Webinar for the Stakeholder Platform

How internet of things can enhance aquaculture farms productivity and ensure sustainability ?

25th February 2021

2.00pm CET (Berlin/Paris time)

via Zoom

by Dr. Sébastien Alfonso (COISPA Tecnologia & Ricerca)

Summary

1.1. Development and promise from aquaculture

- **Aquaculture supports man in his evolution**







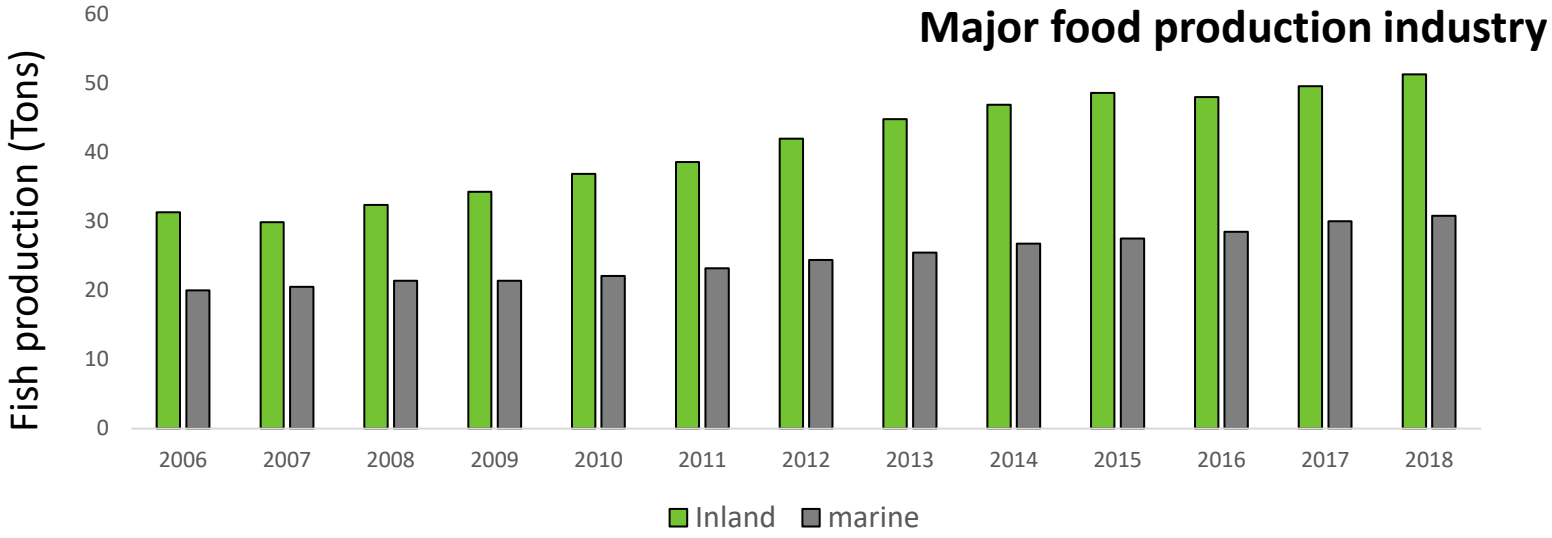

China
(~ -3000 BC)

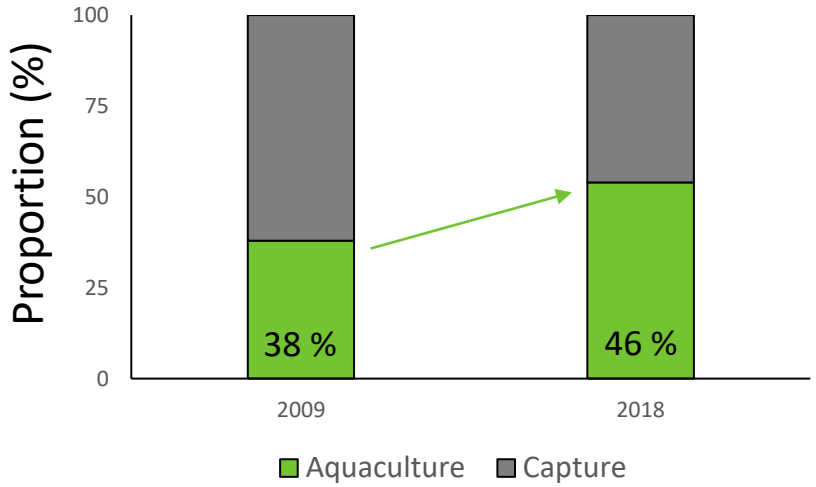
Today

What next ?

1.1. Development and promise from aquaculture

- **Development of aquaculture sector**





The proportion of fish from aquaculture (vs. capture) is increasing
Aquaculture is the fastest growing food industry sector

1.2. Some concern about aquaculture

- **Perils of aquaculture**

Environmental concerns

Welfare concerns

Fish production

Consumer opinion

Economic consequences

FutureEUAqua (Horizon 2020)

- **The project:**
  FutureEUAqua's consortium gathers 32 different SMEs, Associations, Research Institutes and Other companies from Europe (9 different countries).

➔ Objectives are to effectively promote the sustainable growth of environmentally-friendly aquaculture in Europe, to meet future challenges with respect to the growing consumer demand for high quality, nutritious and responsibly produced food

- **Internet of things for healthy fish and environment (WP5, Giuseppe Lembo, COISPA)**
  Monitoring the impact of housing environments and innovative diets on the fish health and welfare during large-scale demonstration activities, by using a wireless communication system to integrate Key Performance Indicators (KPIs).

➔ Enhancing fish welfare
➔ Enhancing fish health
➔ Enhancing environmental sustainability and production

Summary

2.1. What is IoT ?

- **Definition:**

Network of physical objects or « things » embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.

Aquaculture

2.1. What is IoT ?

- **Some examples:**

Home security

Sensors

Alarms

Cameras

Ligh

Microphone

Interface

Humans

Activity tracker

Fatigue

Apetite

Blood presure

Oxygen level

Heart rate

Interface

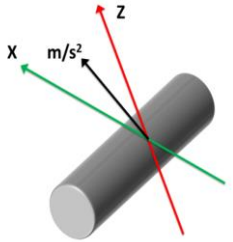
Humans

Unlimited Possibilities

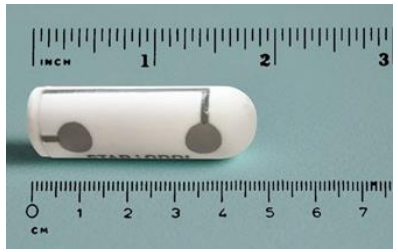
"***The Internet of Things is really just getting started. Years from now we will be connected in ways that are difficult to imagine today***. *IoT applications, especially when combined with artificial intelligence and automation, will improve decision making, efficiency, convenience, wellness, and energy conservation. The integration of these technologies will also enable creative thinking and innovative applications across a wide range of industries.*"

2.2. Tools to be used in aquaculture

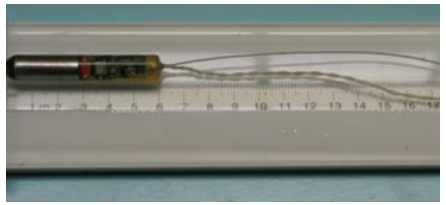
- **Fish health and welfare**



Accelerometer tags



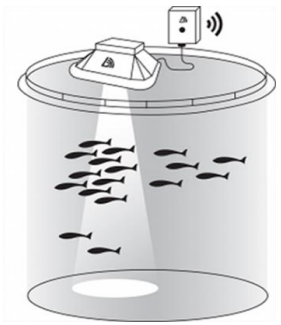
Heart beat rate logger



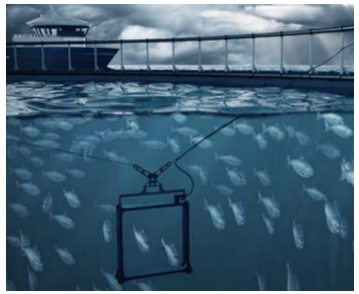
EMG (muscle activity)

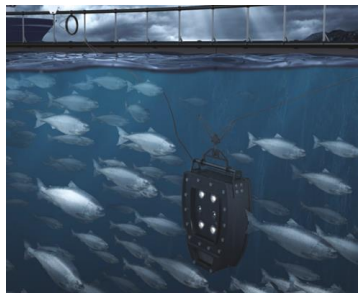
Camera system

- **Biomass estimation**

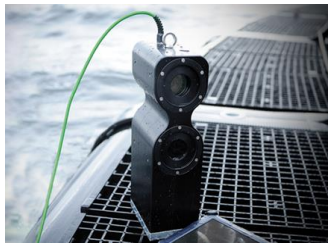


Accoustic transmissions





Infrared technologies

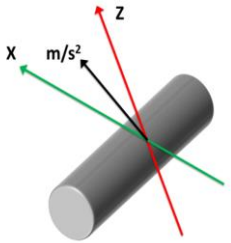


Video cameras

Summary

3.1. Enhance environmental sustainability and fish welfare

- **Health and welfare**



Accelerometer tags

IP camera system

- **Environmental parameters**

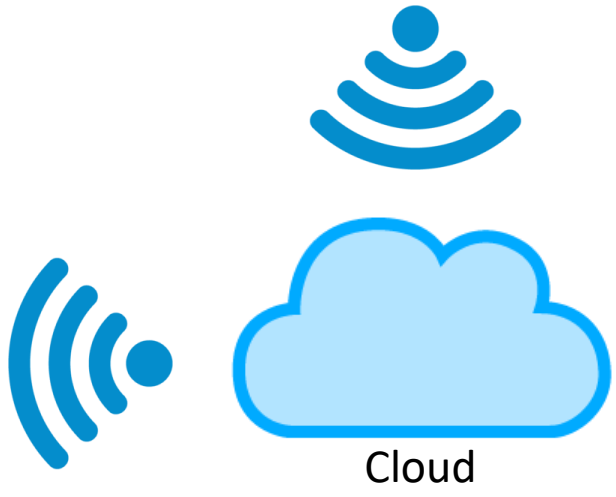
O_2 / temperature

Salinity

Blue/green algae

Turbidity

Chlorophyl

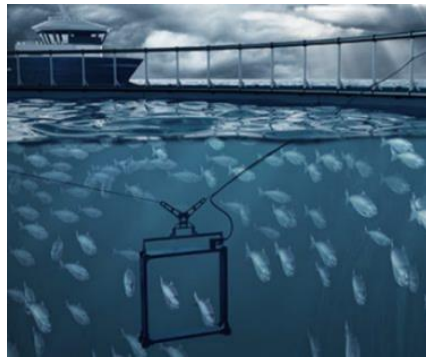


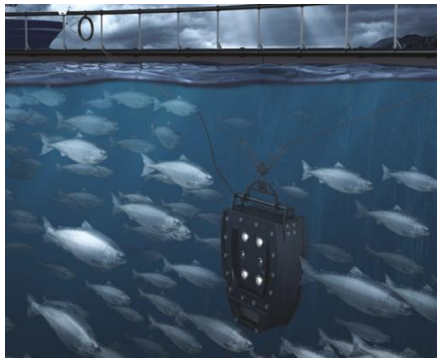
Cloud

Data in real time
➔ Control environmental quality
➔ Fast decisions to prevent health/ welfare issues

3.2. Enhance productivity

- **Biomass estimation**





Data in real time

➔ Constant monitoring of fish growth

➔ Avoid to sample and stress fish

- **Feeding optimization**

Satiation detection

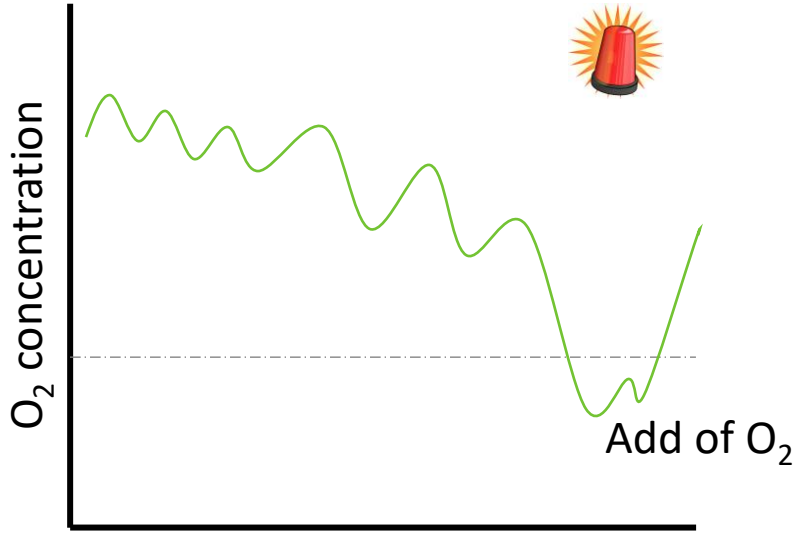
➔ Operations more efficient and reducing feed costs

➔ Avoid to waste feed (environmental sustainability)

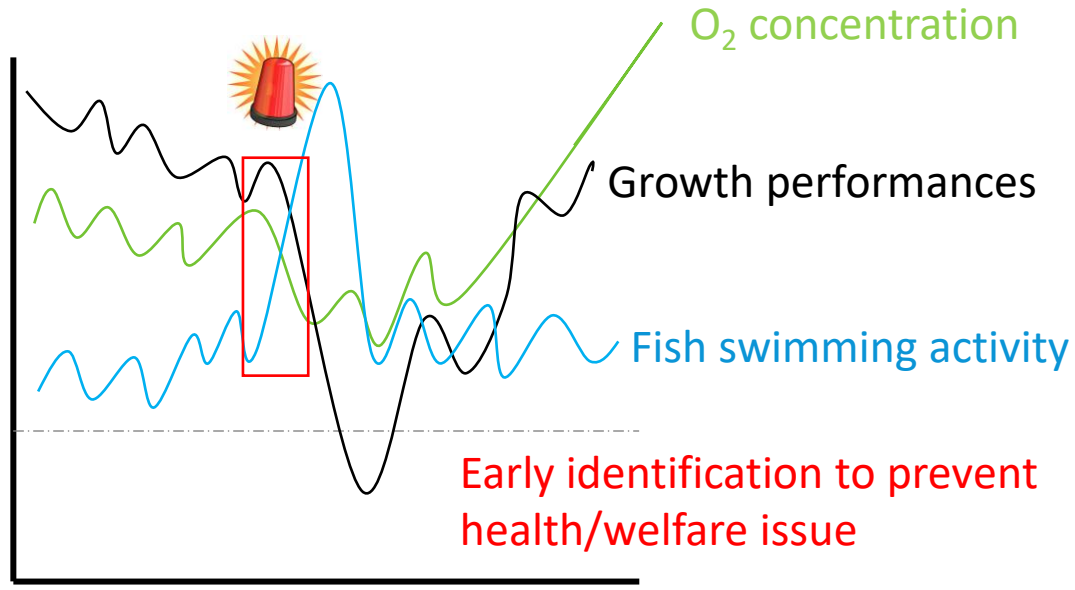
https://www.youtube.com/watch?v=S6hdtsGiqOA&feature=emb_logo

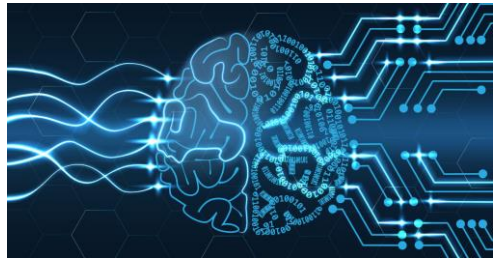
3.3. Some limitations

- **Where are we ?**



- **Where do we want to go ?**





Algorithmes / machine learning

3.3. Some limitations

Price

Time needed for development
(Species specific)

BUT …

International Journal of COMMUNICATION systems

RESEARCH ARTICLE

Design and deployment of a smart system for data gathering in aquaculture tanks using wireless sensor networks

Lorena Parra, Sandra Sendra, Jaime Lloret, Joel J.P.C. Rodrigues

First published: 28 May 2017 | https://doi.org/10.1002/dac.3335 | Citations: 12

frontiers in Physiology

ORIGINAL RESEARCH

Ultra-Low Power Sensor Devices for Monitoring Physical Activity and Respiratory Frequency in Farmed Fish

Juan Antonio Martos-Sitcha, Javier Sosa, Dailos Ramos-Valido, Francisco Javier Bravo, Cristina Carmona-Duarte, Henrique Leonel Gomes, Josep Àlvar Calduch-Giner, Enric Cabrujà, Aurelio Vega, Miguel Ángel Ferrer, Manuel Lozano, Juan Antonio Montiel-Nelson, Juan Manuel Afonso and Jaume Pérez-Sánchez

sensors — MDPI

Article

Design and Deployment of Low-Cost Sensors for Monitoring the Water Quality and Fish Behavior in Aquaculture Tanks during the Feeding Process

Lorena Parra, Sandra Sendra, Laura García and Jaime Lloret

Fisheries Science (2019) 85:641–654
https://doi.org/10.1007/s12562-019-01318-y

REVIEW ARTICLE

Biosensors for the assessment of fish health: a review

Hideaki Endo · Haiyun Wu

Journal Pre-proof

Automatic recognition methods of fish feeding behavior in aquaculture: A review

Daoliang Li, Zhenhu Wang, Suyuan Wu, Zheng Miao, Ling Du, Yanqing Duan

Aquaculture

ANNUAL REVIEWS

Annual Review of Animal Biosciences

Smart Animal Agriculture: Application of Real-Time Sensors to Improve Animal Well-Being and Production

Ilan Halachmi, Marcella Guarino, Jeffrey Bewley and Matti Pastell

And … collaborations between researchers and farmers

FUTURE EUAQUA

Summary

4.1. Objectives

- **The project:**
  FutureEUAqua's consortium gathers 32 different SMEs, Associations, Research Institutes and Other companies from Europe (9 different countries).

➔ Objectives are to effectively promote the sustainable growth of environmentally-friendly aquaculture in Europe, to meet future challenges with respect to the growing consumer demand

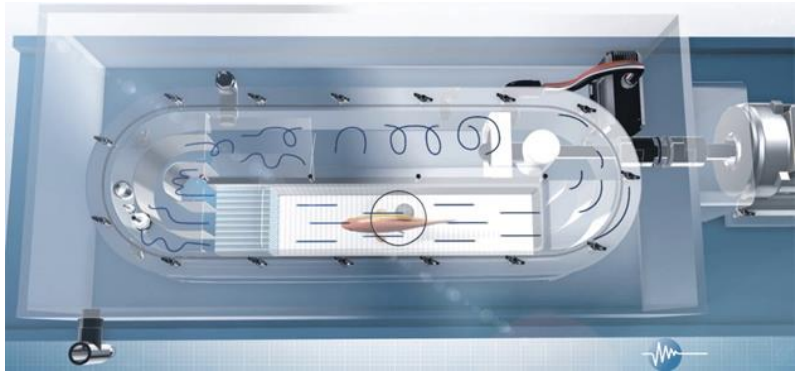
- **Internet of things for healthy fish and environment (WP5, Pino Giuseppe Lembo, COISPA)**
  Monitoring the impact of housing environments and innovative diets on the fish health and welfare during large-scale demonstration activities, by using a wireless communication system to integrate Key Performance Indicators (KPIs).

➔ Enhancing fish welfare
➔ Enhancing fish health
➔ Enhancing environmental sustainability and production

4.2. Ongoing work – Physiological sensors

- **Calibration of tool for measuring fish welfare**

➔ Calibrate acoustic transmitters with energetic costs, as a tool for welfare monitoring in free-swimming fish during the large scale experiments (in cooperation with farmers)

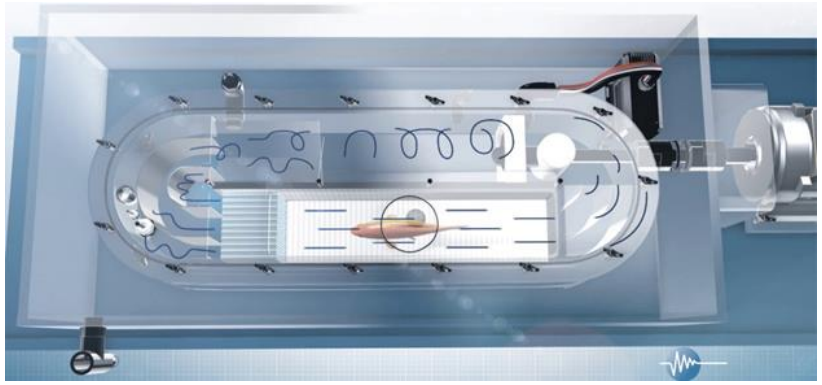


- Estimation of metabolic rates (SMR, MMR, AS)
- Calibration of MO_2 with the acceleration recorded by tag
- Measure red and white muscles activation pattern (EMG)

Experiment			
Progress	200-1000g	200-1000g	*Ongoing*

4.2. Ongoing work – Physiological sensors

- **What are metabolic rates and how to measure it ?**



Swimming chamber

Standard Metabolic Rate (SMR)

$MO_2 = U_0$

The metabolic rate of a resting, fasting, and non-stressed ectotherm at a given temperature

Maximum metabolic rate (MMR)

$MO_2 = U_{crit}$

Maximum oxygen consumption rate sustained in the case of critical swimming test

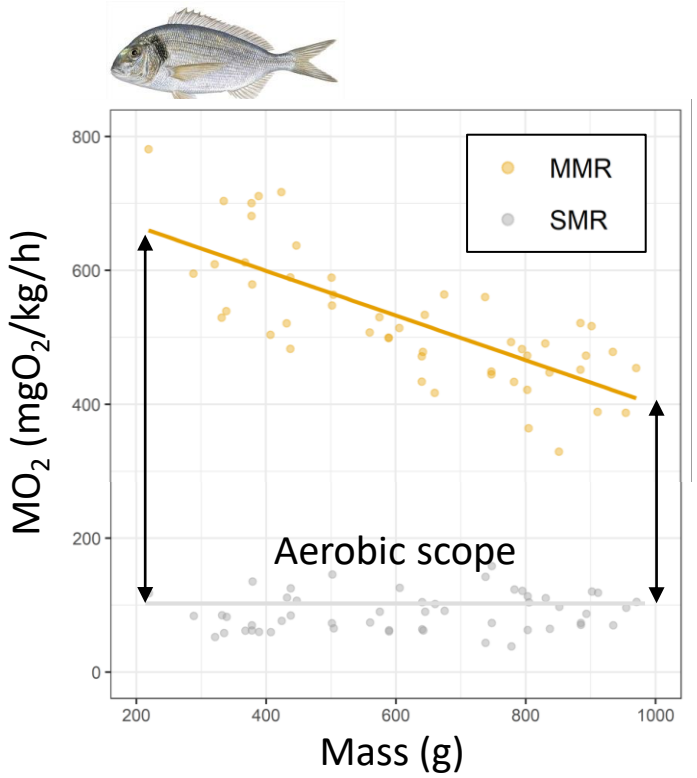
Aerobic scope (AS)

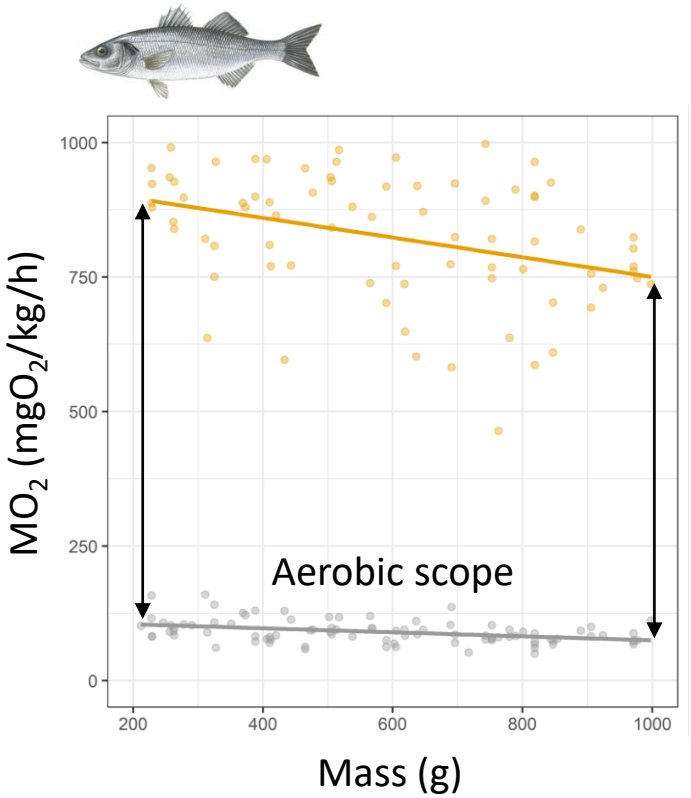
AS = MMR - SMR

Energetic budget available to support all the locomotor and physiological activities

4.2. Ongoing work – Physiological sensors

- **Calibration of tool for measuring fish welfare**

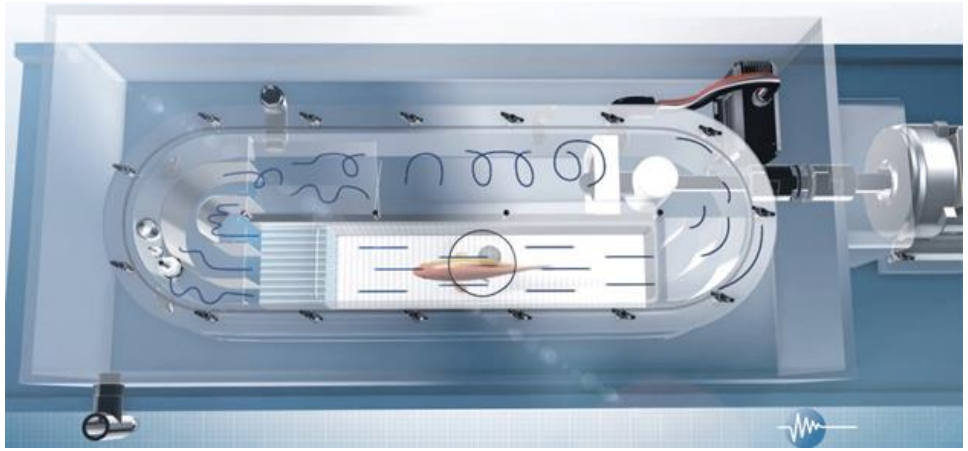




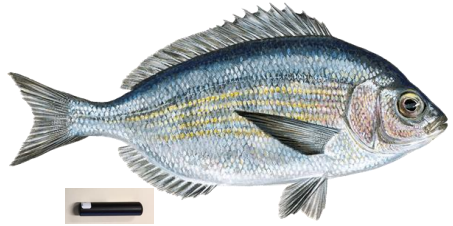
Metabolic rates (MR) are different between species
MR are variables depending on fish size

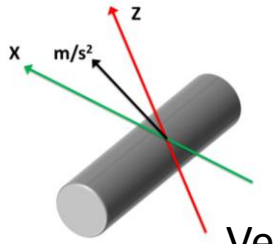
4.2. Ongoing work – Physiological sensors

- **Calibration of tool for measuring fish welfare**

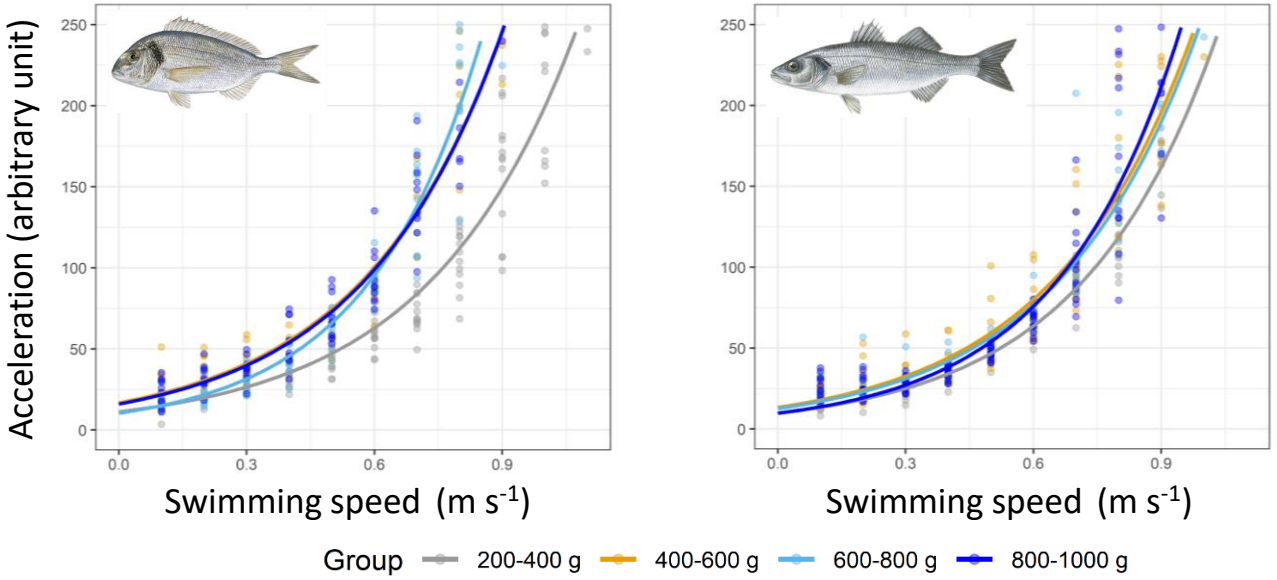


40 mm





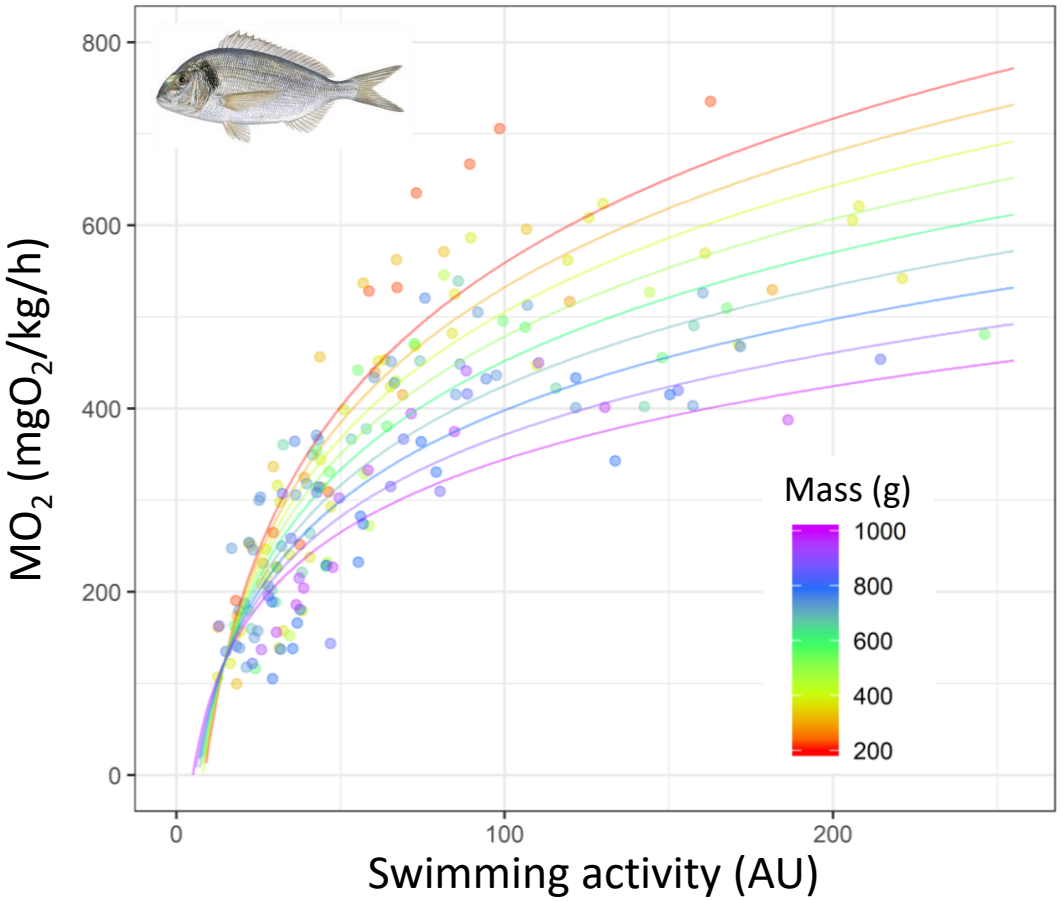
Vemco V9A tag

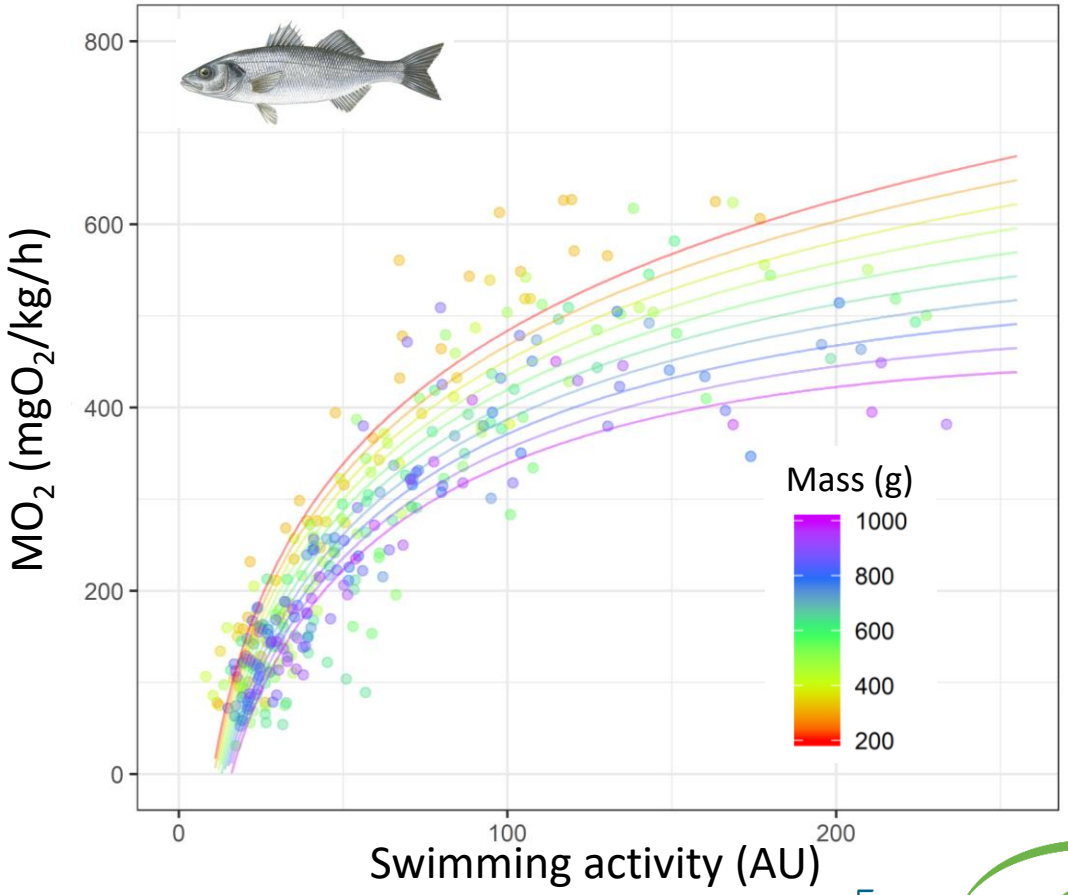


- Acceleration data from accelerometers tags follows an exponential pattern whatever fish size
- Acceleration pattern is different depending on fish size (Sea bream)

4.2. Ongoing work – Physiological sensors

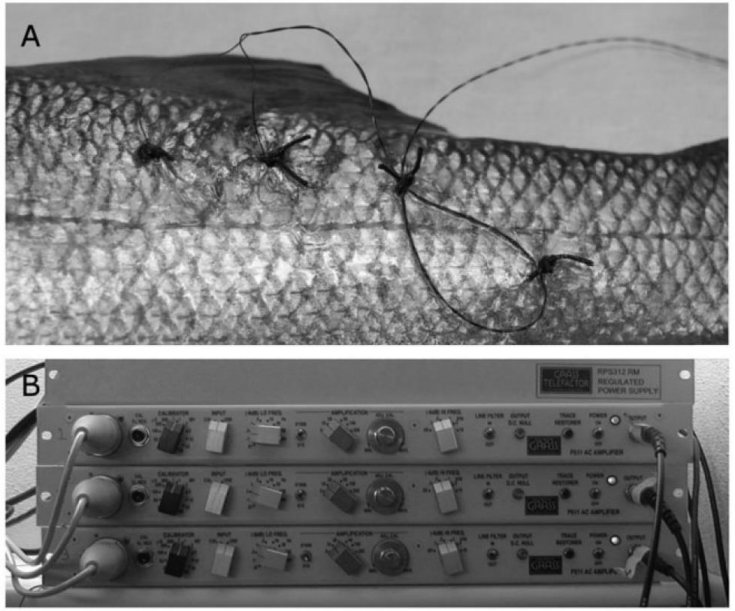
- **Calibration of tool for measuring fish welfare**

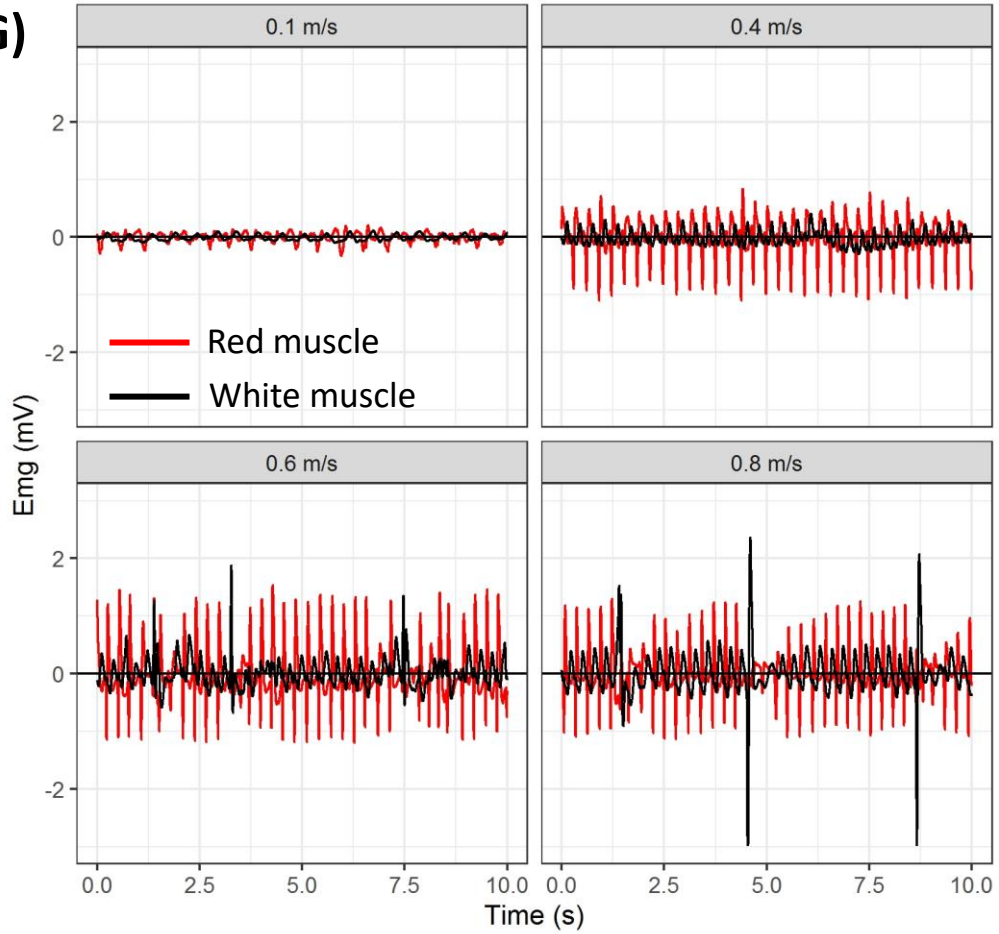




4.2. Ongoing work – Physiological sensors

- **Red and white muscle activation pattern (EMG)**





Red muscle

Aerobic activity

Low speed swimming

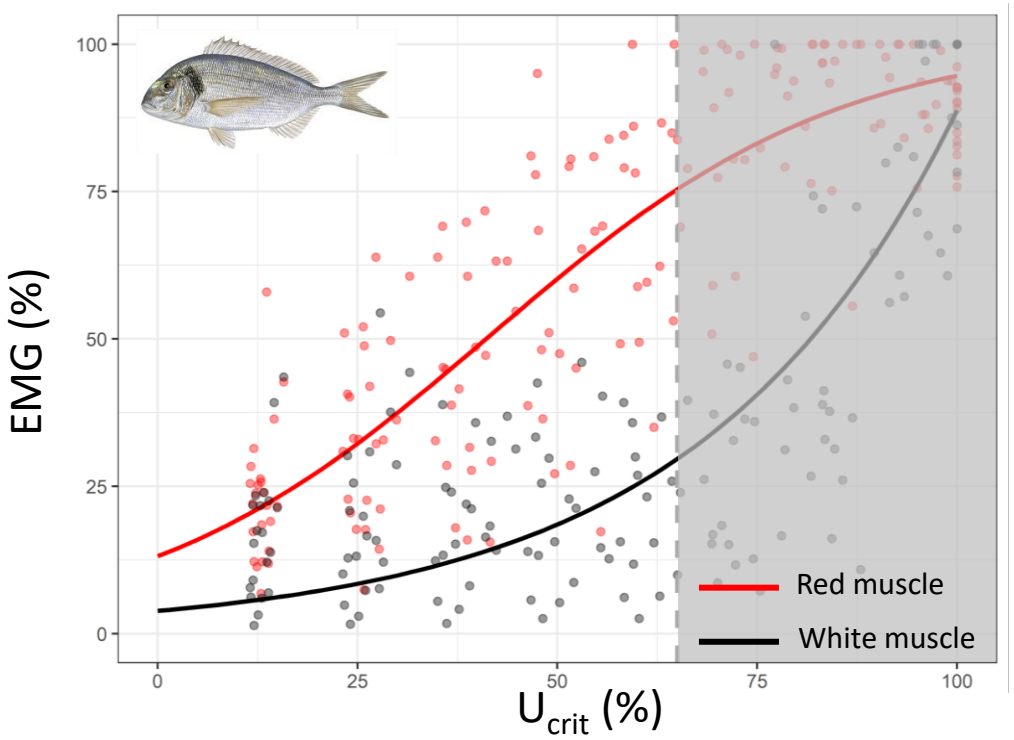
White muscle

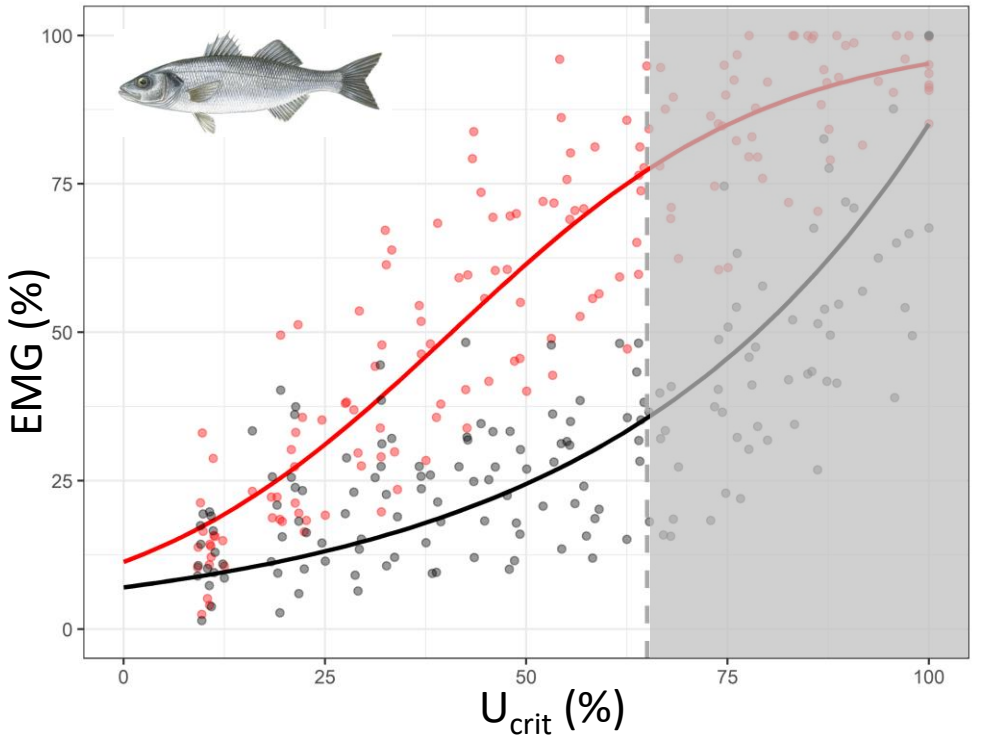
Anaerobic activity

bursts or high-intensity swimming

4.2. Ongoing work – Physiological sensors

- **Red and white muscle activation pattern (EMG)**

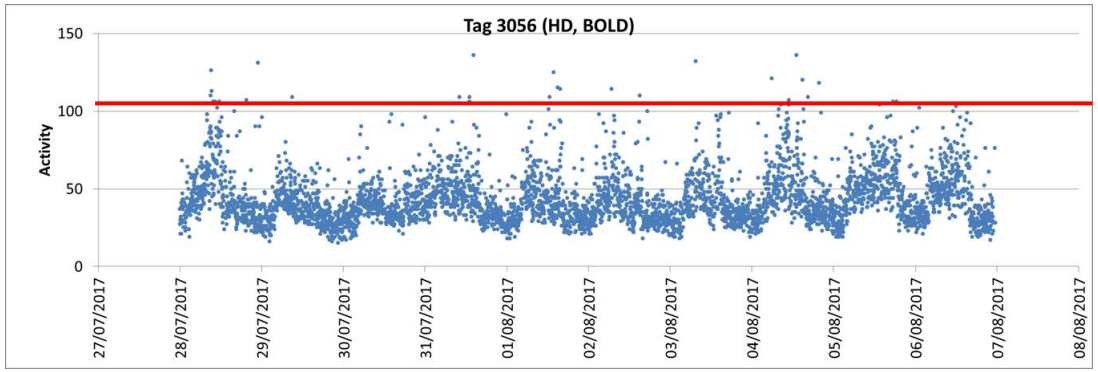




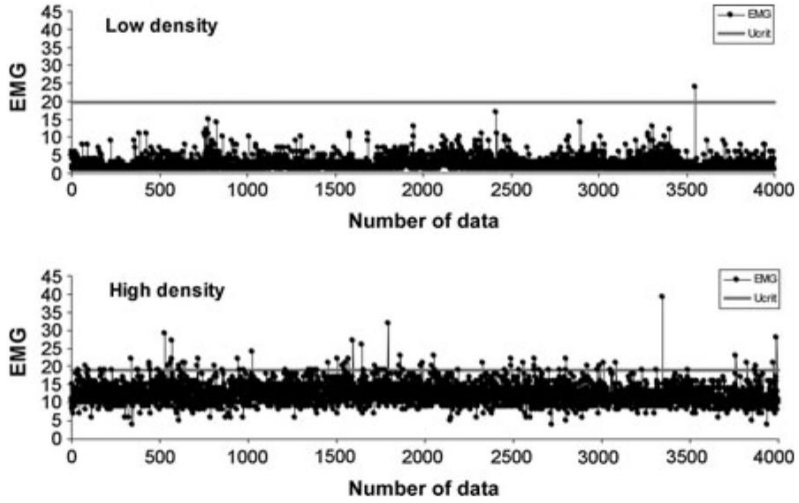
- Activation pattern of red/white muscle is quite similar between the two species
- Around 65 % of the U_{crit}, the anaerobic metabolism begins to progressively compensate the slow-down of aerobic metabolism to fuel the swimming of fish

4.2. Ongoing work – Physiological sensors

- **Modeling the data of swimming activity from long term monitoring with environmental data**



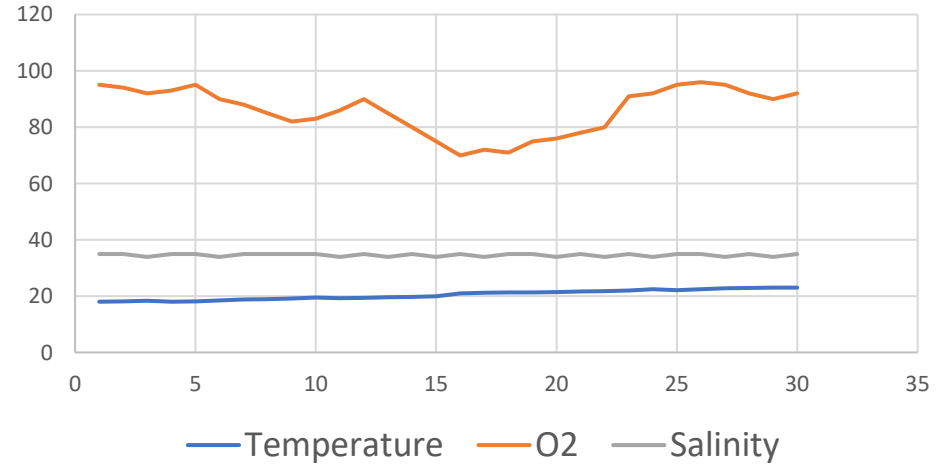
Ucrit (MMR)



10 kg/m^3

50 kg/m^3

Environmental parameters



Coupling sensors data with:
- Environmental data
- Physiological data
- Key performance indicators (e.g. growth)

➔ **Early identification to prevent health/welfare issue**

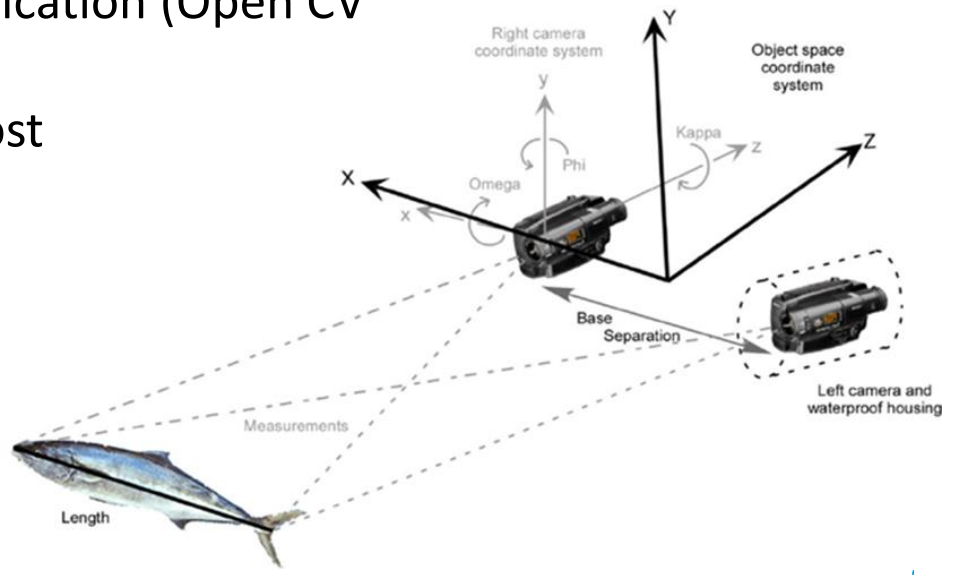
Carbonara *et al.*, 2019; https://doi.org/10.1016/j.physbeh.2019.112698 / Carbonara et al., 2015; https://onlinelibrary.wiley.com/doi/abs/10.1111/are.12369

4.2. Ongoing work – Biomass sensors

- **Calibration of tool for biomass estimation**

  - Successful results in laboratory conditions
  - Use of externally trained neural networks models for object detection
  - Low cost camera is needed (Intel RealSense D435i stereo camera)
  - Open source software for object detection and classification (Open CV computer vision library)

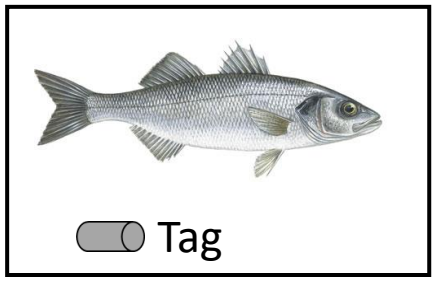
  ➔ Provide tools to use the resulting detections at low cost



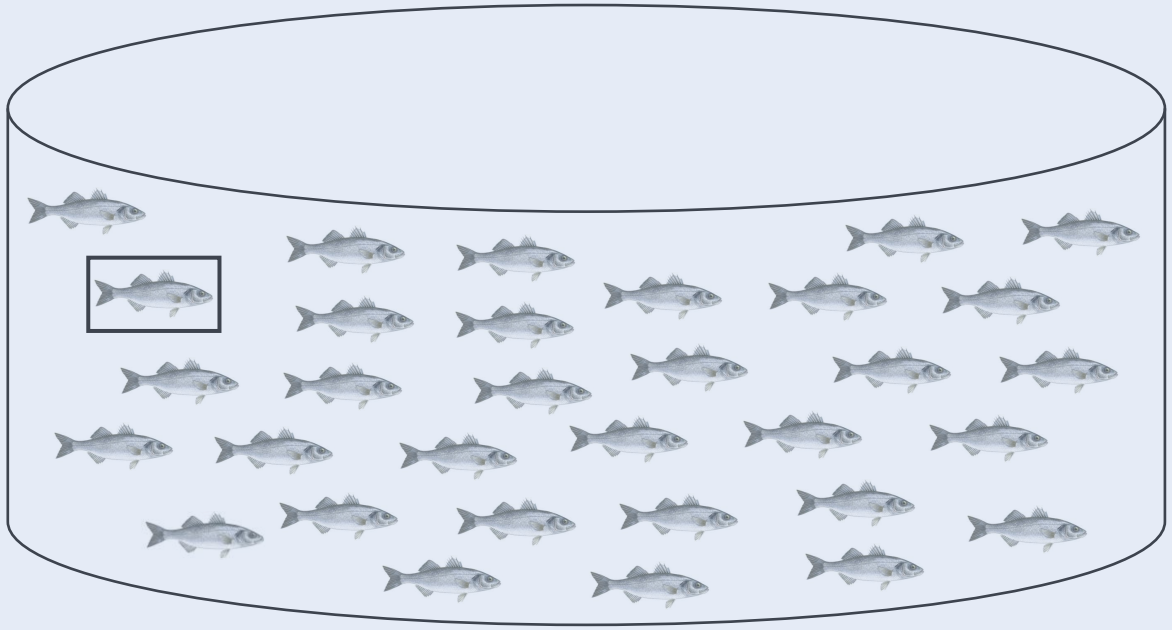
Tests of the system in sea cages is expected to take place in 2021, coupled with other wireless sensors (for environmental and physiological parameters)

4.2. Ongoing work

- **Coupling of tag data with physiological**



Nireus

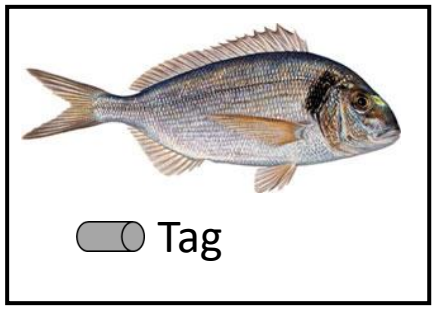


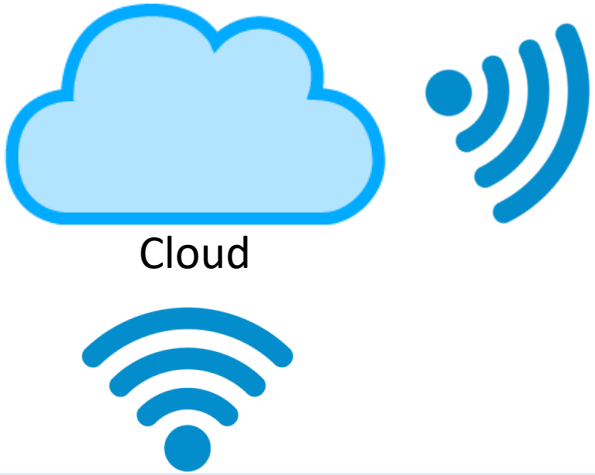
Data recording :

- Swimming activity – proxy of oxygen consumption
- Biological samples (Cortisol, glucose, lactate)

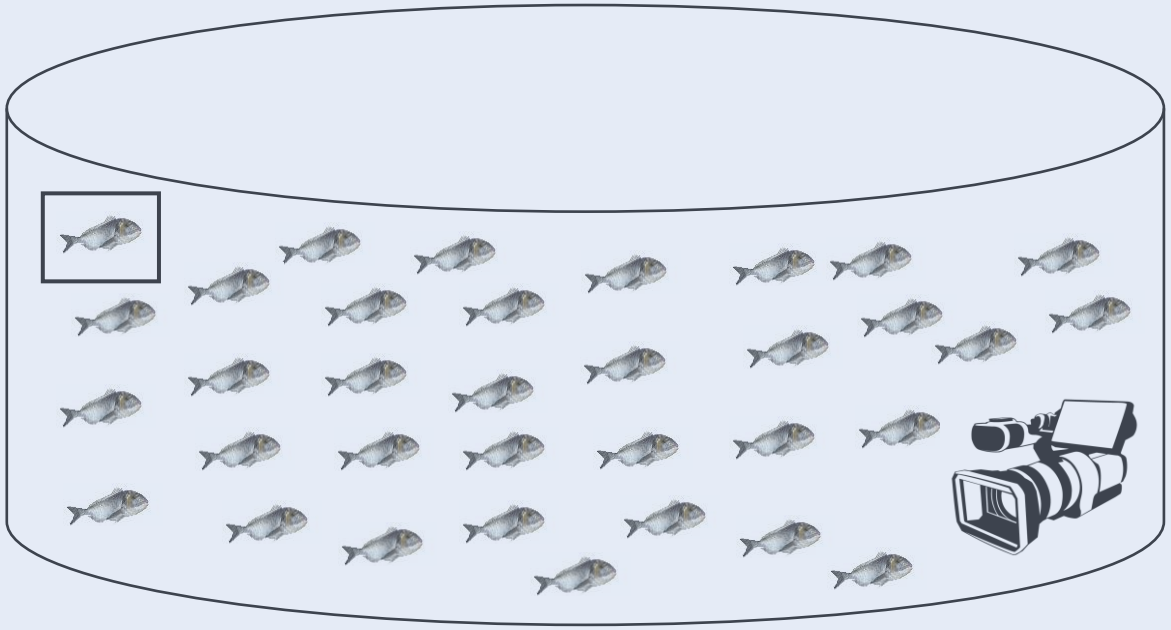
4.2. Ongoing work

- **Connection of tools in a wireless networks**





Kefalonia Fisheries SA



Data recording :

- Swimming activity – proxy of oxygen consumption
- Biomass
- Water quality (temperature, pH, O_2, salinity, turbidity, etc.)

Summary

5. Conclusions and perspectives

A real-time wireless communication system

Water quality

Fish health & welfare

Growth performances

Environmental gains

Economic gains

Take home messages

- **Internet of Things (IoT) helps to improve precision and efficiency of work**
- **IoT is being developed fast in all sectors, including aquaculture**
- **Work is ongoing to improve algorithms to early detect health/welfare issues, improve biomass estimation system and fish behavior (even if solutions currently exist)**
- **European Union finances projects involving both scientists and aquaculture industry to develop the aquaculture of tomorrow, sustainable and environment-friendly**

"The Internet of Things is really just getting started. Years from now we will be connected in ways that are difficult to imagine today."

Acknowledgments

- FutureEUAqua
  - EU funding
  - Collaborations in all Europe
- Institutes and colleagues
  - COISPA Tecnologia & Ricerca, Bari (Italy)
  - Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe), Padova (Italy)
  - University of Thessaly, Vólos (Greece)
  - Aquaculture industries (Nireus Aquaculture/ Kefalonia Fisheries SA)
- Organization
  - Zsófia Kertész (Campden BRI Hungary): z.kertesz@campdenkht.com
  - Åsa Maria O. Espmark (Nofima): Asa.Espmark@Nofima.no
  - Magnus Ljung (Swedish University of Agricultural Sciences): Magnus.Ljung@slu.se

FUTURE EUAQUA

Thanks for your attention, questions ?

Sébastien Alfonso
salfonso@coispa.eu
COISPA Tecnologia & Ricerca – Bari, Italy