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ESTIMATION OF RAINBOW TROUT (ONCORHYNCHUS MYKISS) RESPIRATION RATE WITHIN A COMMERCIAL RACEWAY USING A DATA ASSIMILATION APPROACH

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Summary

- GAIN H2020 Project
- Context and experimental setup
- Kalman Filter and DO model
- Results
- Conclusion

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Green Aquaculture INtensification in Europe

- Support the ecological intensification of aquaculture
  - Increasing production and competitiveness of the industry
  - Ensuring sustainability and compliance with EU regulations
- Consortium
  - 10 academic and research institutes
  - 8 companies
  - 2 non-profit organisations

Research areas

- Production optimization
- Valorization of secondary inputs
- Sustainability assessment

Impacts

- Eco-intensification tools
- Professional developments

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Context

- **Troticultura Fratelli Leonardi**, Preore, Northern Italy
  - Rainbow trout (*Oncorhynchus mykiss)*
  - 7 Raceways : 200 m x 8 m

- **Objectives**
  - **Real-time** estimation of oxygen fish demand
  - Control and **optimization** of oxygen supply

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Data Assimilation: Principles

- **Principle**

Model predictions + Observations = Improved system knowledge



- **Assumptions**
  - Non-observable variables => state variables (augmented state)
  - State variables => stochastic variables

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Data Assimilation: Kalman Filter

- **Overview**
  - One of the most popular DA method
  - Introduced by Kalman (1960)
  - Originally used in spacecraft guidance, navigation and control (GNC), since Apollo
  - Sensor fusion and data fusion algorithm

- **Versatility**
  - Linear and Non-Linear system
  - Continuous or discrete time … or both !!

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DO Model

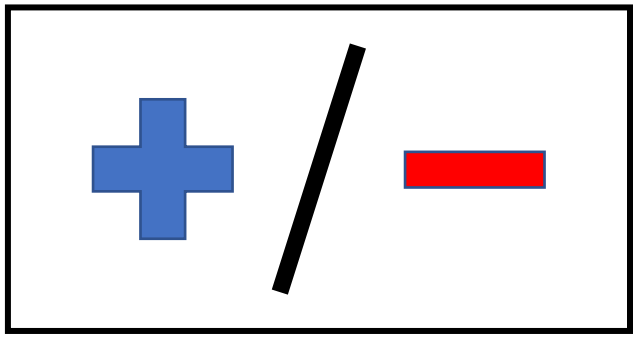
- **DO mass balance**

State Variable

$$\frac{dDO}{dt} = \frac{dDO_{in}}{dt} - \frac{dDO}{dt} + O2\ Supply + Reaeration - Fish\ Respiration$$

- **Underlying assumptions**
  - Complete mixing of water within the raceway
  - No significant primary production

- **Fish Respiration**
  - Hourly respiration rate [mg/(kg.h)]
  - Use of average weight and fish number
  - Exponential influence of temperature



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Monitoring system: Sensors

Animal variables

- Biomass Daily (Vaki Ltd)
- Daily Average Weight
- Cloud Connected

Environmental variables

- EXO 2 (YSI)
- DO and Temperature
- Manual download

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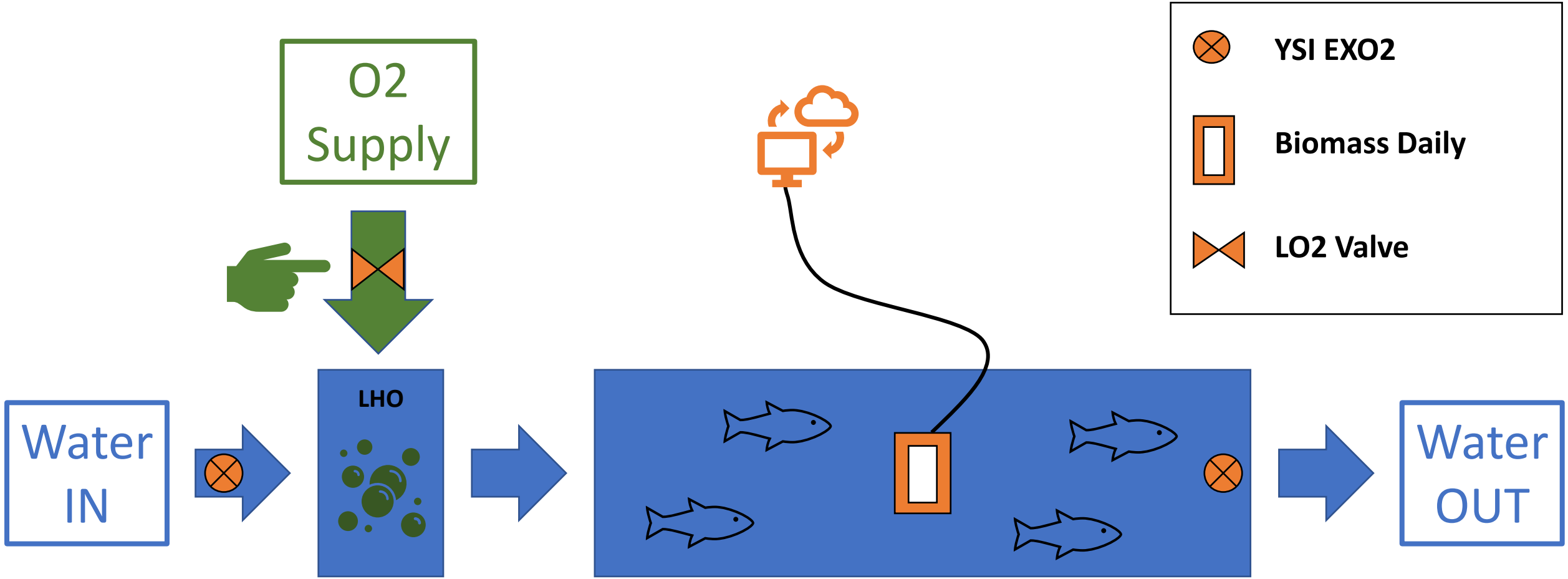
Monitoring system: Overview



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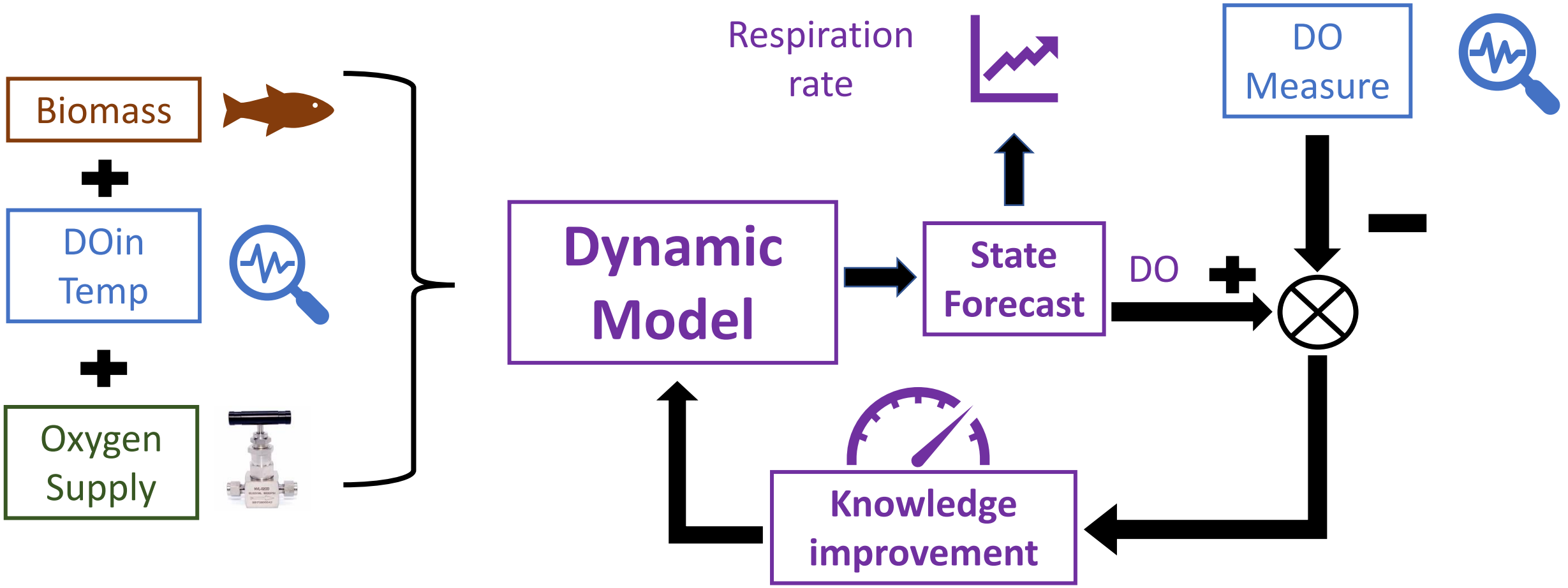
Algorithm: Schematic View



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Application

- **Period**
  - July 3rd-31st 2019
- **Environmental variables**
  - Water temperature: 12°C - 21 °C; daily oscillations up to 4 °C
  - DO concentration: 8 mg/L - 10 mg/L ; daily oscillations around 1 mg/L
- **Fish**
  - Initial average weight: 1080 g
  - Initial number: 20470 fishes

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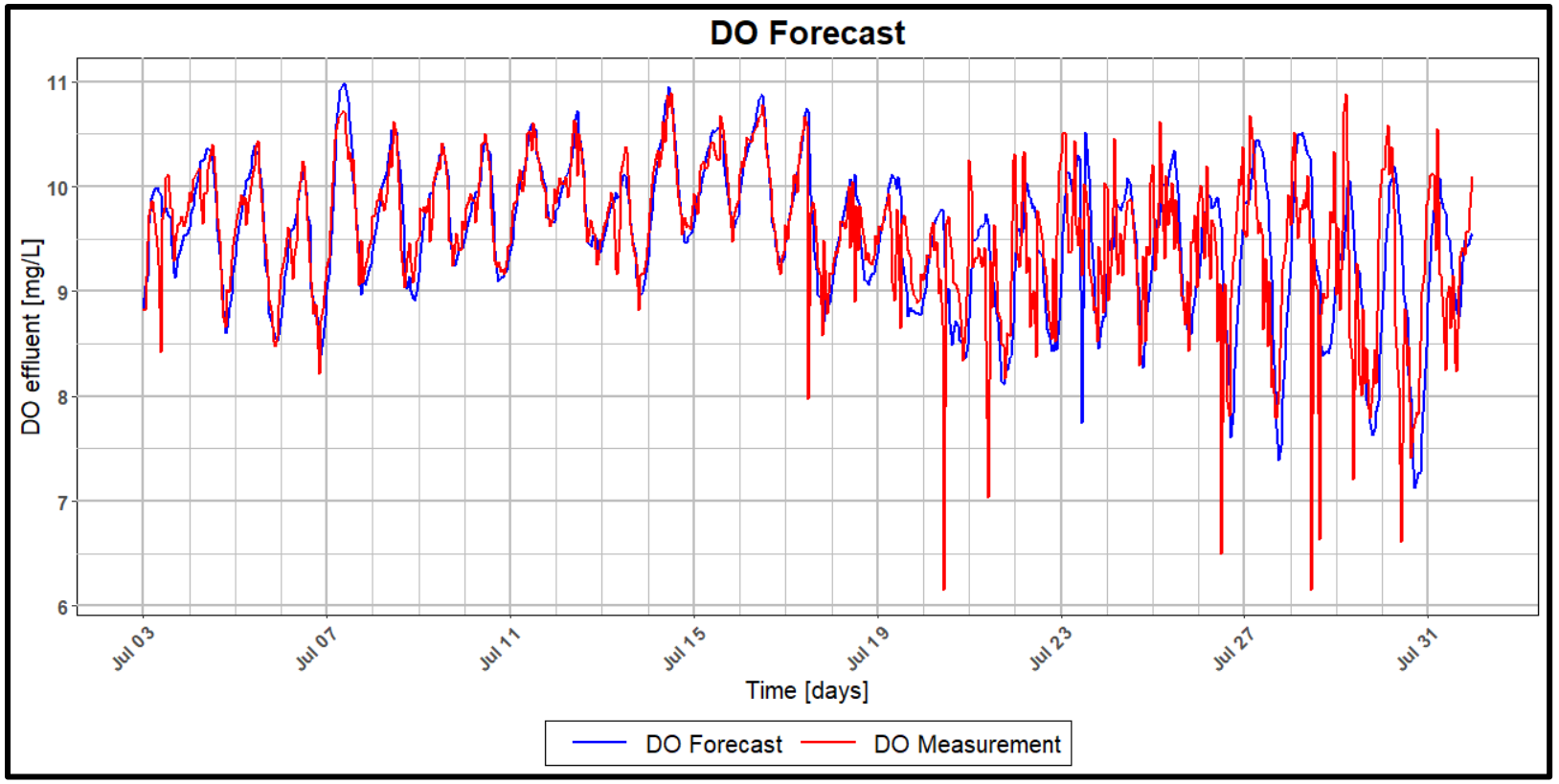
Results: DO forecast



- **Good reliability** of hourly DO forecast (RMSE = 0,37 [mg/L])
- Even with high variability (second half of the month)
- Possible to **forecast water quality** in the effluent

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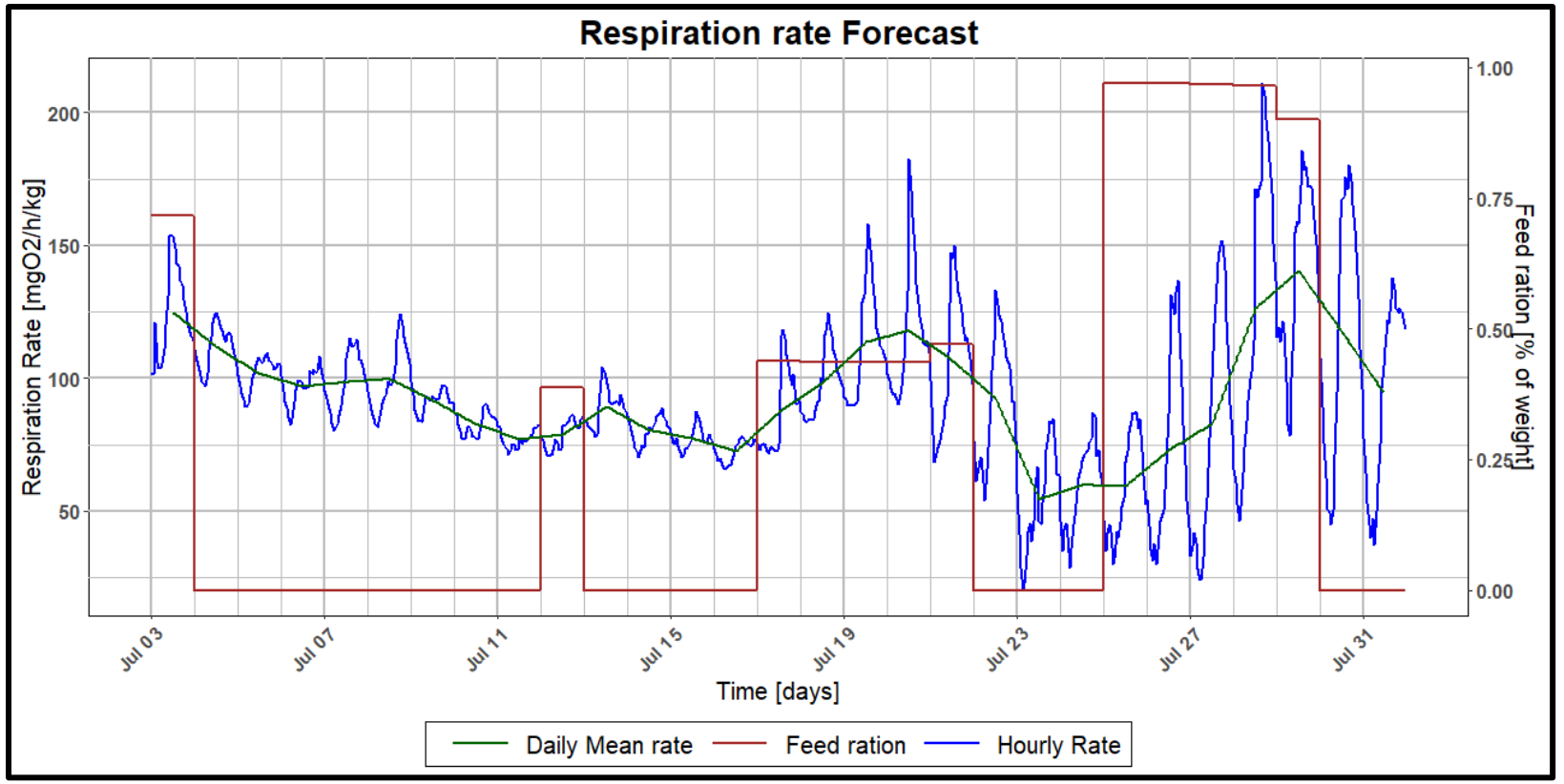
Results: Respiration rate



- Mean specific respiration rate : 95 $mgO_2/(kg.h)$
- Daily oscillations due to **circadian rhythm**
- Daily averages are related to the **feeding regime**

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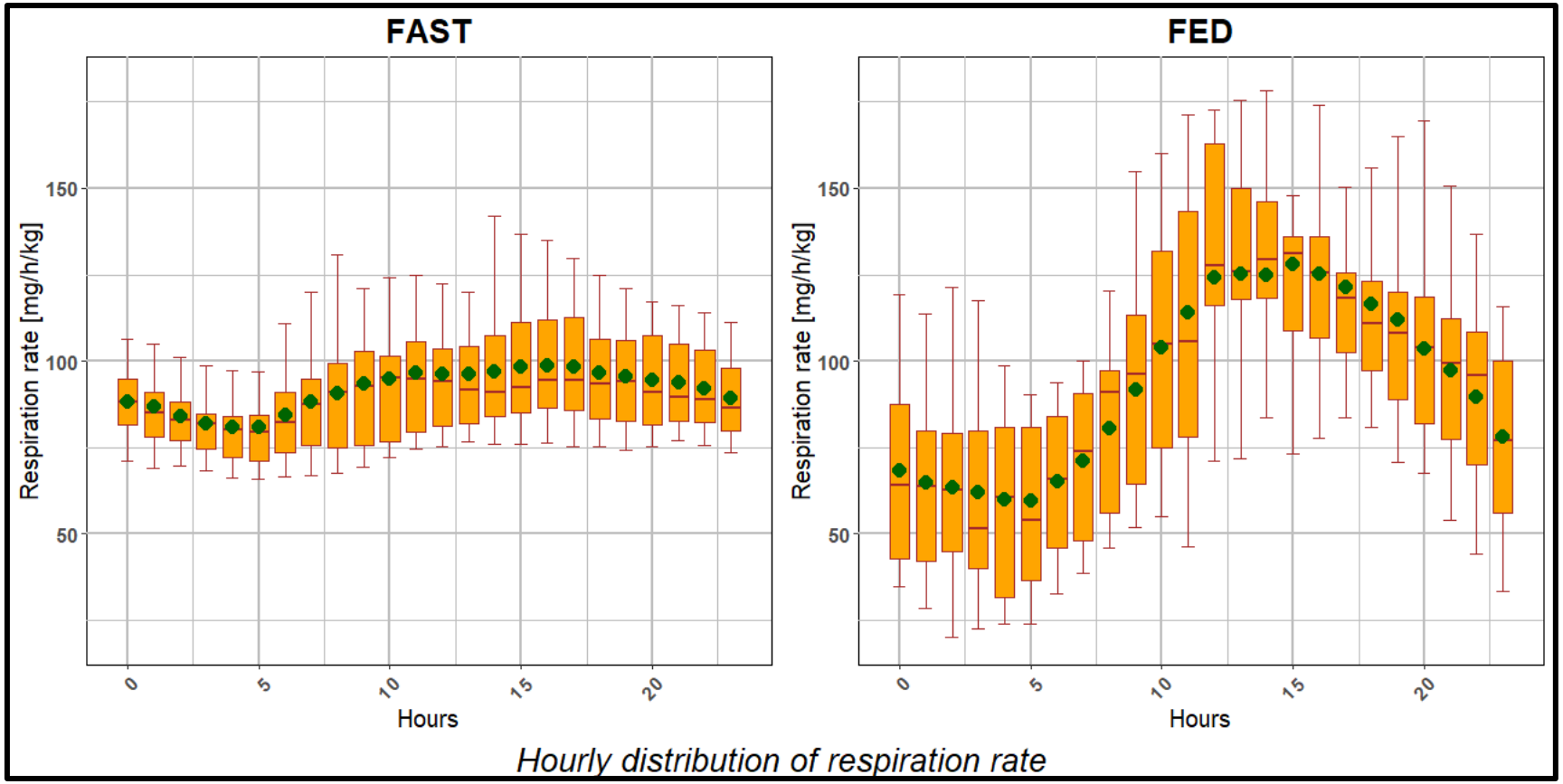
Results: Daily Respiration rate



Hourly distribution of respiration rate

- Low variability when fish were starved
- High variability when fish were fed
- Peak around 4 to 6 hours after feeding time (9 a.m)

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Conclusion

- **Simple model + DA = reliable forecast & improved decision support**

- **DO concentration**
  - Good accuracy of 1 hour ahead DO forecast

- **Respiration Rate**
  - Estimation of short-term and long-term variability

- **<u>Application</u>**
  - O_2 supply **smart control**
  - **Early warning** on effluent water quality

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THANK YOU FOR YOUR ATTENTION !!

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