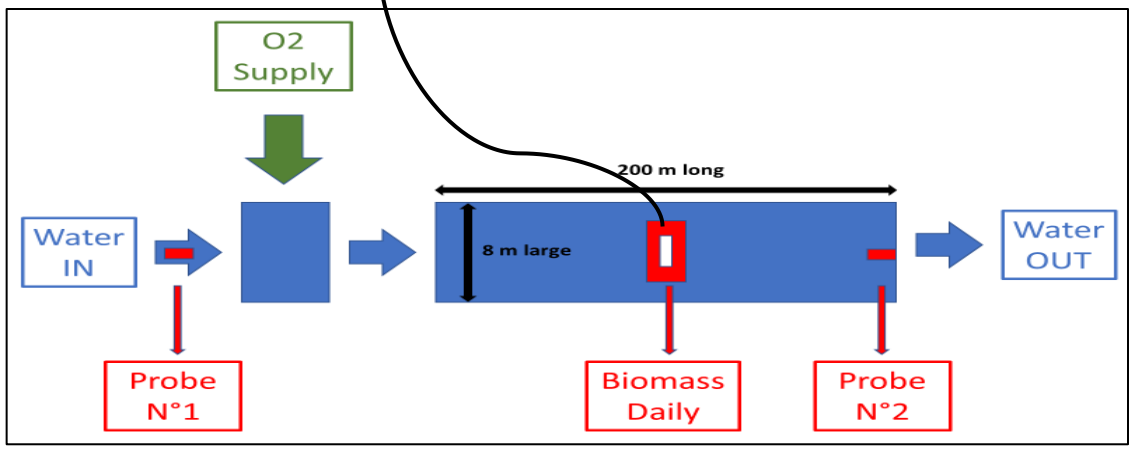
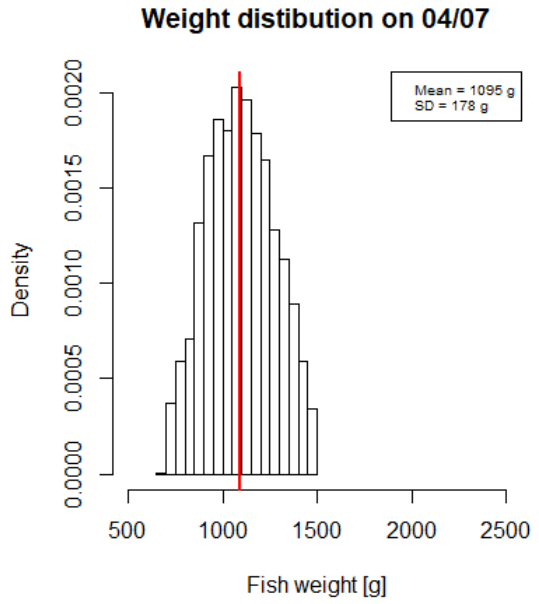
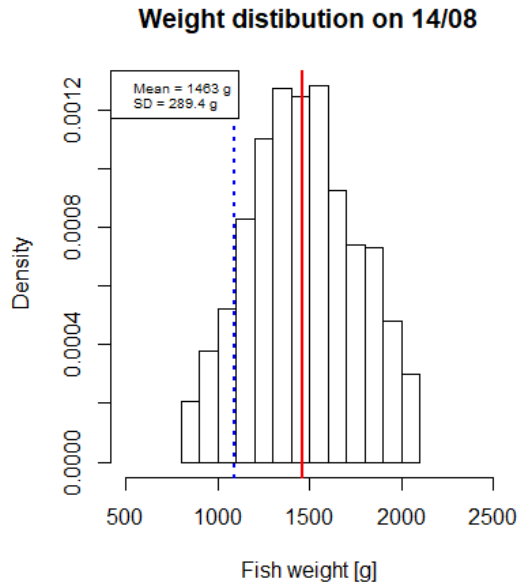
GAIN Italy – Monitoring strategy

Biomass Daily (BD)









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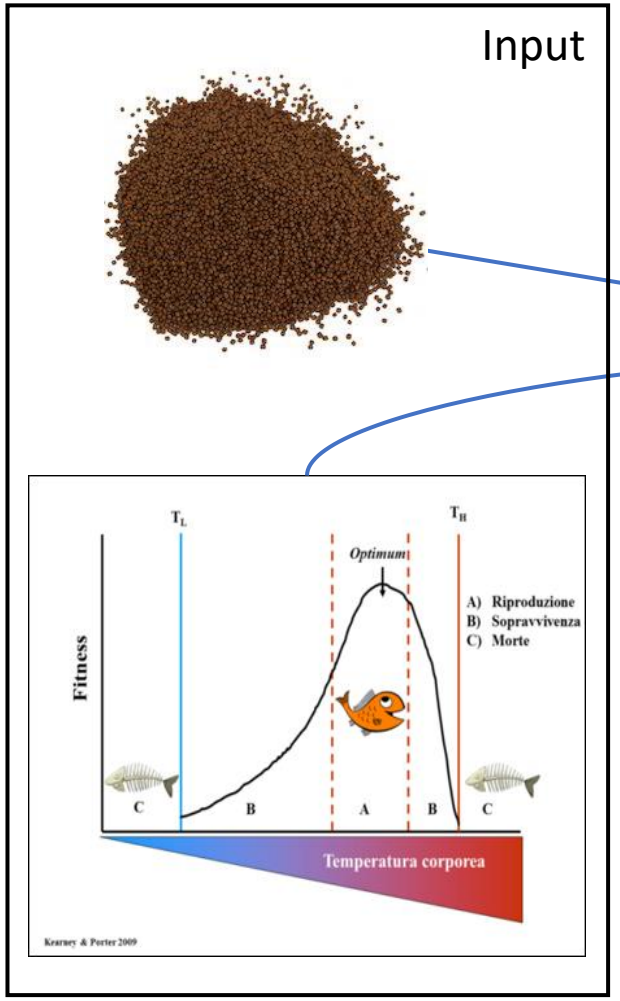
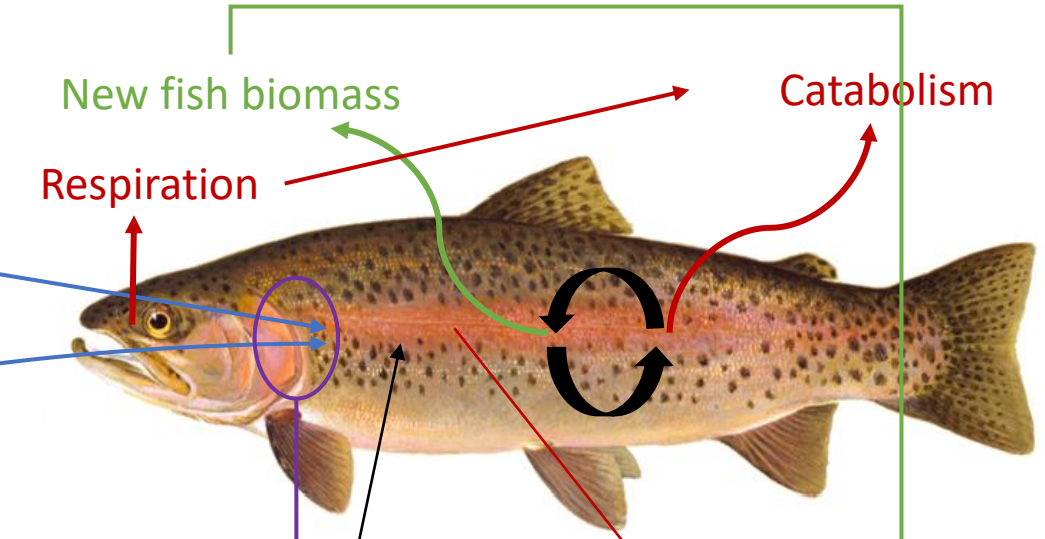
PFF Animal variable: average weight, W, based on an energy budget





New fish biomass

Catabolism

Respiration

Digestion

Non-digested feed

Anabolism

$$\frac{dW}{dt} = \frac{A - C}{\varepsilon_T}$$

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Definition of the Model

Notation	Description
α	Feeding catabolism coefficient
β_P	ADC for proteins
β_C	ADC for carbohydrates
β_L	ADC for lipids
ε_P	Energy content of proteins
ε_C	Energy content of carbohydrates
ε_L	Energy content of lipids
ε_{O_2}	Energy consumed by respiration of $1g$ of O_2
pk	Temperature coefficient for the fasting catabolism
k_0	Fasting catabolism at 0°C
n	Weight exponent for catabolism
ε_T	Energy content of $1g$ of somatic tissue

The model requires the explicitation of 13 parameters, that reproduce the physiology of rainbow trout

$$\frac{dW}{dt} = \frac{A - C}{\varepsilon_T}$$

Energy consumed for basal metabolism

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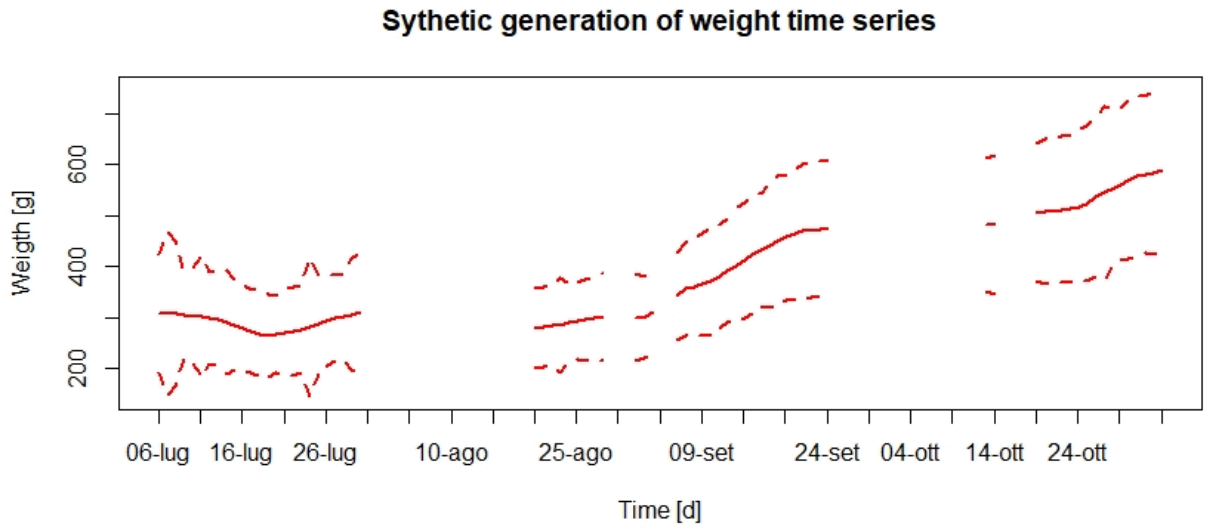
Method for Calibration of the Model

- k_0 was estimated minimizing the distance between model predictions (Royer et al., 2021) and observations of DO
  - CALIBRATION: 23/07/2020 – 29/07/2020
  - VALIDATION: 03/07/2019 – 29/07/2019

https://doi.org/10.1016/j.aquaeng.2020.102141

- α was estimated by minimizing the distance between growht model and daily observations made by BD
  - CALIBRATION: 06/07/2020 – 03/11/2020
  - VALIDATION: 06/07/2019 – 07/11/2019

For both procedures, method of Monte Carlo were used to estimate mean value and its standard deviation



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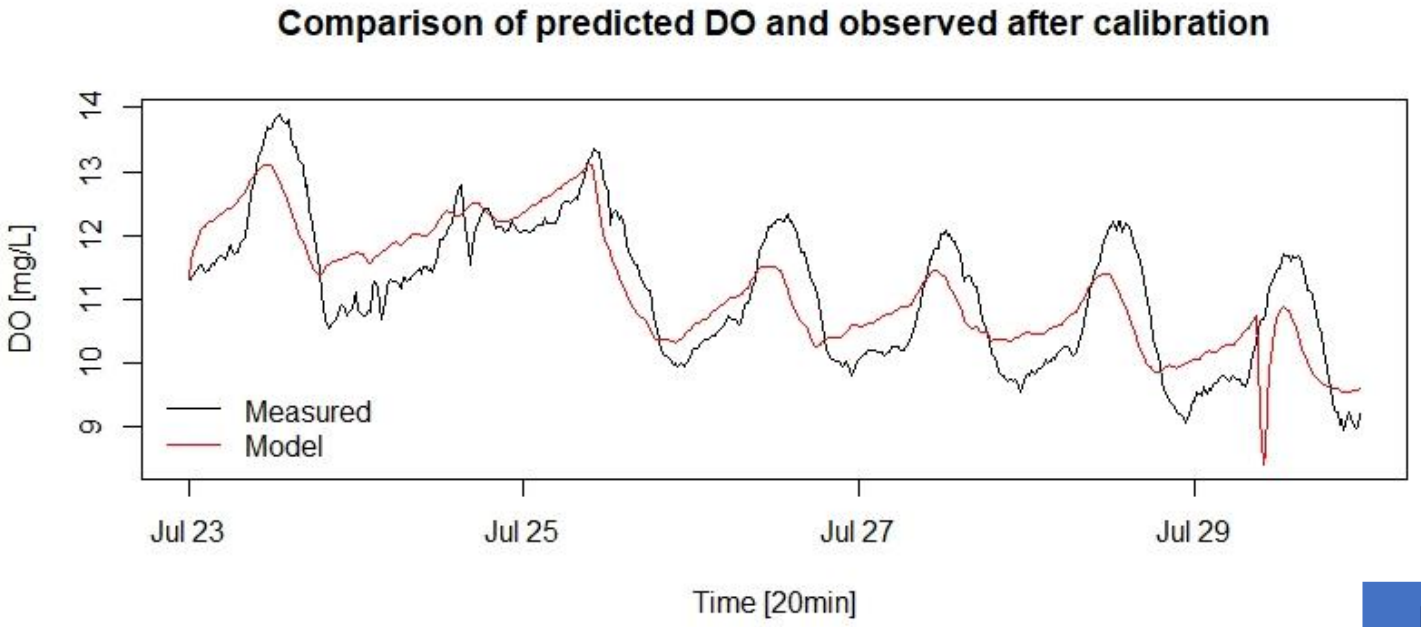
Calibration of Basal Metabolism - Catabolism



$$4\% < RMSE < 7\%$$
$$R^2 = 0{,}64$$

Parameter	Value	SD	Unit
k_0	$8{,}5 * 10^{-4}$	$4{,}3 * 10^{-5}$	$\frac{mgO_2}{g_{fish} * day}$

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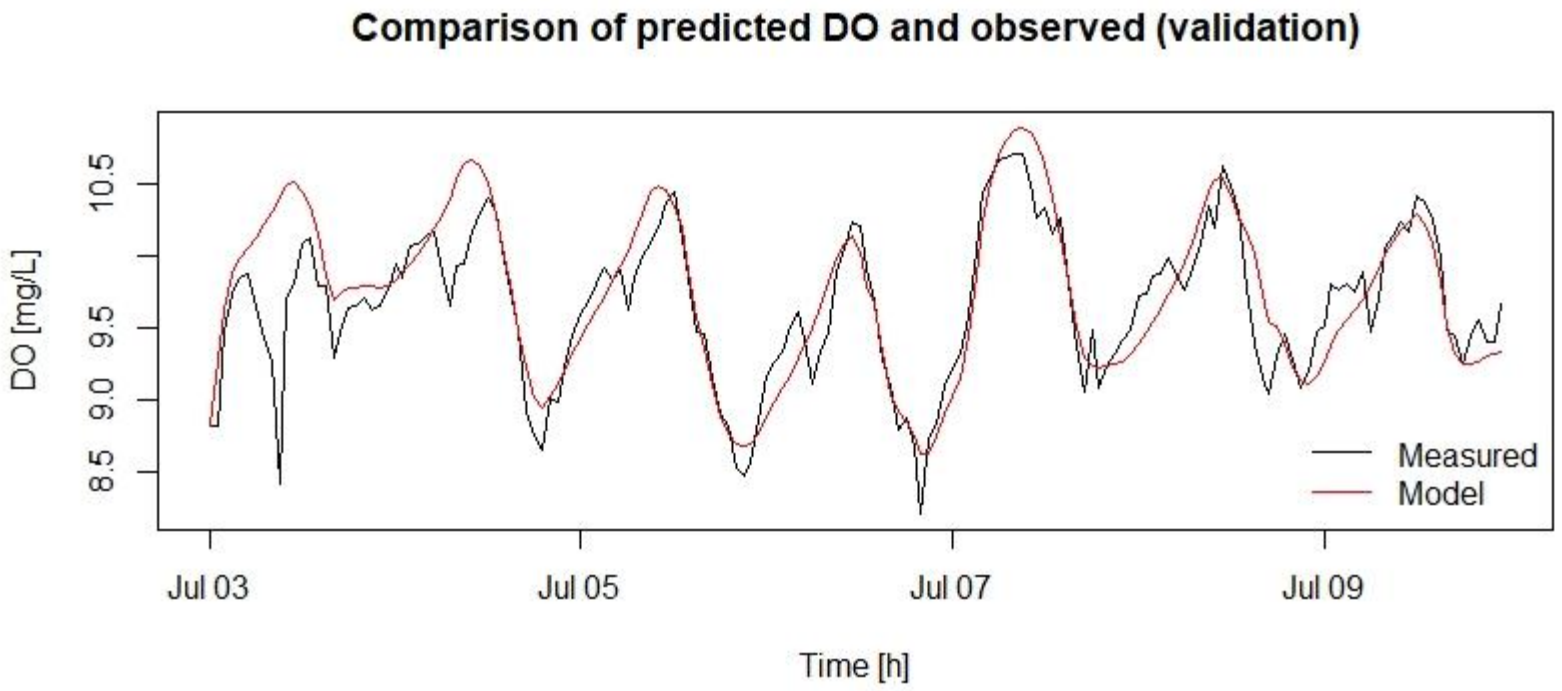
Validation of Basal Metabolism - Catabolism



$$1{,}9\% < RMSE < 2{,}4\%$$
$$R^2 = 71{,}8\%$$

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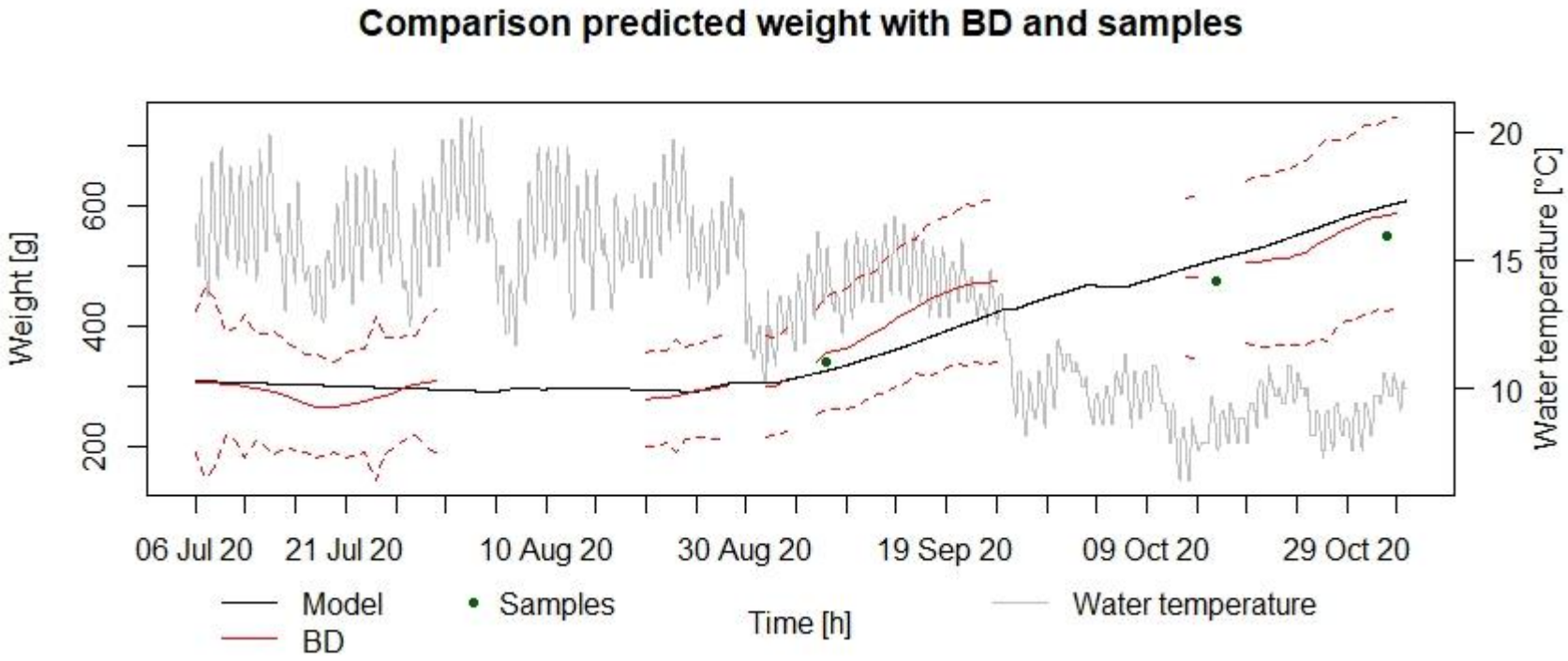
Calibration of Anabolism



$$R^2 = 92{,}09\%$$

$$5\% < RMSE < 10\%$$

Parameter	Value	SD	Unit
α	0,58	0,05	-

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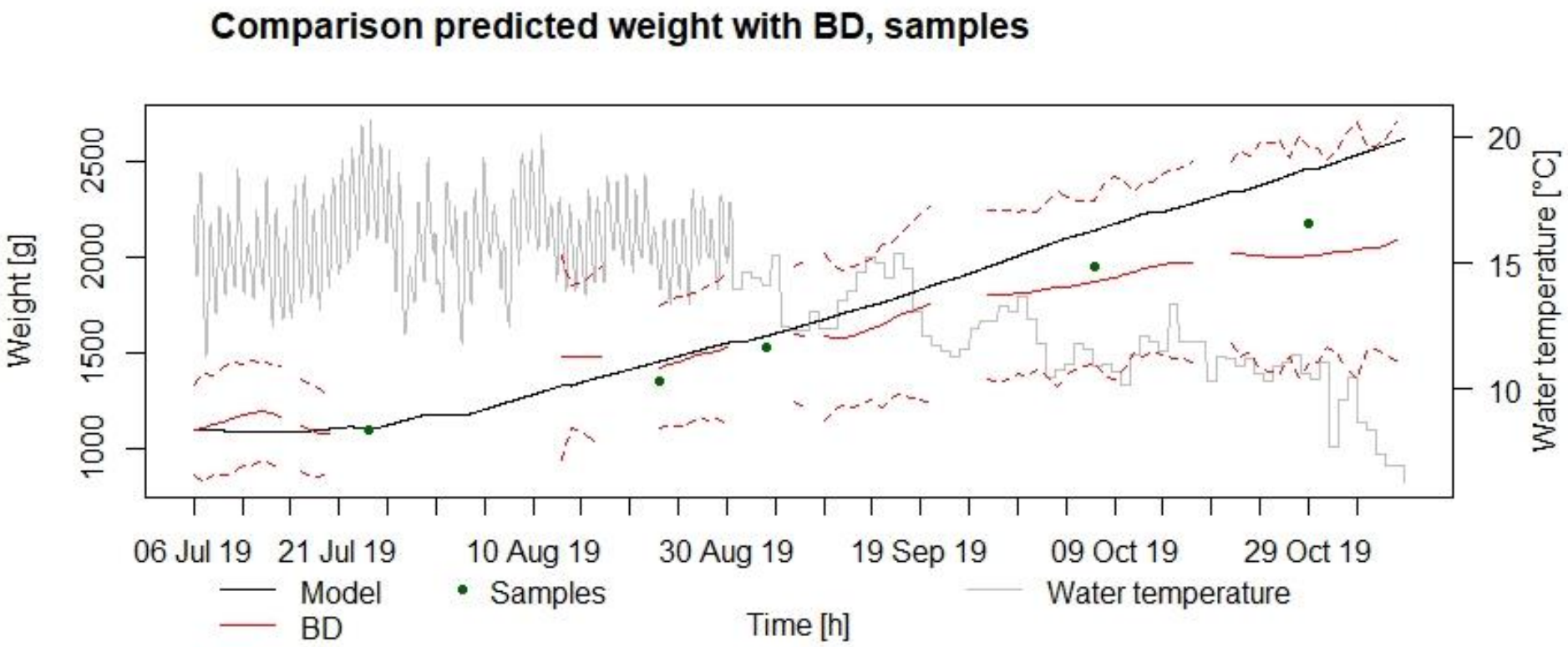
Validation of Anabolism



$R^2 = 96{,}8\%$

$10\% < RMSE < 23{,}5\%$

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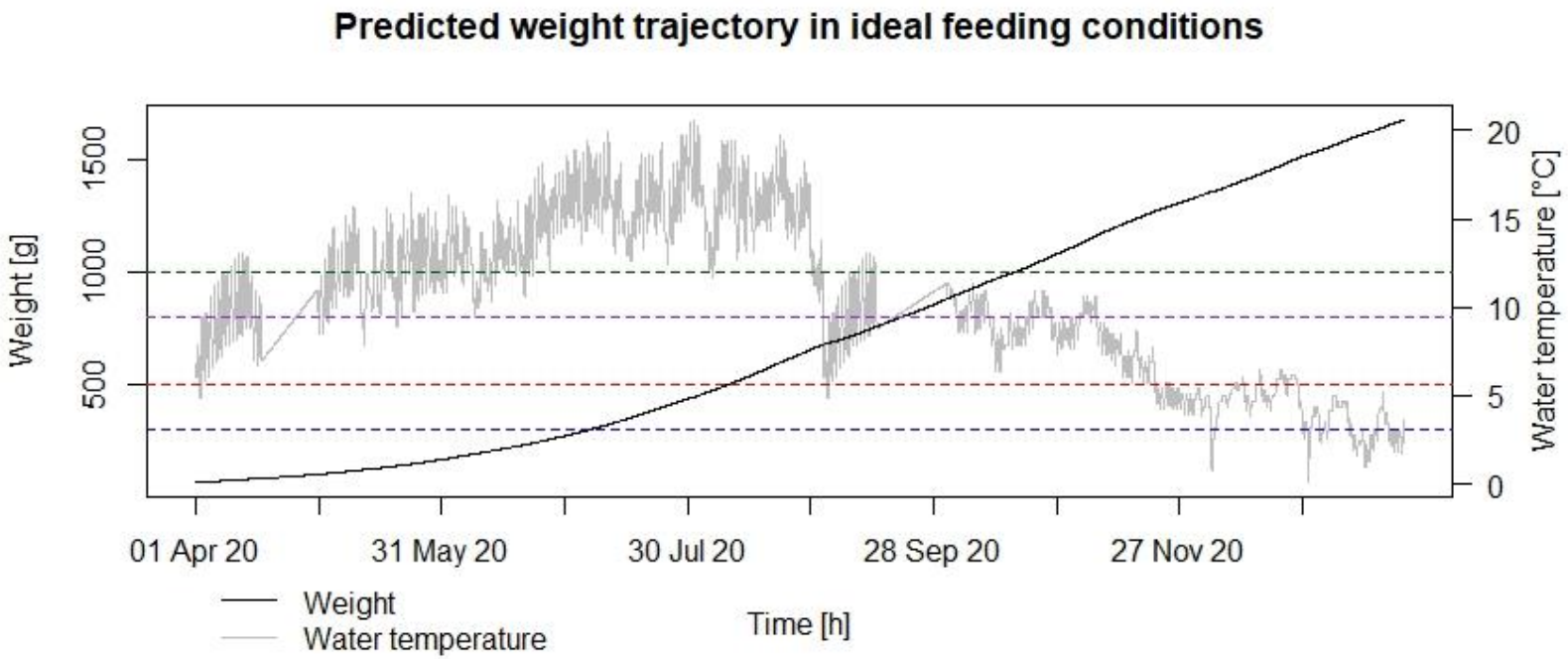
Results – Ideal Feeding Growth

Now that we have a model of rainbow trout, which kind of informations can we exctract?



Commercial size [g]	Number of days
66,25	1
300	97
500	131
800	173
1000	201

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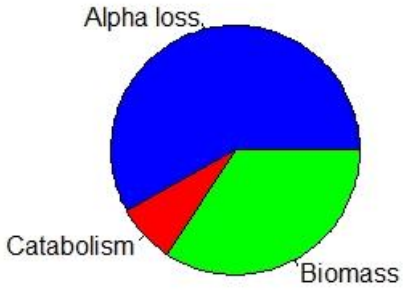
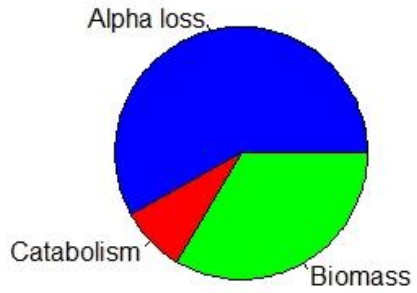
Results – Energy budget

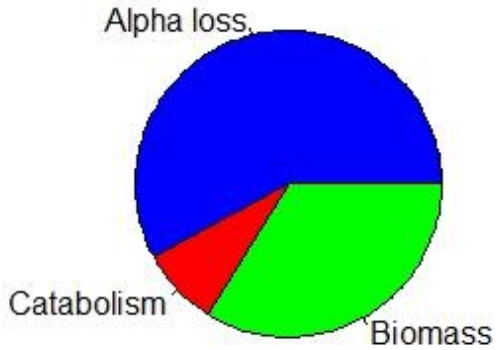
Compartimental Energy budget 66 - 300g



Compartimental Energy budget 300 - 500g



Compartimental Energy budget 500 - 800g



Compartimental Energy budget 800 - 1000g

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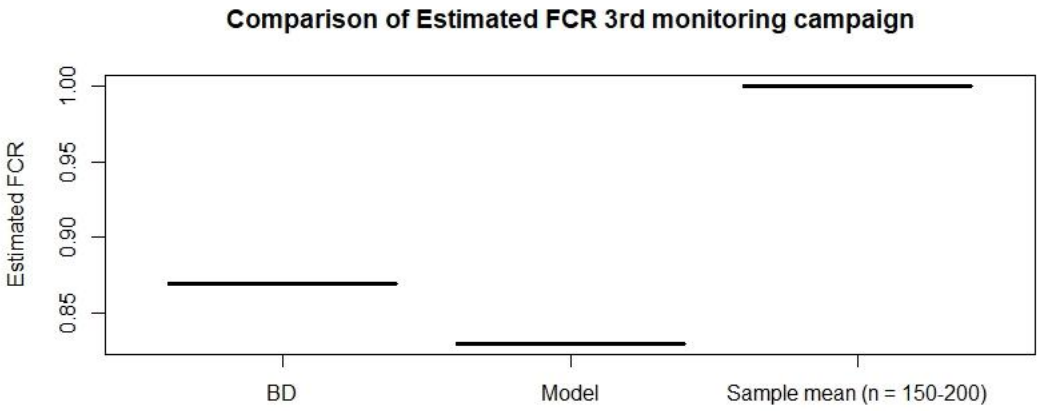
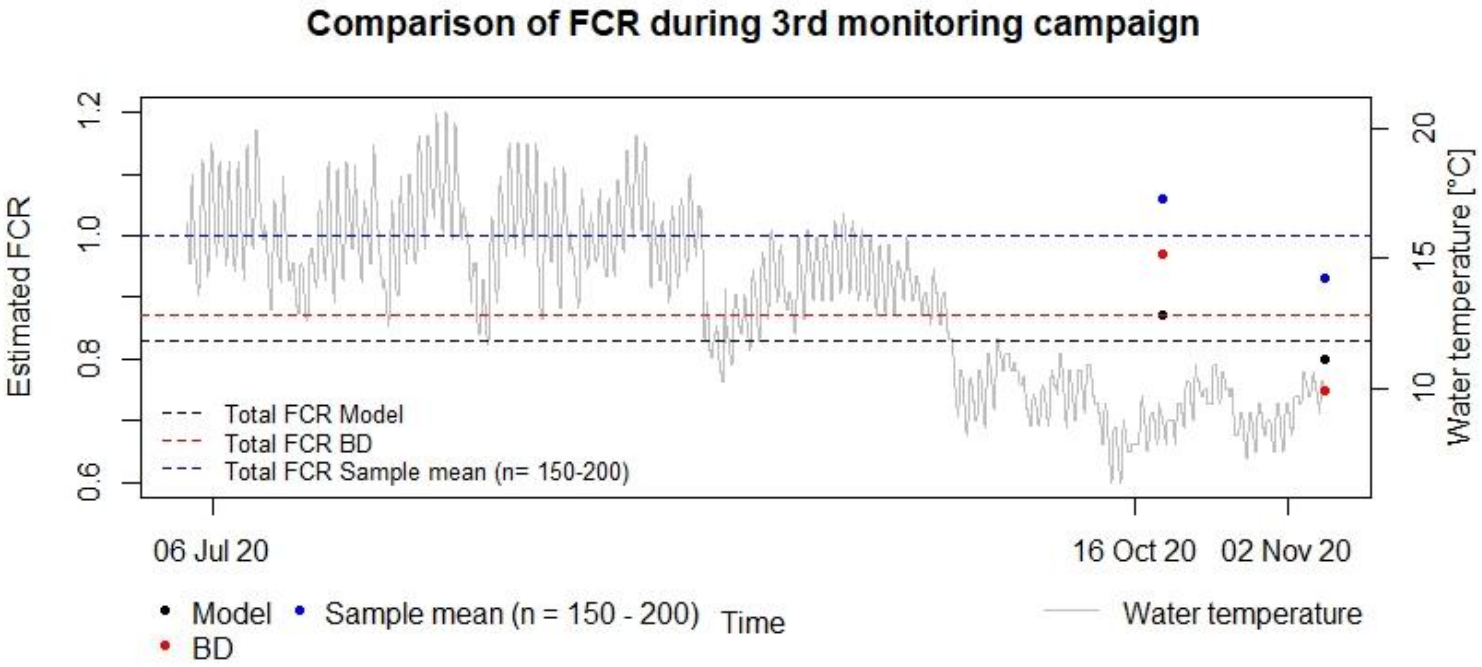
Results - FCR





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Conclusions

- In this work, we developed an Individual – based Bioenergetic Growth Model of rainbow trout.
- The model was calibrated by using **Montecarlo method** to generate synthetic time – series of interested variables. This method is based on the knowledge of the **distribution** of observable variables in time. In particular, two parameters were calibrated:
  1. k_0 which is related to the energy consumed for maintenance;
  2. α which is related to the anabolism of fish;
- The model is simple enough to implement **Data Assimilation methods** to improved the husbandary operations in trout farm