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

10th March 2023

2.00pm CET (Berlin/Paris time)

via Zoom

Sébastien Alfonso

COISPA Tecnologia & Ricerca,

Bari, Italy

Summary

FUTURE EUAQUA

Summary

1. Aquaculture: promise and perils

1.1. Development and promise from aquaculture

1.2. Some concerns about aquaculture

1.1. Development and promise from aquaculture

- **Aquaculture supports man in his evolution**







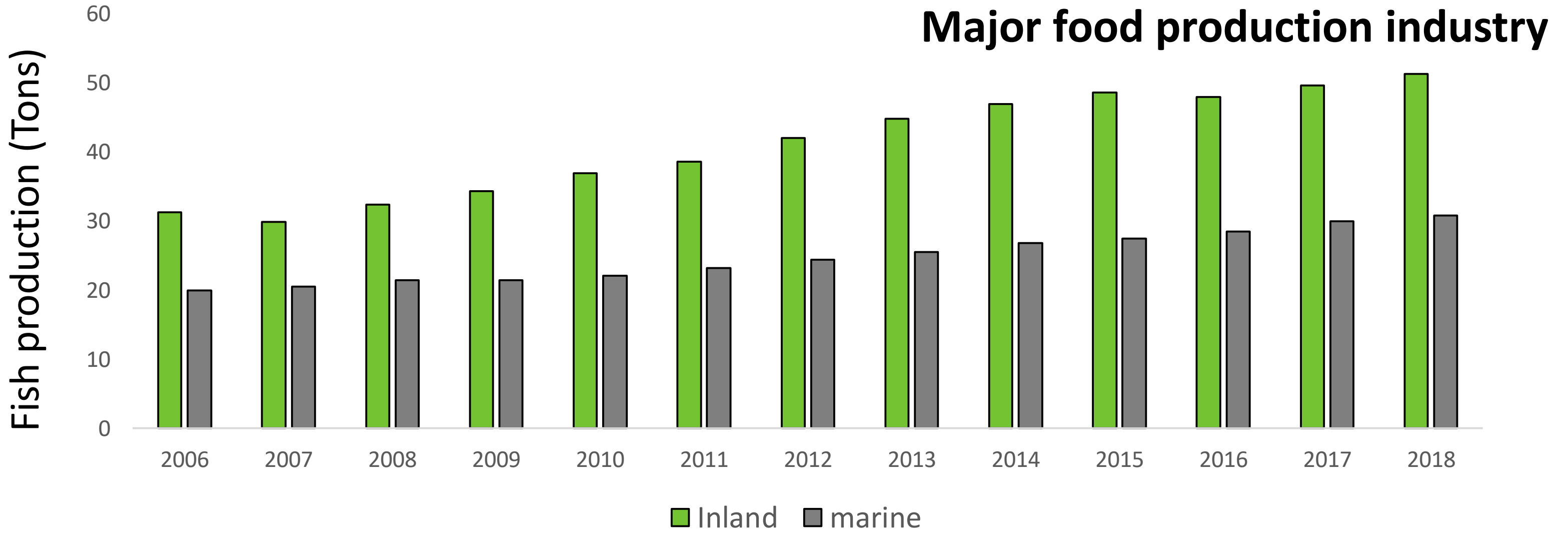

China
(~ -3500 BC)

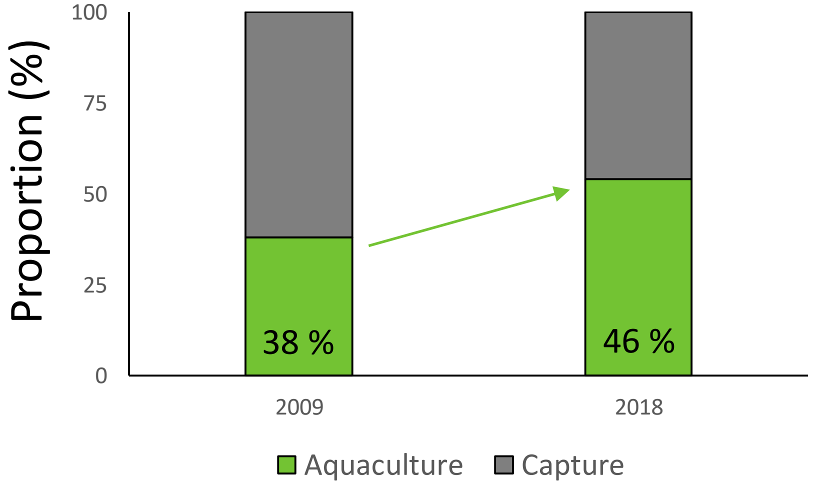
Today

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

FUTURE EUAQUA

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 partners including SMEs, Associations, Research Institutes and aquaculture farms from Europe (9 different countries).

➔ **Objectives are to effectively promote the sustainable growth of environmentally-friendly aquaculture in Europe, to meet future challenges of our modern society**

- **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 health
➔ Enhancing fish welfare
➔ 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

FUTURE EUAQUA

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

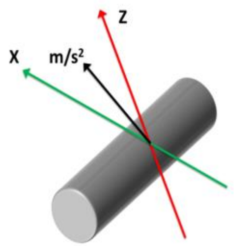
Unlimited Possibilities

*“**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.**”*

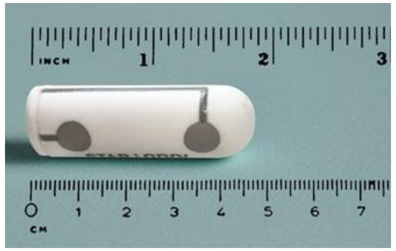
FUTURE EUAQUA

2.2. Tools to be used in aquaculture

- **Fish health and welfare**

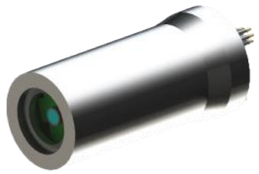


Accelerometer tags



Heart beat rate logger

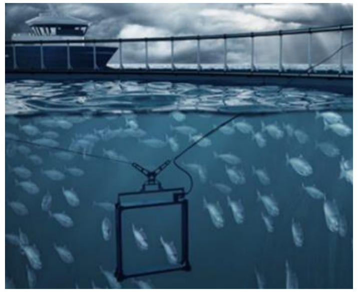
EMG (muscle activity)

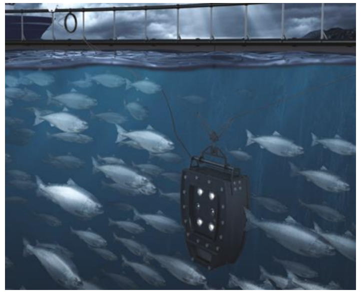


Camera system

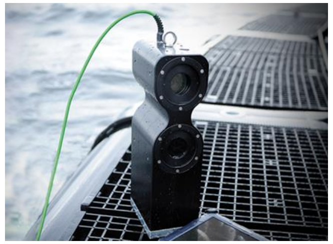
- **Biomass estimation**

Accoustic transmissions





Infrared technologies

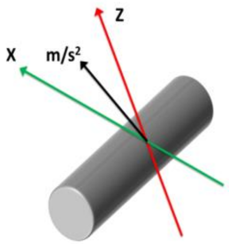


Video cameras

Summary

3.1. Enhance environmental sustainability and fish welfare

- **Health and welfare**



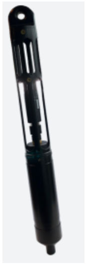
Accelerometer tags

IP camera system

- **Environmental parameters**

O_2 / temperature

Salinity



Blue/green algae

Turbidity

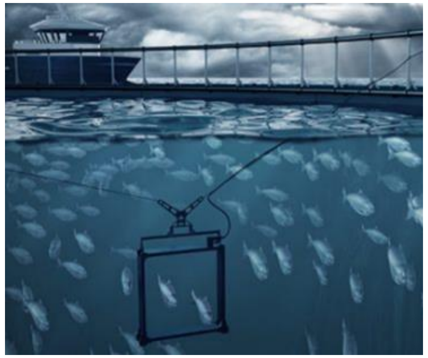
Chlorophyl

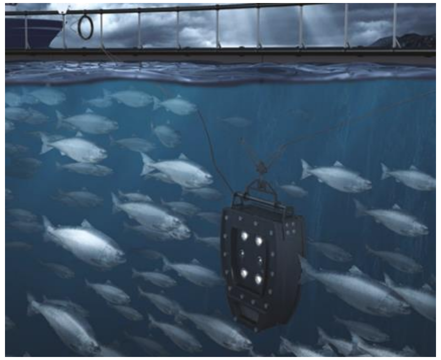
Cloud

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

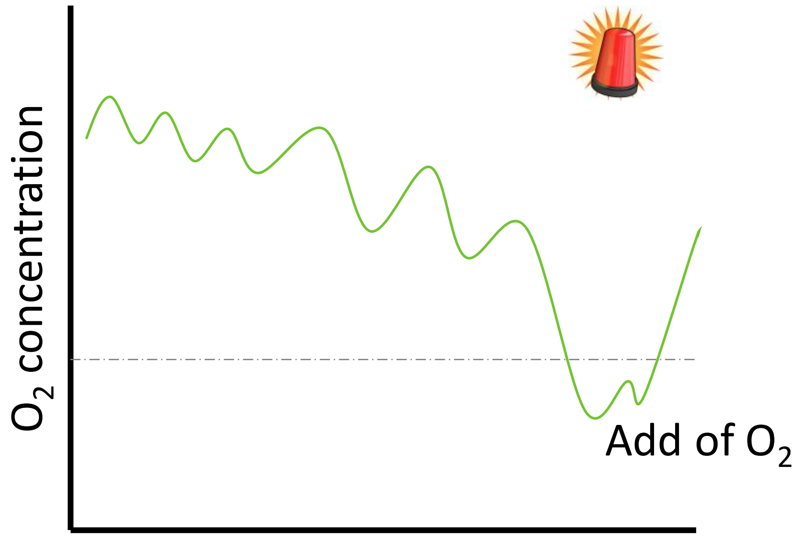
➔ Operations more efficient and reducing feed costs

➔ Avoid to waste feed (environmental sustainability)

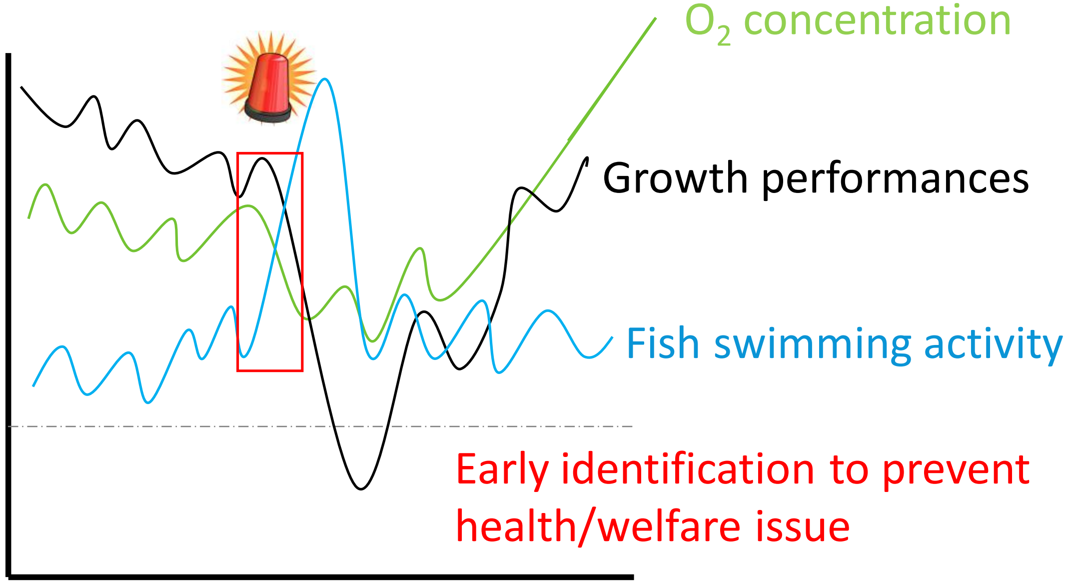
https://www.youtube.com/watch?v=Yez95aTxU0o

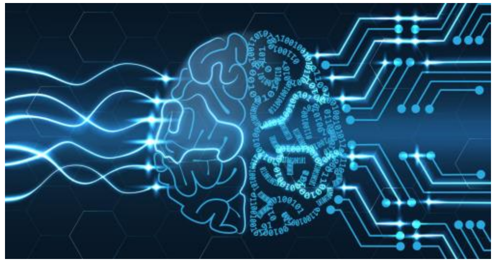
3.3. Some limitations

- **Where are we ?**



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





Algorithmes / machine learning

3. How IoT could help in aquaculture ?

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

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 [1], Sandra Sendra [2], Laura García [1] and Jaime Lloret [1,*]

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

frontiers in Physiology

ORIGINAL RESEARCH
published: 29 May 2019
doi: 10.3389/fphys.2019.00667

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

Juan Antonio Martos-Sitcha[1,2], Javier Sosa[3], Dailos Ramos-Valido[3], Francisco Javier Bravo[4], Cristina Carmona-Duarte[5], Henrique Leonel Gomes[6], Josep Àlvar Calduch-Giner[1], Enric Cabruja[4], Aurelio Vega[3], Miguel Ángel Ferrer[5], Manuel Lozano[4], Juan Antonio Montiel-Nelson[3], Juan Manuel Afonso[7] and Jaume Pérez-Sánchez[1]*

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[1] · Haiyun Wu[1]

ANNUAL REVIEWS

Annual Review of Animal Biosciences

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

Ilan Halachmi,[1] Marcella Guarino,[2] Jeffrey Bewley,[3] and Matti Pastell[4]

And … collaborations between researchers and farmers

FUTURE EUAQUA

FutureEUAqua (Horizon 2020)

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

➔ **Objectives are to effectively promote the sustainable growth of environmentally-friendly aquaculture in Europe, to meet future challenges of our modern society**

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

FUTURE EUAQUA

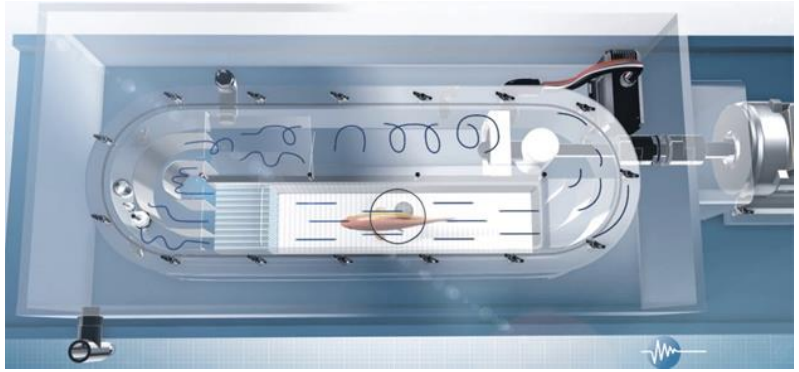
4. FutureEUaqua project

4.2. Calibration of physiological sensors

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

➔ Calibrate acceleration recorded by sensors with energetics features (MO_2 / muscle activity),

➔ Tool for welfare monitoring in free-swimming fish during the large scale experiments

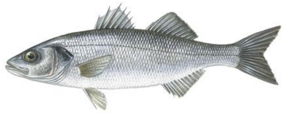


➔ Estimation of metabolic rates

➔ Calibration of MO_2 with the acceleration recorded by tag

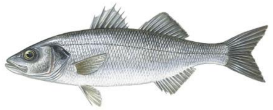
➔ Measurements of red/white muscles activation pattern (EMG)

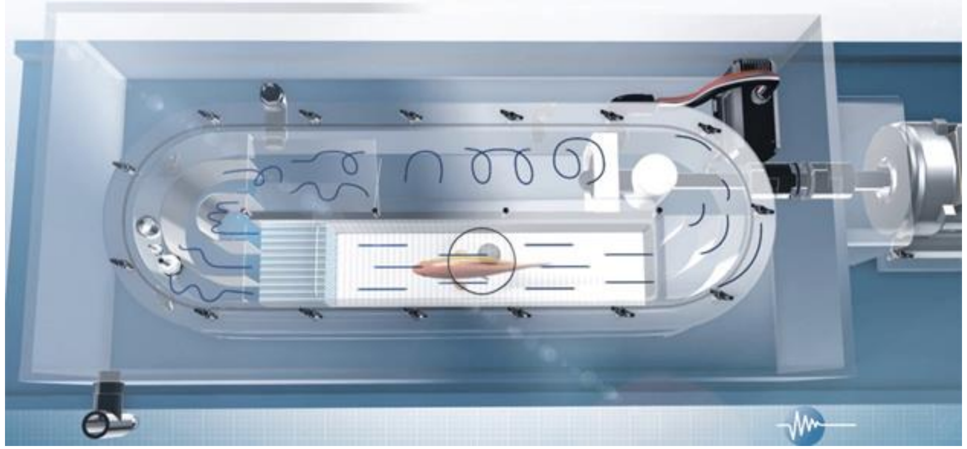
➔ **The calibration of the acceleration recorded by tag with these parameters would provide reliable proxy of fish energy expenditure to be use in free swimming fish during large scale experiments**

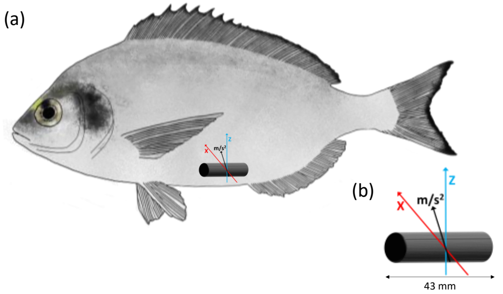
Calibration				
	FOCUSED in the presentation			

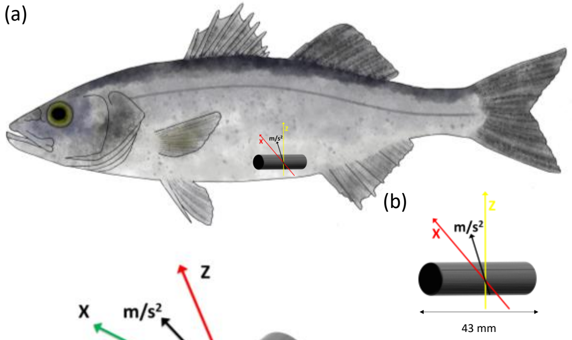
4.2. Calibration of physiological sensors

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

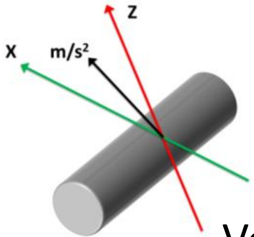




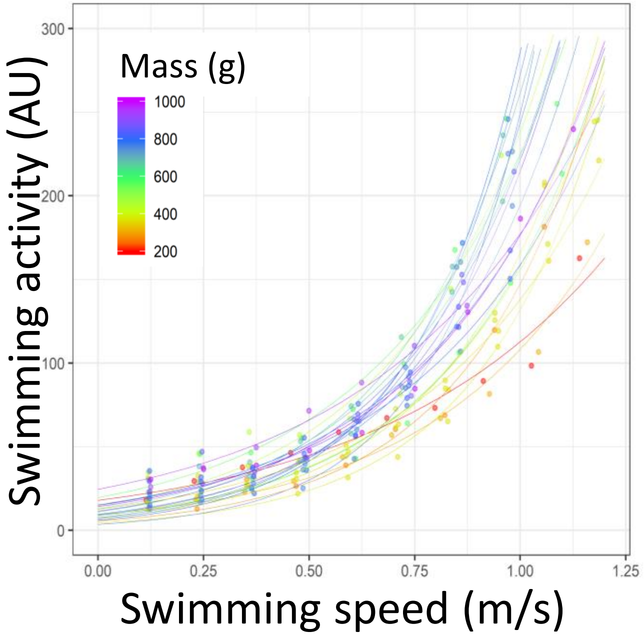


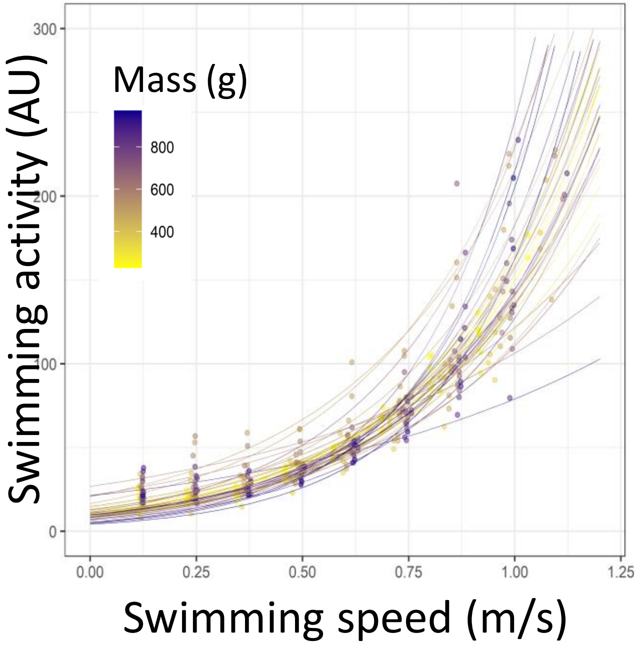


40 mm



Vemco V9A tag





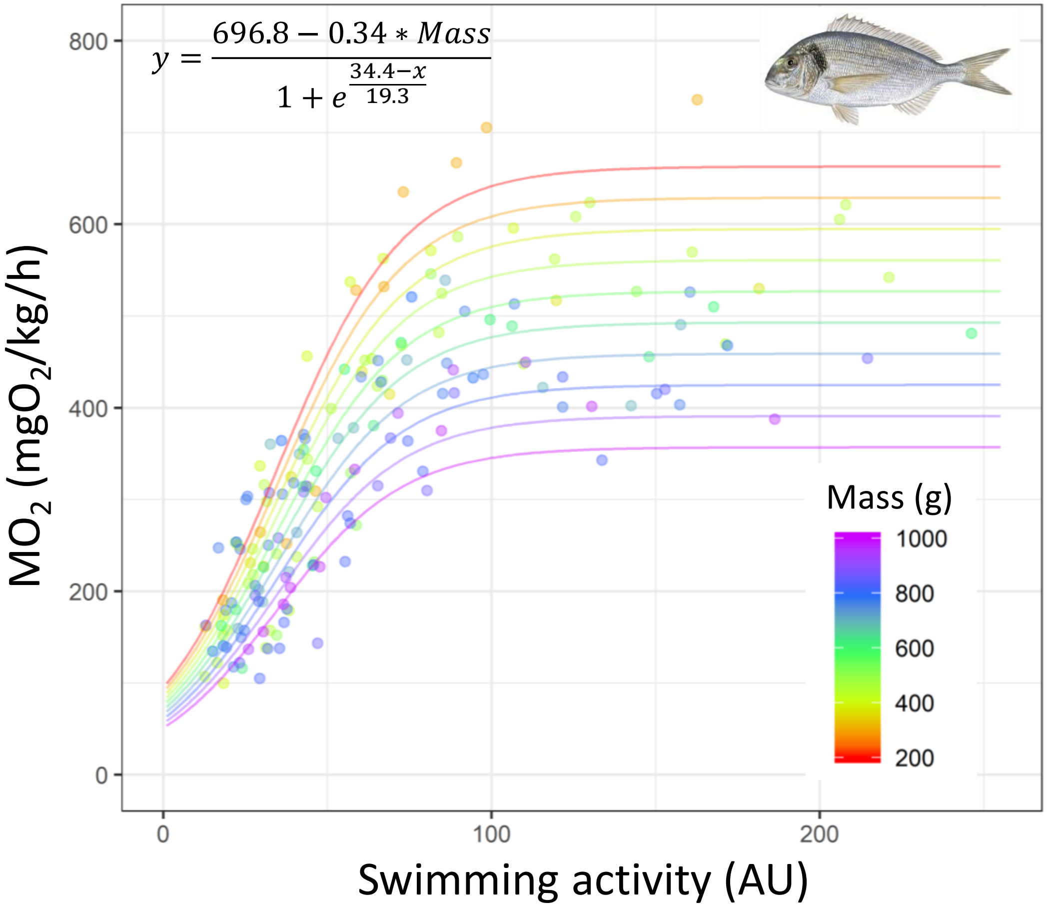
- Acceleration data from accelerometers tags follows an exponential pattern whatever fish size in the swimming tunnel

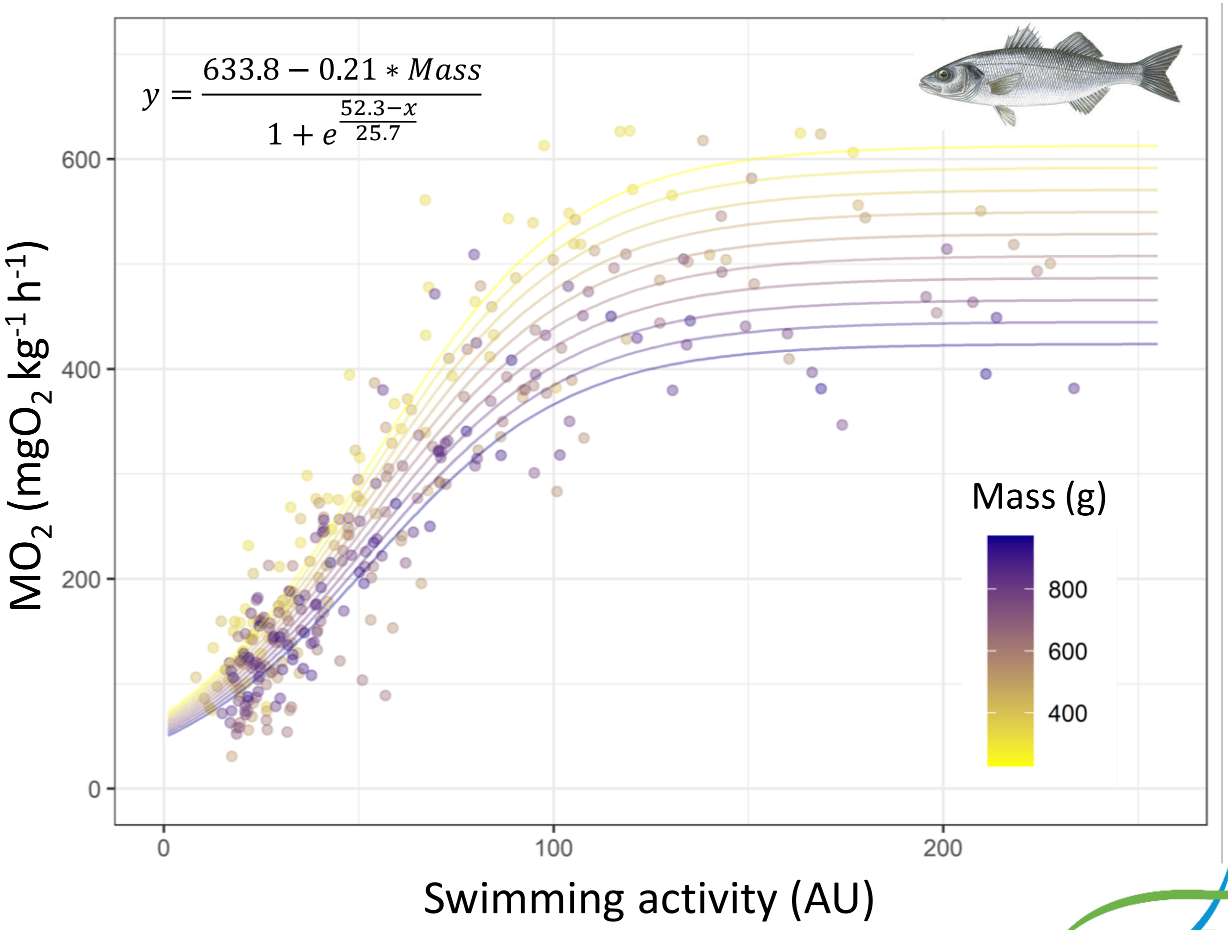
FUTURE EUAQUA

Alfonso *et al.*, 2021; https://doi.org/10.3390/biology10121357 / Alfonso *et al.*, 2022; https://doi.org/10.3389/fanim.2022.885850

4.2. Calibration of physiological sensors

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



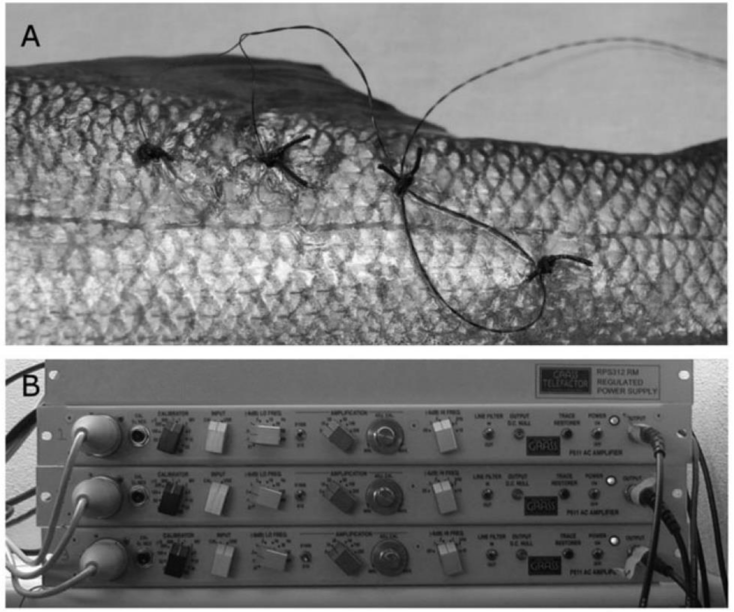


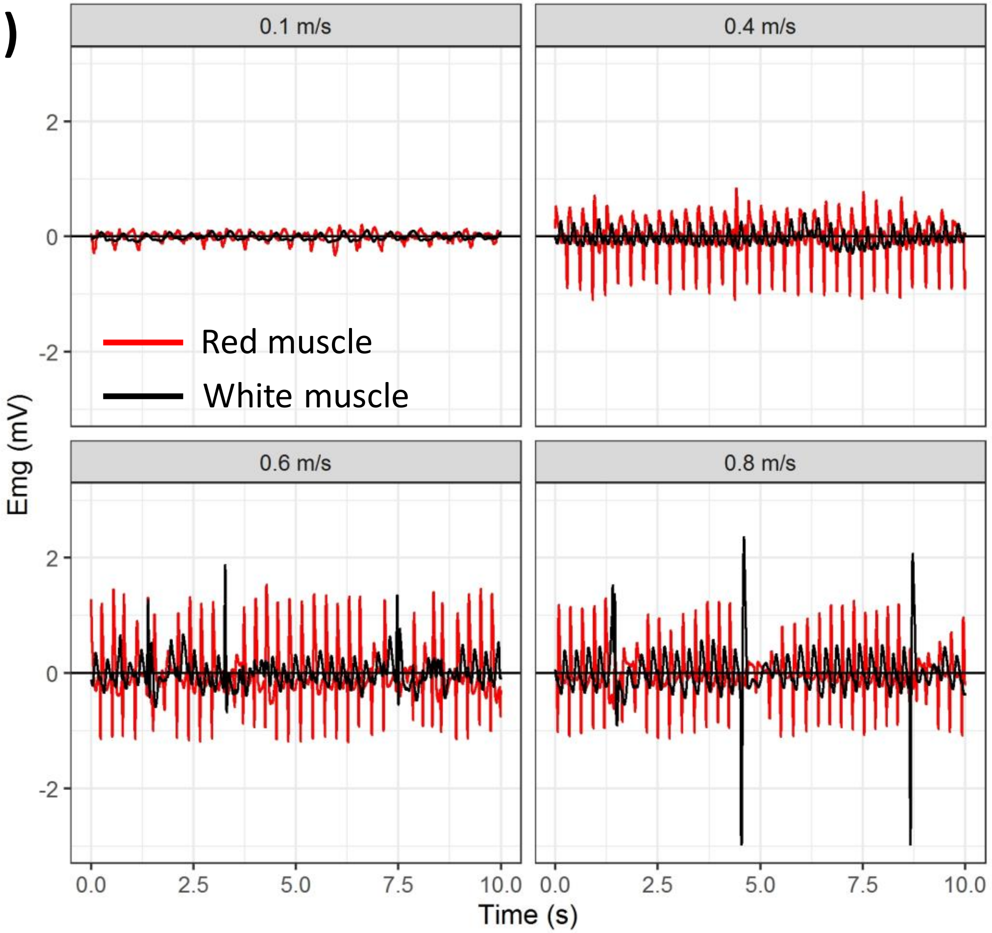
Calibration of acceleration with MO2 ➔ indicative of energy expenditure

Alfonso *et al*., 2021; https://doi.org/10.3390/biology10121357 / Alfonso *et al*., 2022; https://doi.org/10.3389/fanim.2022.885850

4.2. Calibration of physiological sensors

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





Red muscle

Aerobic activity

Low speed swimming

White muscle

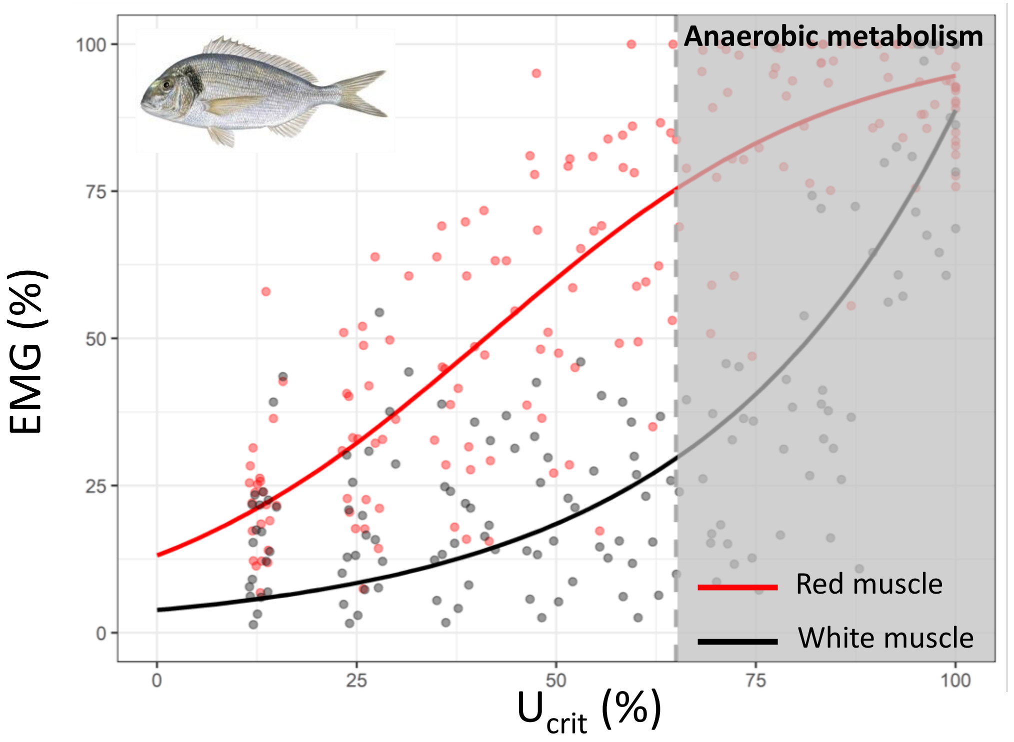
Anaerobic activity

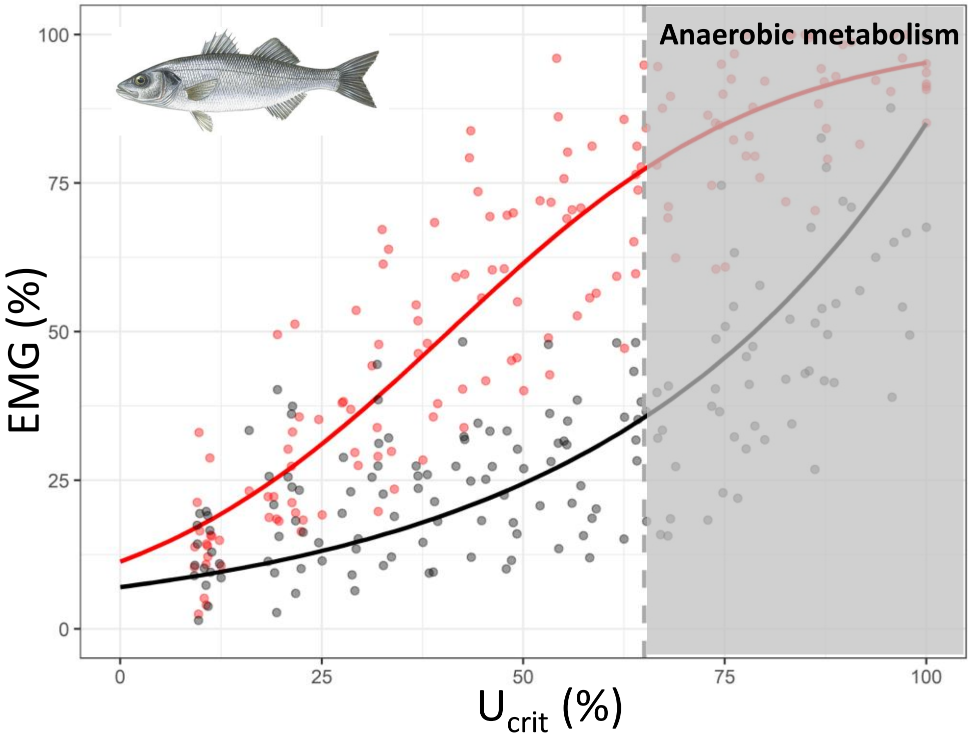
bursts or high-intensity swimming

Alfonso *et al.*, 2021; https://doi.org/10.3390/biology10121357 / Zupa *et al.*, 2015; http://dx.doi.org/10.1080/10236244.2015.1073456

4.2. Calibration of 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

Alfonso *et al.*, 2021; https://doi.org/10.3390/biology10121357 / Zupa *et al.*, 2015; http://dx.doi.org/10.1080/10236244.2015.1073456

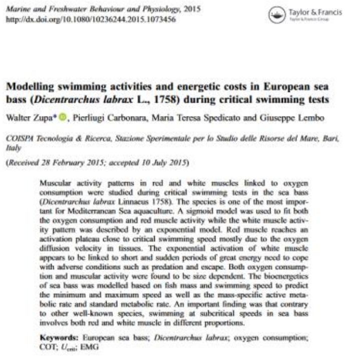
4.2. Calibration of physiological sensors

- **Conclusions from the calibration of physiological sensors**

Take home messages:

- **Calibrating the acceleration recorded by acceleration** tag with the oxygen consumption rate (MO2) and red/white muscles activity allows to use the acceleration recorded by such sensor as a **reliable proxy of fish energy expenditure** (**referring especially to aerobic/anaerobic metabolism**).

➔ **Such sensors could be used for remote health/welfare monitoring purposes in aquaculture context.**


Marine and Freshwater Behaviour and Physiology, 2015
http://dx.doi.org/10.1080/10236244.2015.1073456

Modelling swimming activities and energetic costs in European sea bass (*Dicentrarchus labrax* L., 1758) during critical swimming tests

Walter Zupa*, Pierliugi Carbonara, Maria Teresa Spedicato and Giuseppe Lembo

COISPA Tecnologia & Ricerca, Stazione Sperimentale per lo Studio delle Risorse del Mare, Bari, Italy

(*Received 28 February 2015; accepted 10 July 2015*)

Muscular activity patterns in red and white muscles linked to oxygen consumption were studied during critical swimming tests in the sea bass (*Dicentrarchus labrax* Linnaeus 1758). The species is one of the most important for Mediterranean Sea aquaculture. A sigmoid model was used to fit both the oxygen consumption and red muscle activity while the white muscle activity pattern was described by an exponential model. Red muscle reaches an activation plateau close to critical swimming speed mostly due to the oxygen diffusion velocity in tissues. The exponential activation of white muscle appears to be linked to short and sudden periods of great energy need to cope with adverse conditions such as predation and escape. Both oxygen consumption and muscular activity were found to be size dependent. The bioenergetics of sea bass was modelled based on fish mass and swimming speed to predict the minimum and maximum speed as well as the mass-specific active metabolic rate and standard metabolic rate. An important finding was that contrary to other well-known species, swimming at subcritical speeds in sea bass involves both red and white muscle in different proportions.

Keywords: European sea bass; *Dicentrarchus labrax*; oxygen consumption; COT; U_{crit}; EMG

https://doi.org/10.1080/10236244.2015.1073456


biology MDPI

Article

Mapping the Energetic Costs of Free-Swimming Gilthead Sea Bream (*Sparus aurata*), a Key Species in European Marine Aquaculture

Sébastien Alfonso *, Walter Zupa, Maria Teresa Spedicato, Giuseppe Lembo and Pierluigi Carbonara

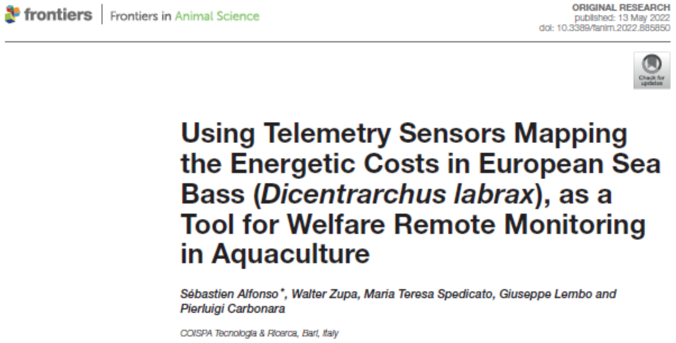
COISPA Tecnologia and Ricerca, Experimental Station for the Study of Sea Resources, Via dei Trulli 18-20, 70126 Bari, Italy; zupa@coispa.it (W.Z.); spedicato@coispa.it (M.T.S.); lembo@coispa.it (G.L.); carbonara@coispa.it (P.C.)
* Correspondence: salfonso@coispa.eu

Simple Summary: Assessment of the energetic costs of different living activities is of primary interest among fish biologists. However, assessing energy expenditure in free-swimming fish is challenging owing to the difficulty of performing such measurements in the field. Therefore, the use of implant fish with sensors that transmit signals that serve as a proxy for energy expenditure is a promising method to counter these limitations, allowing remote monitoring in tagged fish. The aim of this study was to correlate the acceleration recorded by the tag with the activities of the red and white muscles and the oxygen consumption rate (MO_2), which could serve as a proxy for energy expenditure, in gilthead sea bream (*Sparus aurata*), a key species in European marine aquaculture. The acceleration recorded by the tag was successfully correlated with MO_2. Additionally, through electromyographic analyses, we determined the activities of the red and white muscles, which are indicative of the contributions of aerobic and anaerobic metabolisms during swimming. Finally, the tag implantation did not affect the swimming performance, metabolic traits, and swimming efficiency of the sea bream. By obtaining insights into both aerobic and anaerobic metabolisms, sensor mapping with physiological indicators may be useful for the purposes of aquaculture health/welfare remote monitoring of gilthead sea bream.

check for updates

Citation: Alfonso, S.; Zupa, W.; Spedicato, M.T.; Lembo, G.; Carbonara, P. Mapping the Energetic Costs of Free-Swimming Gilthead

https://doi.org/10.3390/biology10121357


frontiers | Frontiers in Animal Science

ORIGINAL RESEARCH
published: 13 May 2022
doi: 10.3389/fanim.2022.885850

Check for updates

Using Telemetry Sensors Mapping the Energetic Costs in European Sea Bass (*Dicentrarchus labrax*), as a Tool for Welfare Remote Monitoring in Aquaculture

Sébastien Alfonso, Walter Zupa, Maria Teresa Spedicato, Giuseppe Lembo and Pierluigi Carbonara*

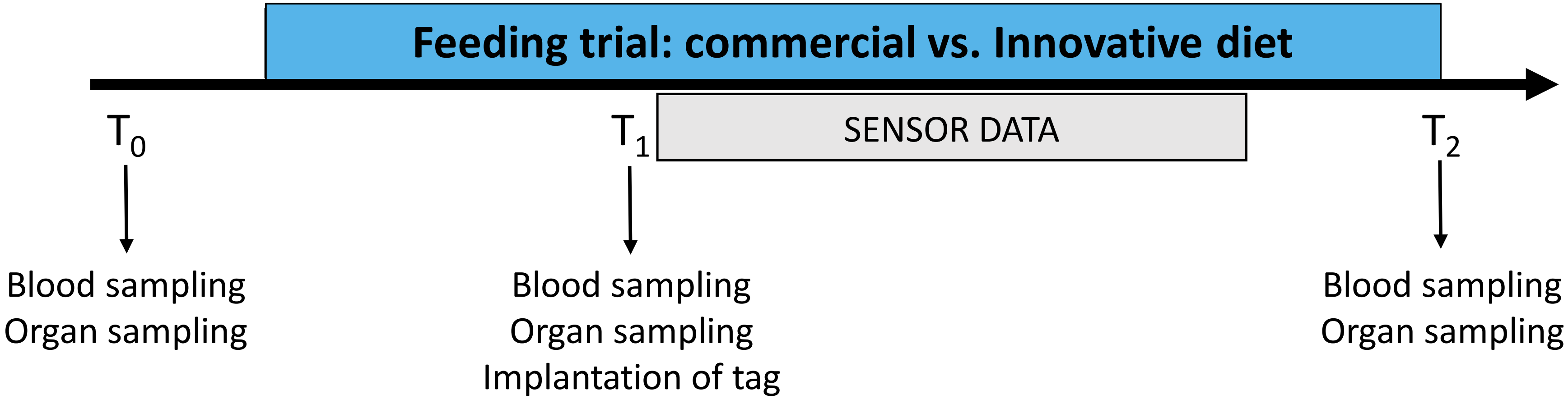
COISPA Tecnologia & Ricerca, Bari, Italy

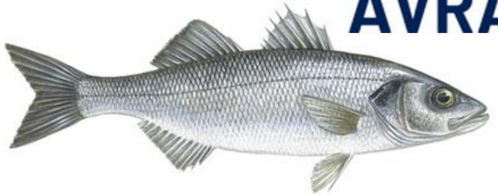
https://doi.org/10.3389/fanim.2022.885850

FUTURE EUAQUA

4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

- Experimental protocol | **Trial**





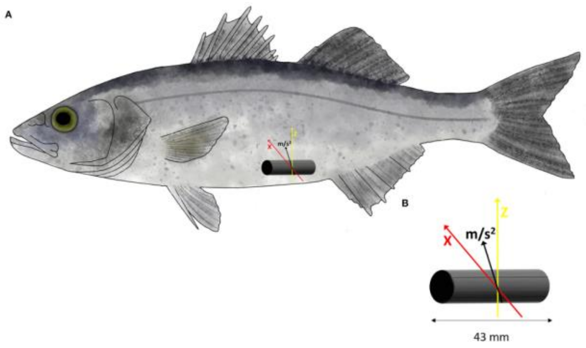
AVRAMAR

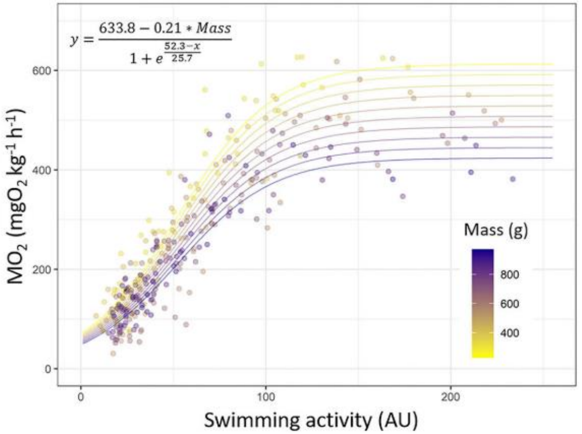
	T0	**T1**	**T2**
Date	14-15/07/2020	24-25/04/2021	06-07/07/2021
Sample size	10	18 per condition	20 per condition
Mass (g)	29.71 ± 4.24	310.44 ± 128.75	379.94 ± 137.70
TL (mm)	137.34 ± 6.15	290.97 ± 33.21	316.58 ± 38.48

FUTURE EUAQUA

4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

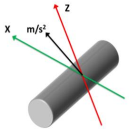
- **Monitoring health and welfare of European sea bass over growth trial**





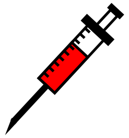
- **Accelerometer tags**

Implantation in body cavity
Indicative of oxygen consumption rate (MO_2)
Proxy of energy expenditure
➔ Continuous monitoring over trial



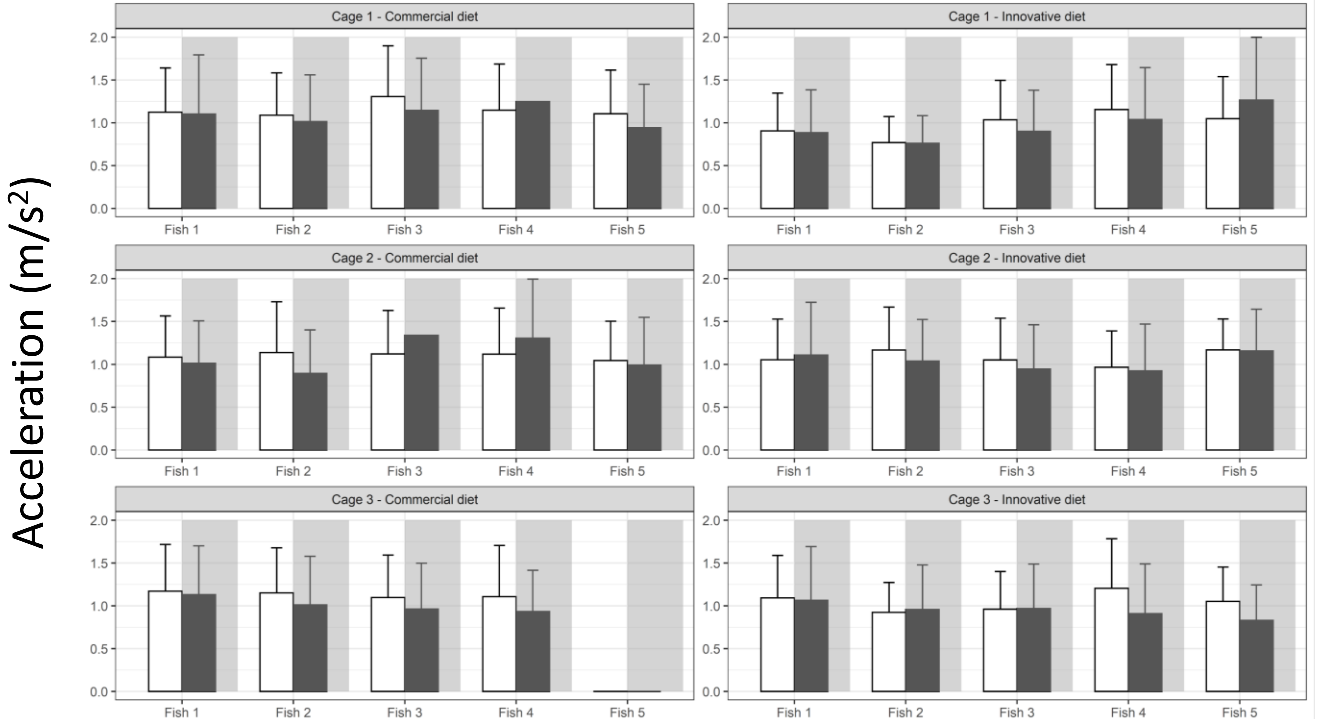
- **Physiological parameters**

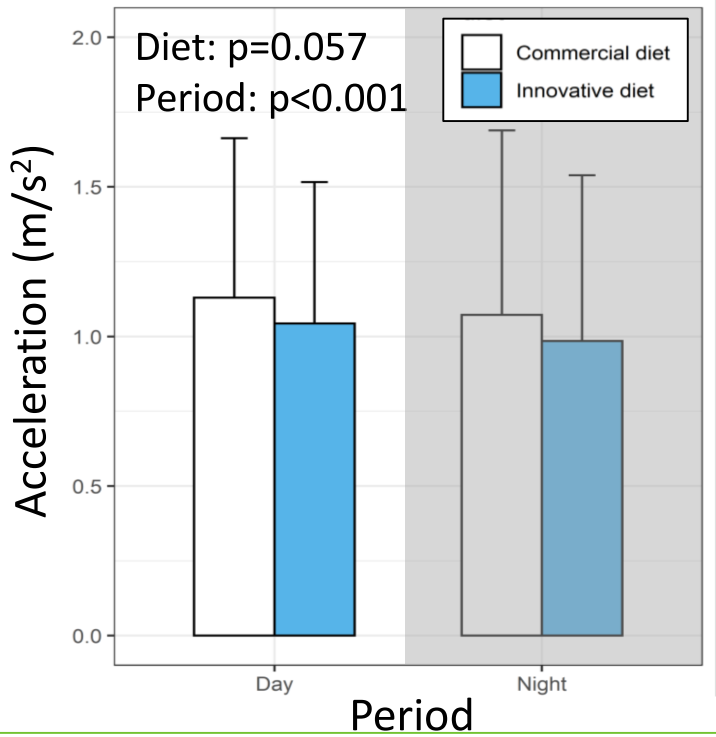
Cortisol / Glucose / Lactate
Adrenaline / Noradrenaline / Lysozyme
Hematocrit / Hemoglobin / Red blood cells count
Total proteins / Prealbumin / albumin / etc.



4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

- **Accelerometer tags | Acceleration displayed by fish over trial**



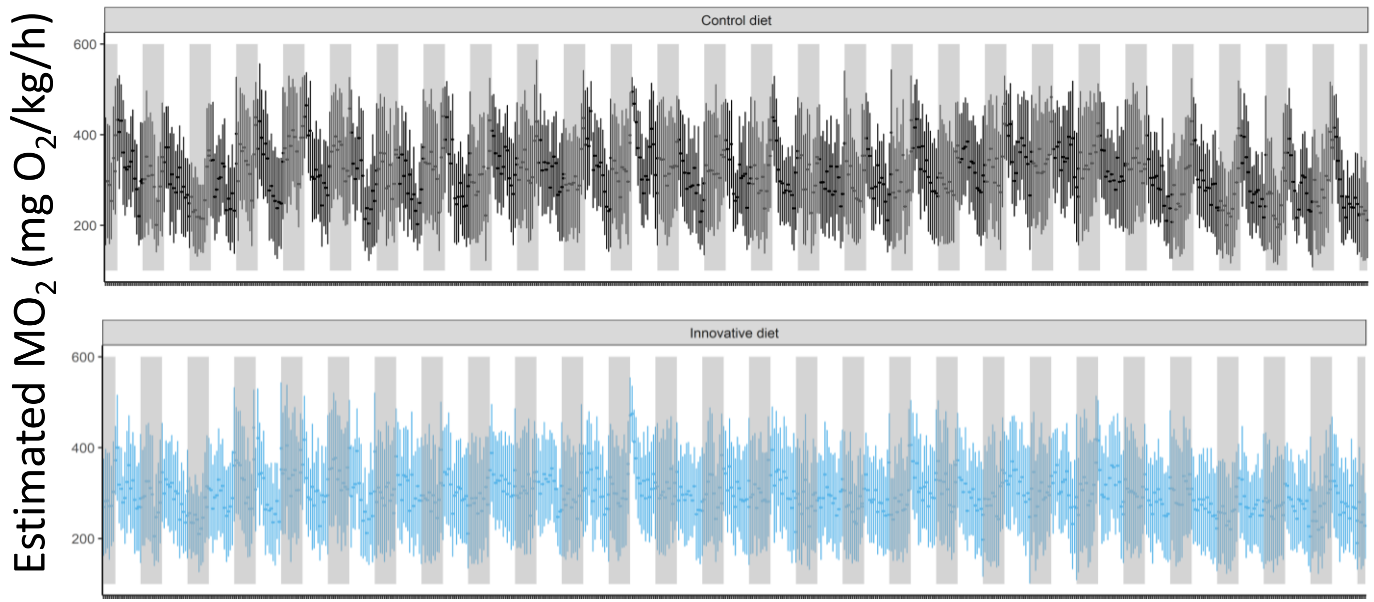


- **Conclusion:**

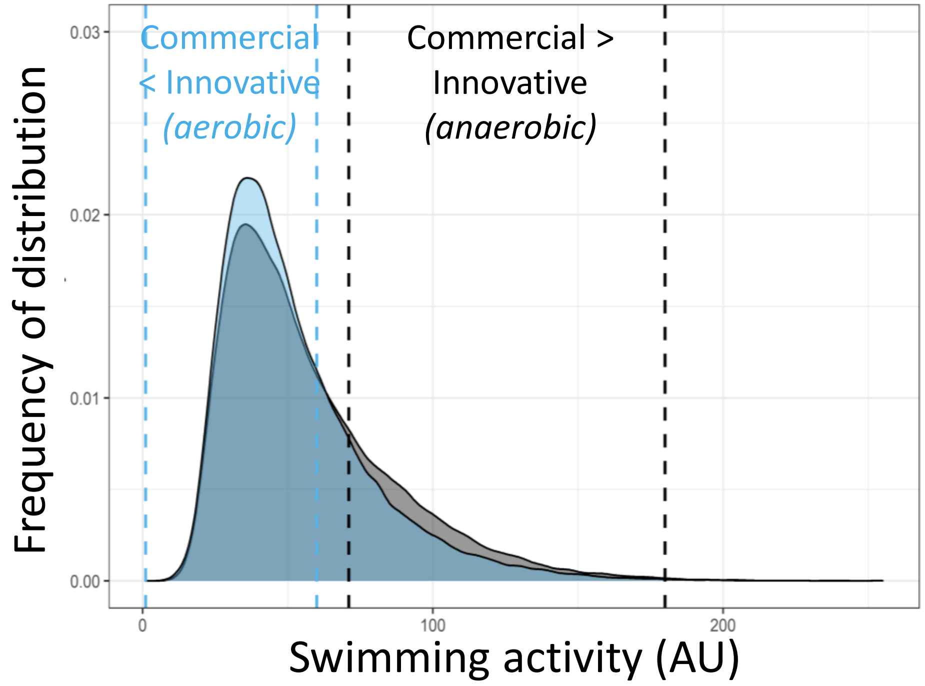
The acceleration of sea bass is lower at night compare to day. Similar to what we previously observed in this species. Sea bass fed innovative diet tends to display lower acceleration over the experimental duration (p=0.057).

4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

- **Accelerometer tags | Frequency distribution of accelereration**



Based on tag calibration



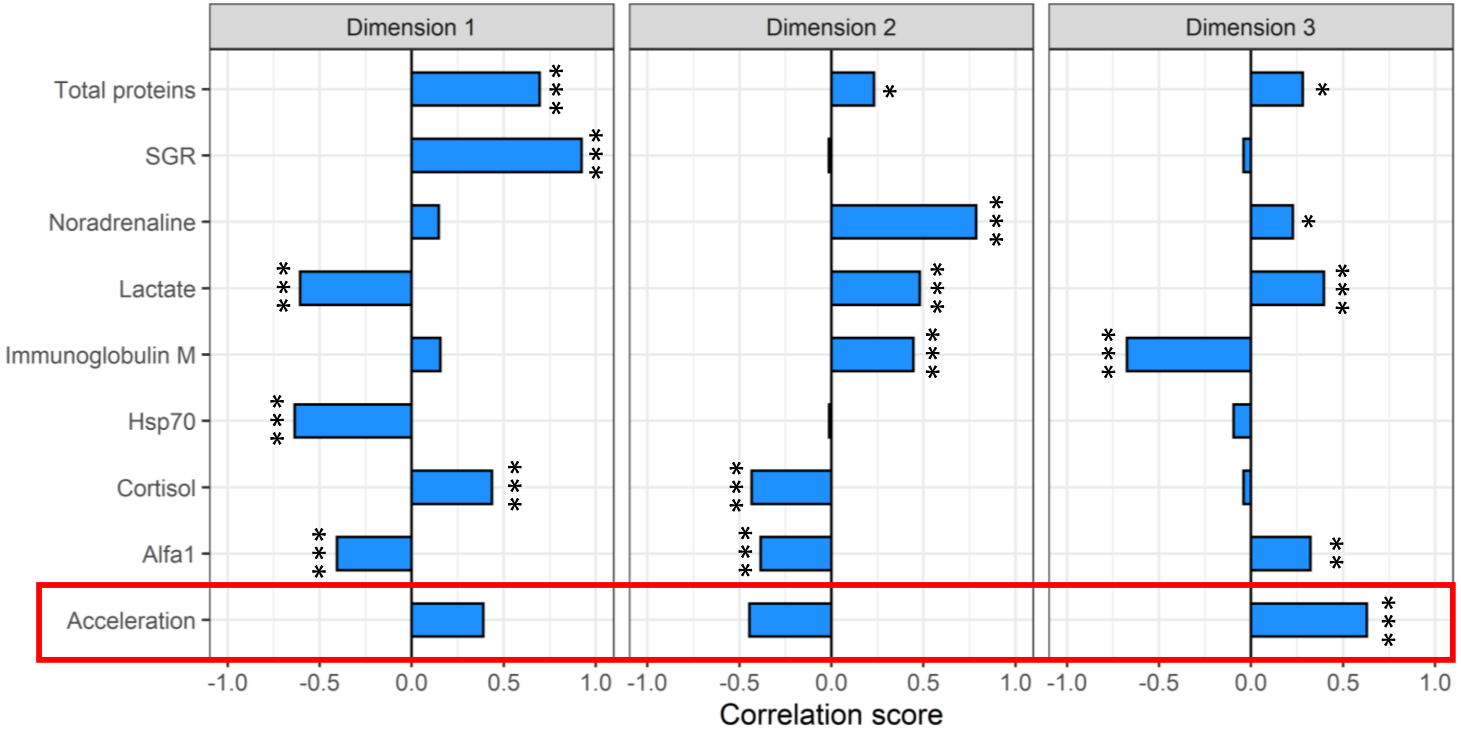
- **Conclusion:**

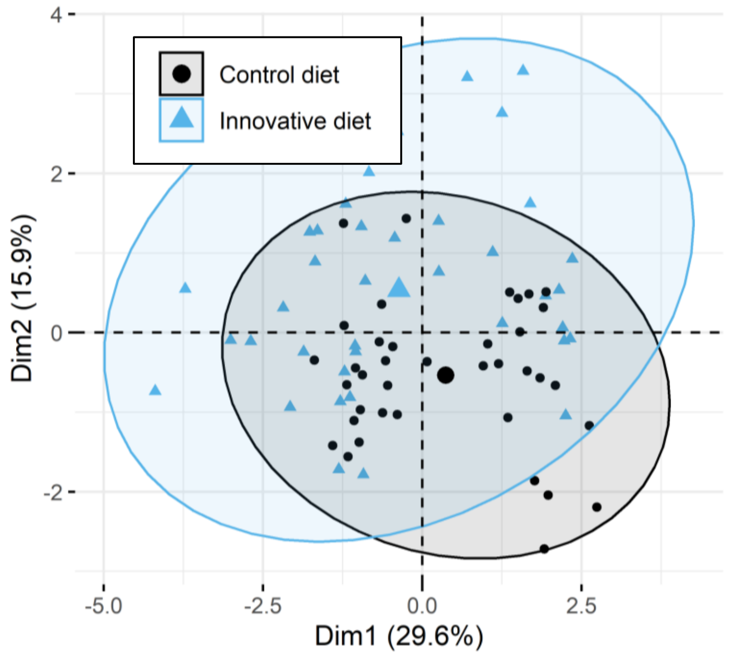
Greater number of data for swimming activity values ranging from to 11-50 for fish fed innovative diet than commercial one. At the contrary, Greater number of data for swimming activity values ranging from to 71-170 for fish fed innovative diet than commercial one.

➔**It suggests lower use of anaerobic metabolism in fish fed innovative diet (and *vice versa*)**

4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

- **PCA analysis| Combination of tag data with other health/welfare markers**





Dim 2. Innov > control diet

- **Conclusion:**

Acceleration recorded by tag could be linked to other health/welfare markers (e.g. cortisol, lactate, total proteins)
➔ Give a larger and more comprehensive overview of health/welfare state of fish because continuous welfare monitoring

4.3. Study 1 – Assessing physiological effects of feeding an innovative diet

- **Conclusions from the study 1 – use of tag data**

Take home messages:

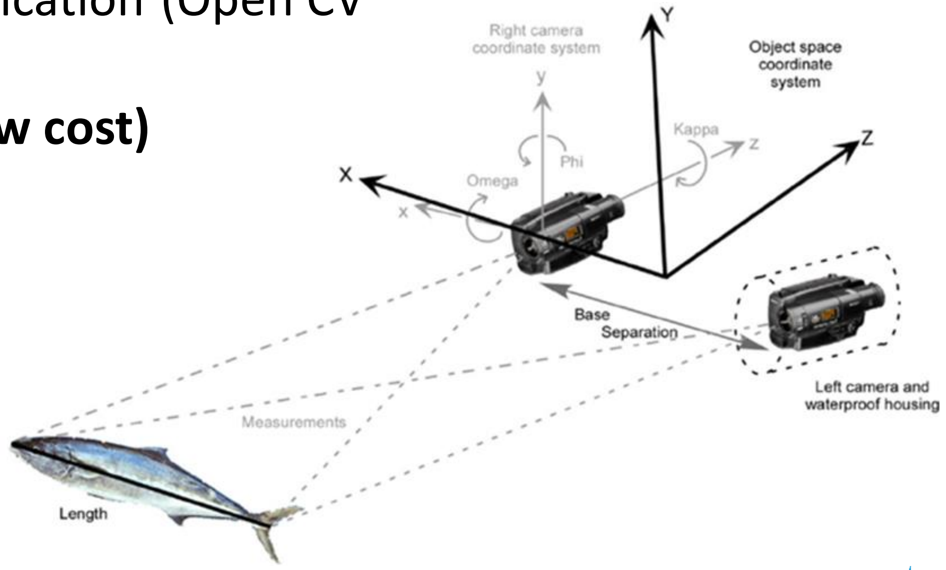
- The swimming activity recorded by tag allowed continuous **health/welfare remote monitoring**, especially **by estimations on energy expenditure** (**linked to aerobic/anaerobic metabolism**).
- Tagging did not affect health/welfare of fish (data non presented). Also high survival of fish tagged (29 out of the 30 tagged fish), **supporting the use of physiological sensors for welfare monitoring in aquaculture**.
- The insights gathered from tag can be combined to other more classical health/welfare parameters (e.g. blood stress markers, welfare scores, immunity, growth performances).
  ➔ **Give a larger overview of health/welfare state of fish**
- Although only presented in the large scale trial in sea bass, the use of tag was proved useful for large scale demonstrations for both conventional and organic large-scale trials in **sea bream** and **rainbow trout**.
  ➔ **See Deliverable D5.5** *(in preparation)*

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **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 estimate biomass in sea cages (at low cost)**

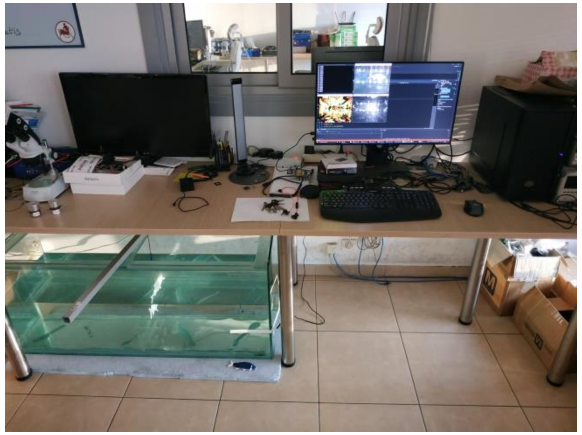


University of Thessaly (NITlab)

Nikos Sidiropoulos
Giannis Kazdaridis
Assoc. Prof. Thanasis Korakis

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

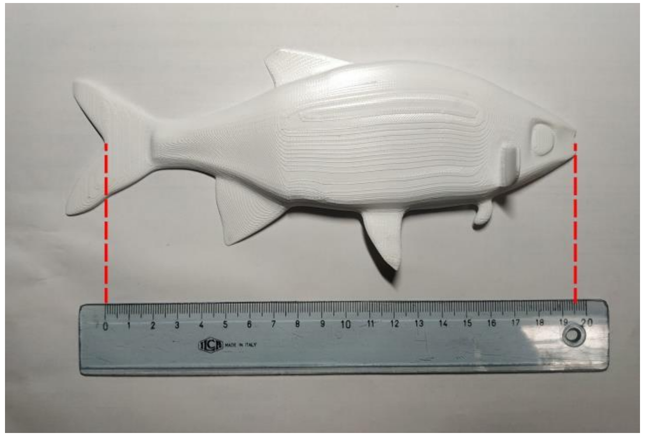
- **Calibration of tool for biomass estimation**



- The camera was attached to the side pane of the tank which serves as a housing front cover

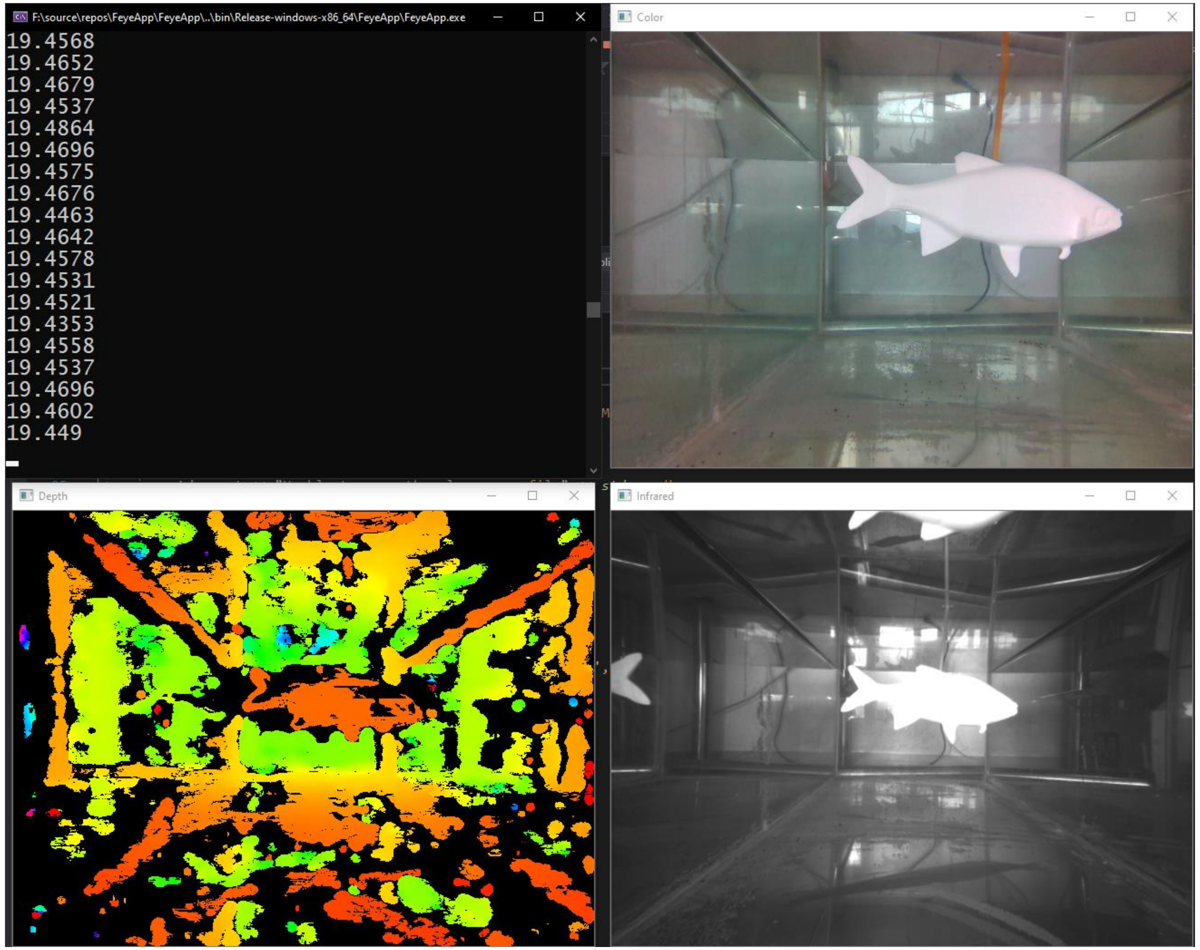
- The two parts of the software (off-shore) and (on-shore) were merged into a single application for testing purposes.

- The actual measurement of the fish prop was taken and was 19.5 cm



4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Calibration of tool for biomass estimation**

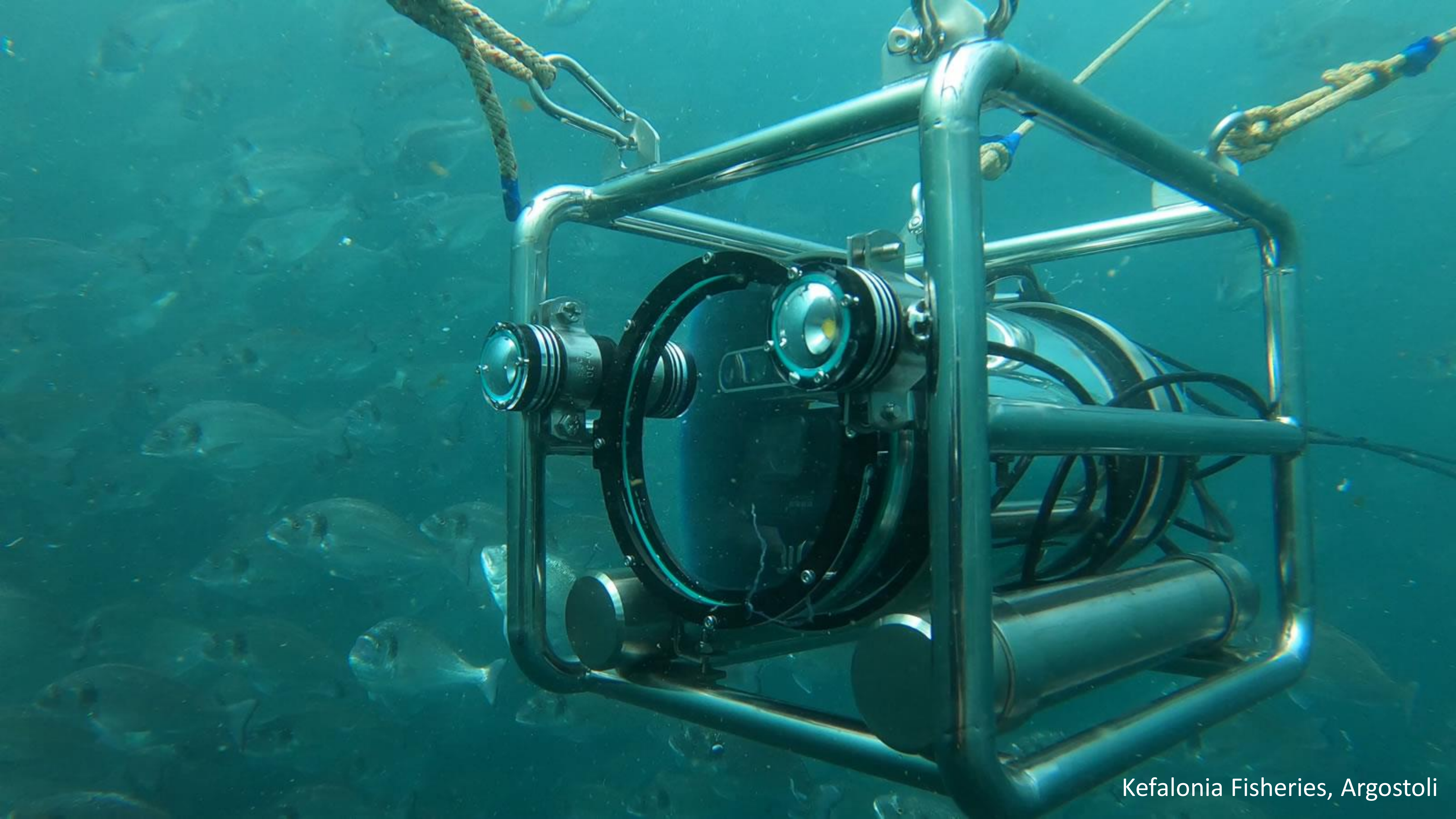


Depth data image | Infrared Image

The software starts taking measurements by clicking on two points in either the depth visualization window or the infrared one.

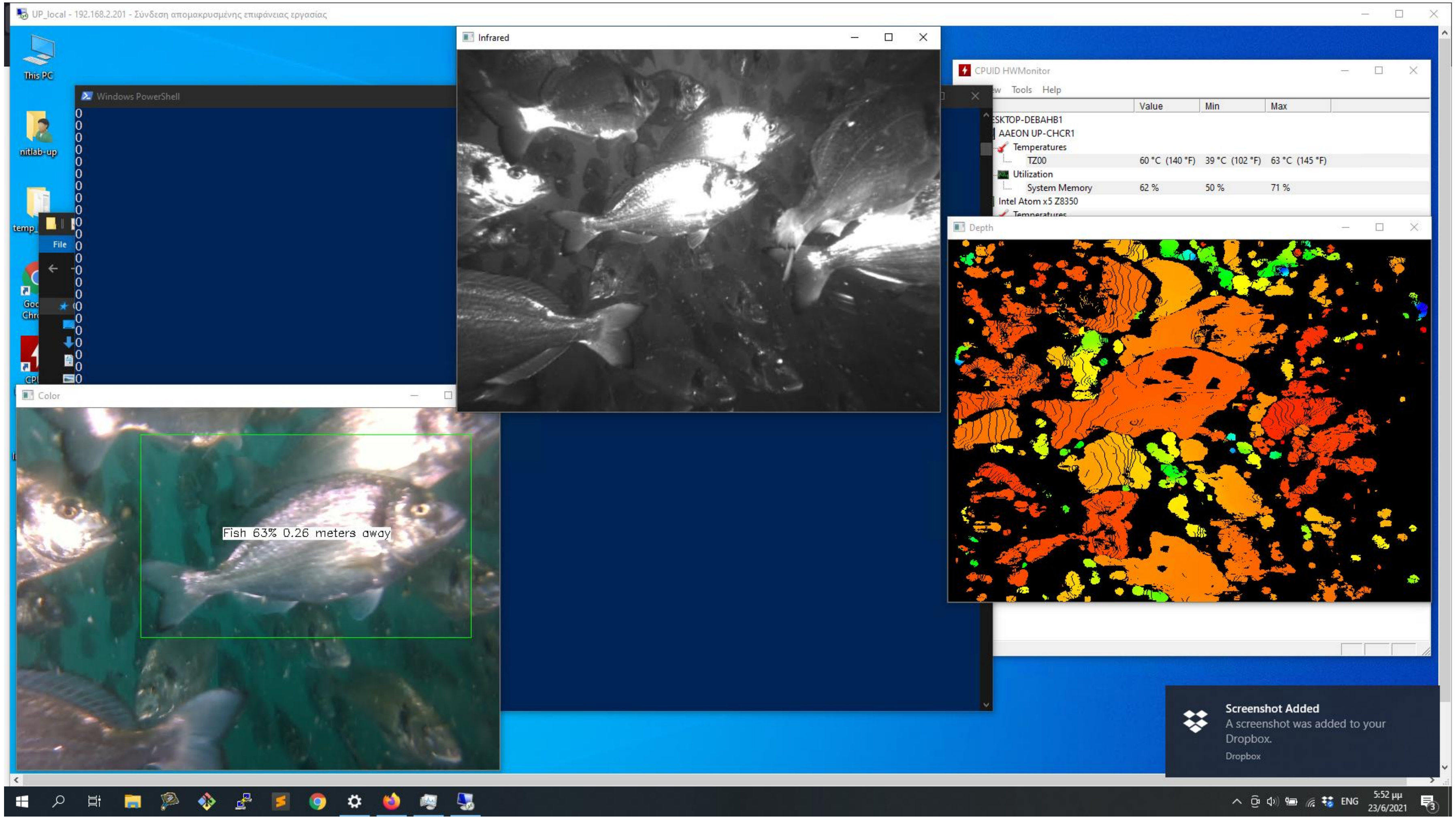
The result of this measurement, happening once per video stream frame, is visible in the top left window in the image.

➔ **The measurement error across multiple tests was 1% - 2% in the lab.**



Kefalonia Fisheries, Argostoli

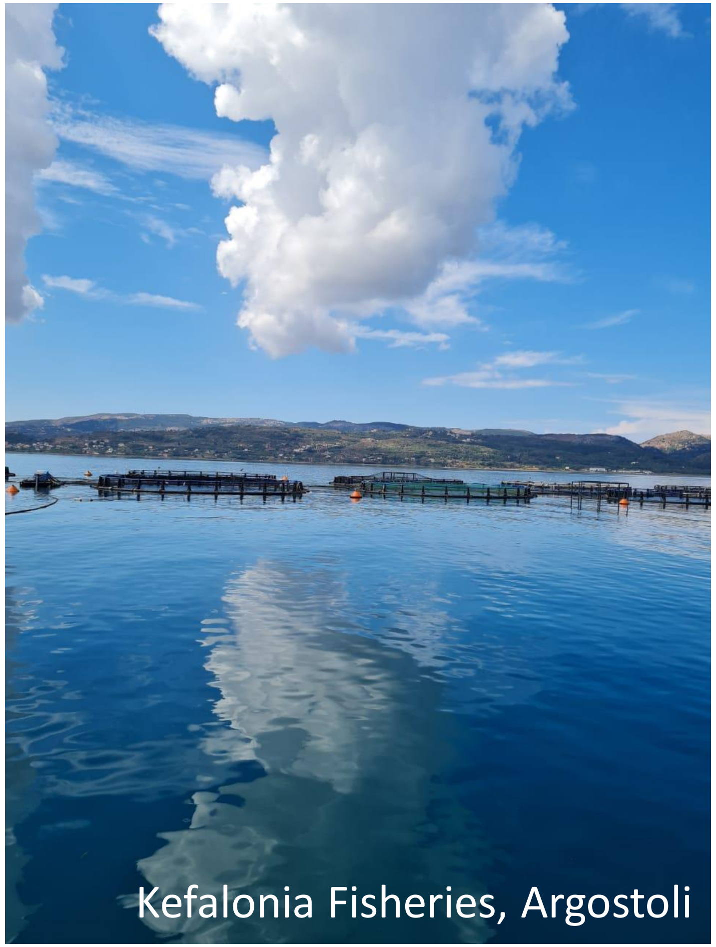
4.4. Study 2 – Real-time monitoring of environmental and physiological parameters



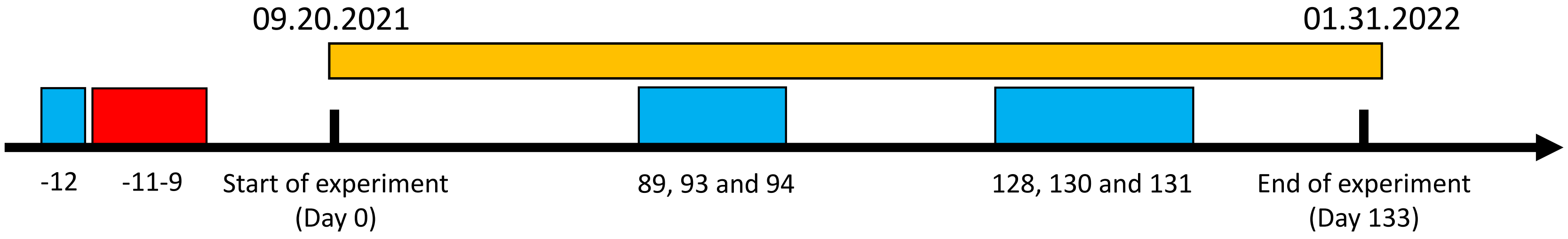
See final results in the deliverable D5.7 *(in preparation)*

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- Experimental protocol | **Trial**



KEFALONIA fisheries



- (blue) Morphometrics measurements → estimation of weigth gained per day
- (red) Implantations of physiological and environmental sensors
- (yellow) Monitoring period

FUTURE EUAQUA

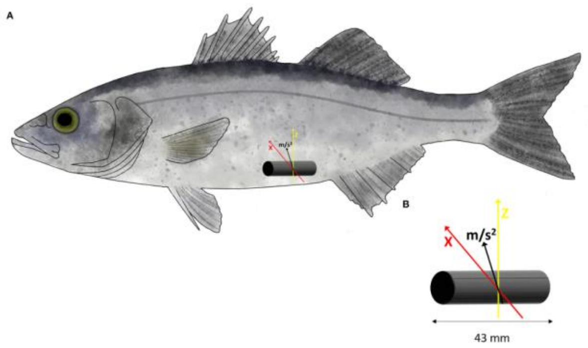
4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

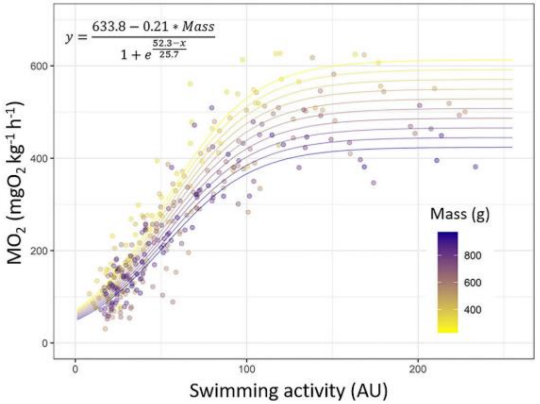
- **Physiological sensor | Implantation of accelerometer tag**






- **Physiological sensor| Monitoring energy expenditure**





- **Accelerometer tags**

Implantation in body cavity

Indicative of oxygen consumption rate (MO_2)

Proxy of energy expenditure

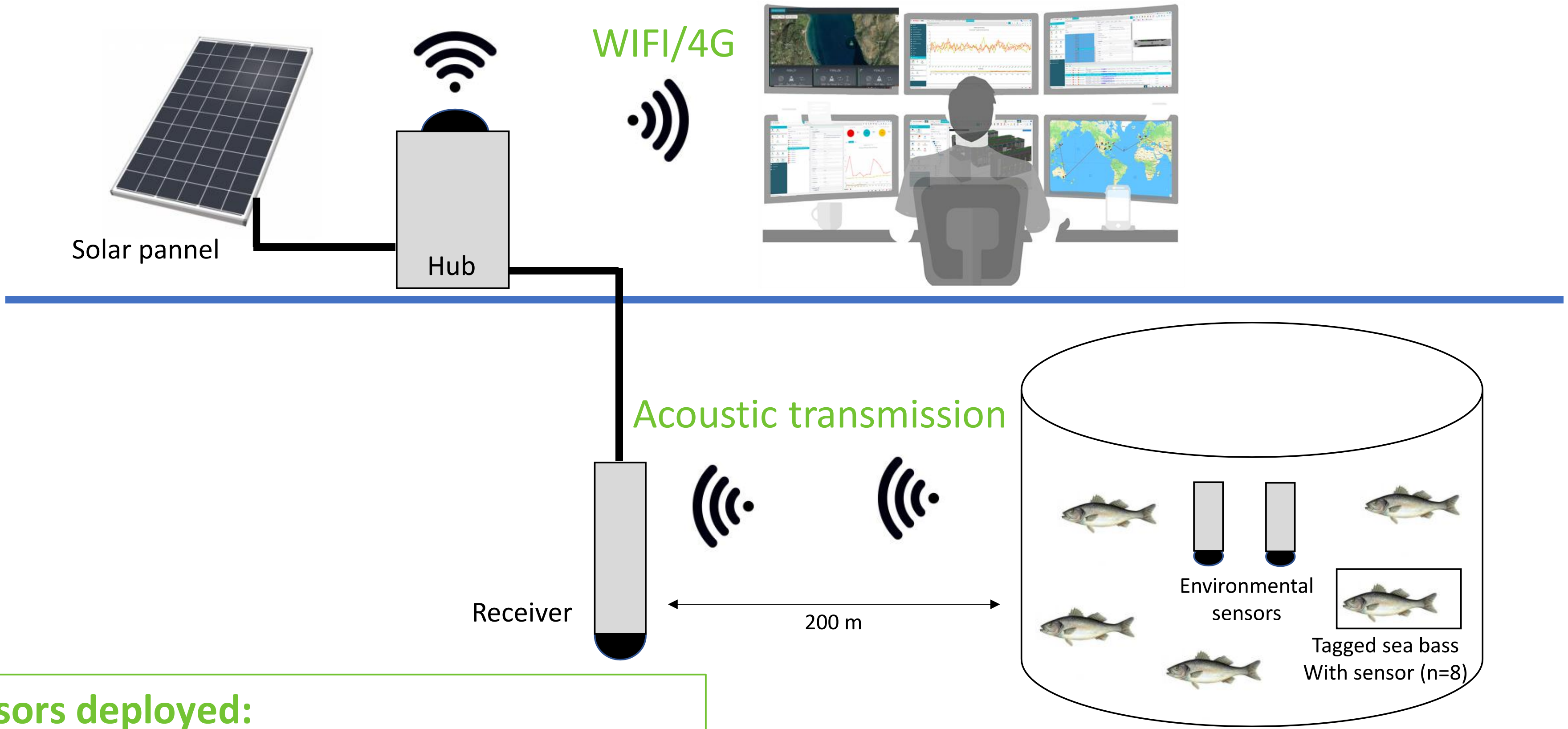
Measurements of depth

➔ Continuous monitoring over trial

FUTURE EUAQUA

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Implementation of environmental sensors | Connection of wireless sensor system**

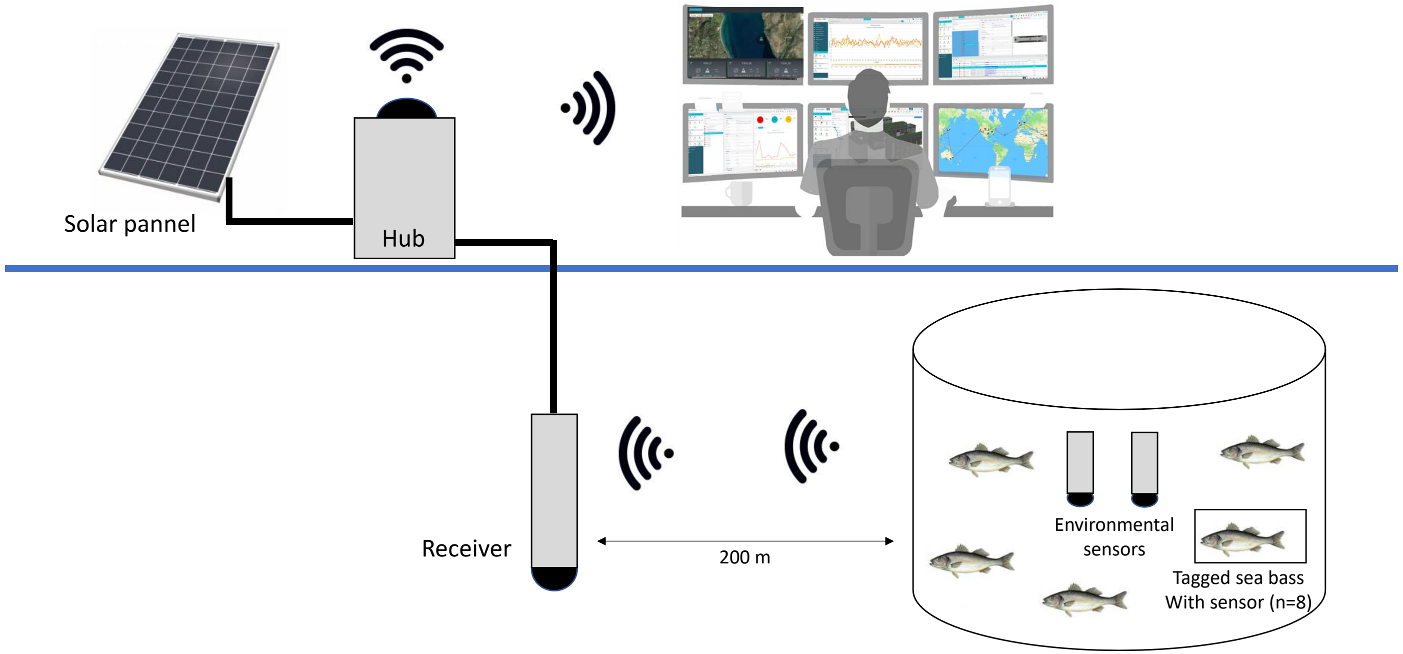


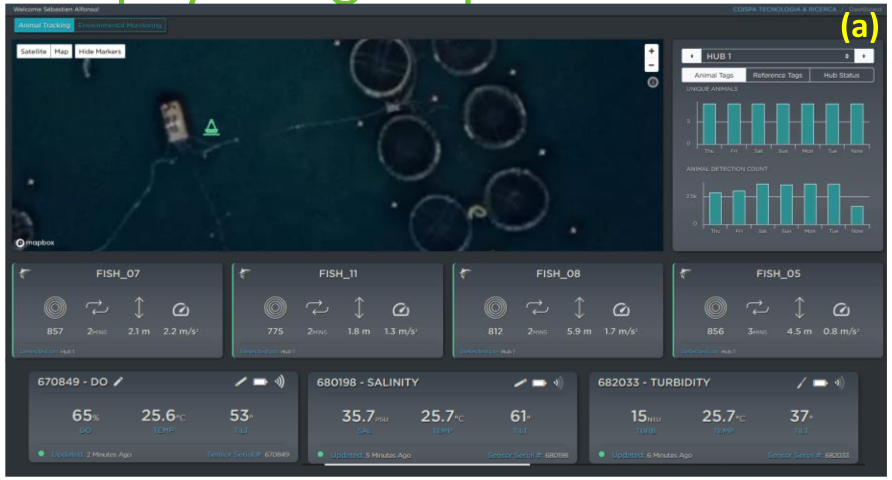
- **Sensors deployed:**

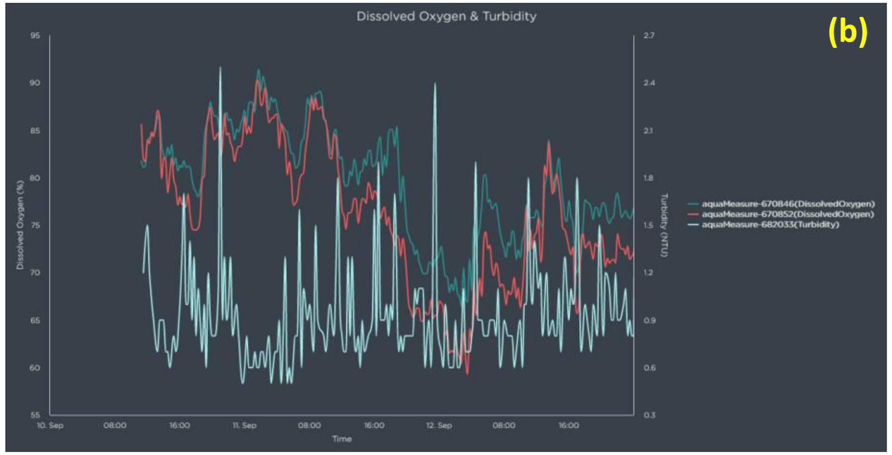
- Fish tagged with accelerometer tags (n = 8)
- DO and temperature sensors
- Salinity and turbidity sensors

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Data visualization in real time**





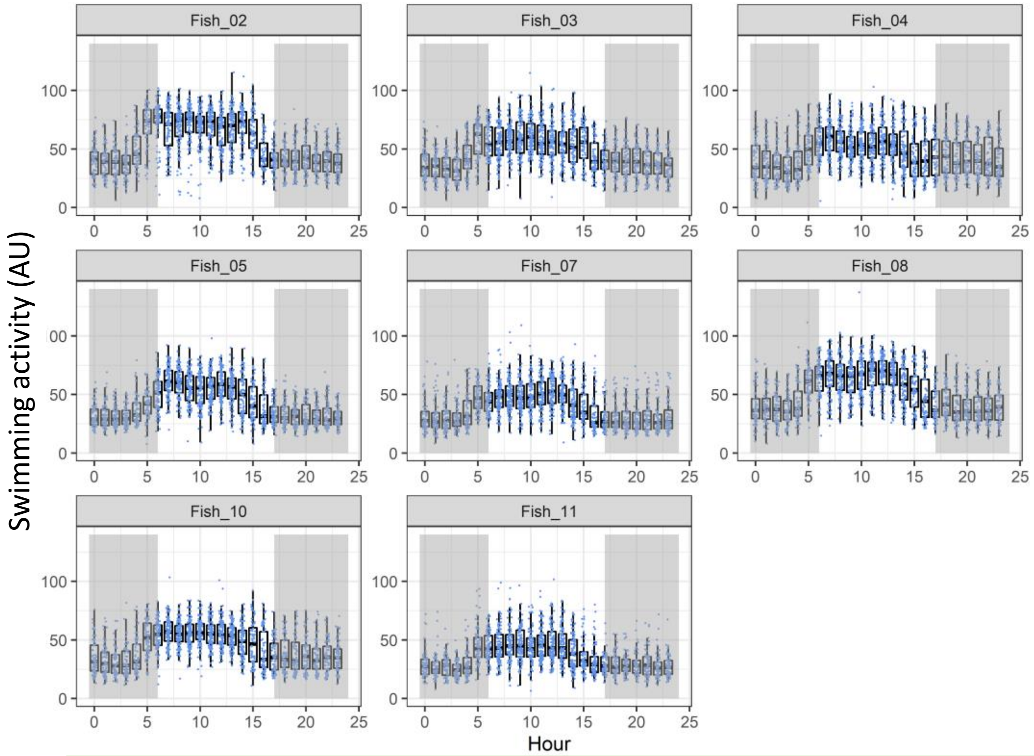


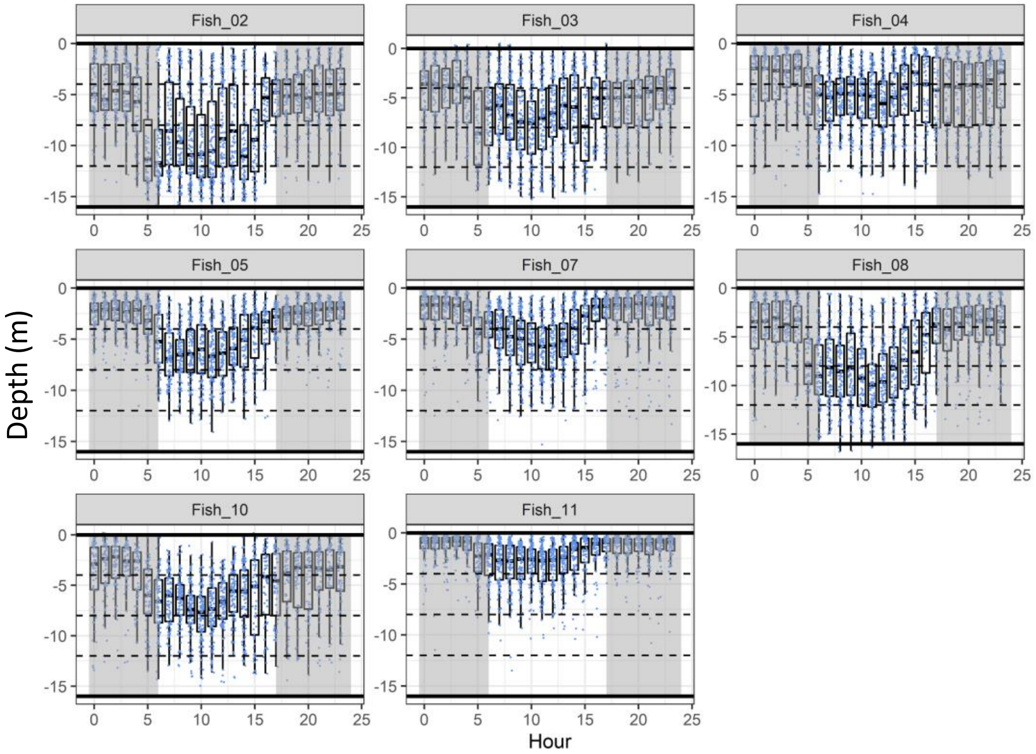
- **Sensors deployed:**

- Fish tagged with accelerometer tags (n = 8)
- DO and temperature sensors

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Physiological sensors data| Effect of daytime**





- **Conclusion:**
- Swimming activity and fish depth both follow diurnal pattern
- At day time, the swimming activity is greater and fish are located deeper than at night time

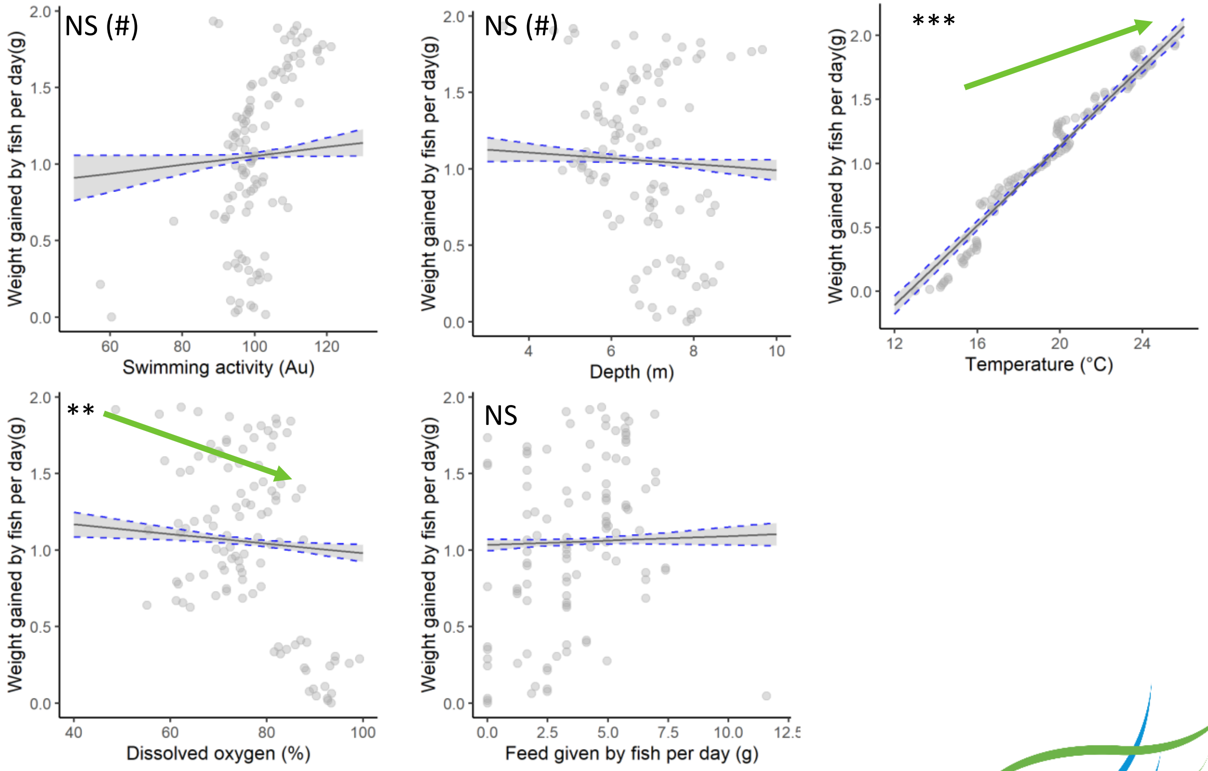
➔ Consistent with results found in previous work regarding behaviour of sea bass

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Modelling KPI| Growth performance**

Weight gained ~ Swimming activity + Depth + Temperature + DO + Feed given

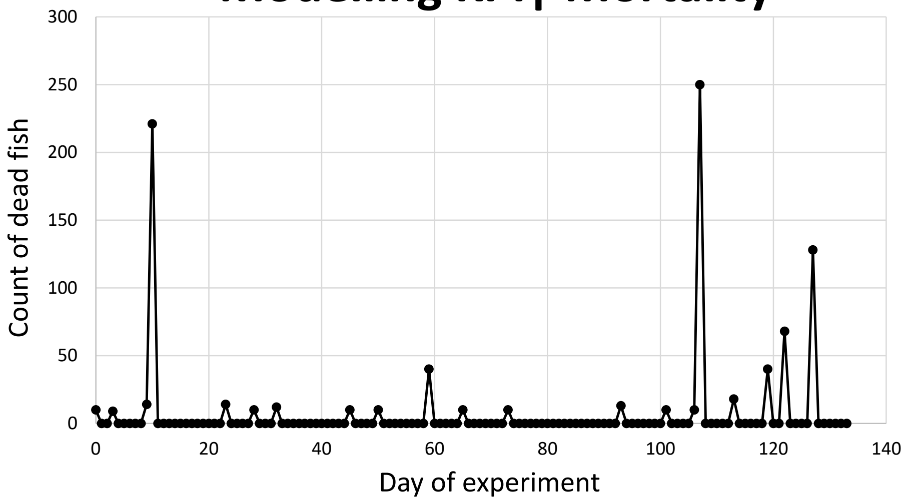
Fixed effects	Estimate	Std. error	P value
(Intercept)	-1.910304	0.124227	<0.001 (***)
Swimming activity	0.002888	0.001480	0.05373 (#)
Depth	-0.019231	0.010267	0.06397 (#)
Temperature	0.155274	0.004631	<0.001 (***)
Dissolved oxygen	-0.003138	0.001094	<0.001 (***)
Feed given	0.005800	0.004419	0.19237 (NS)



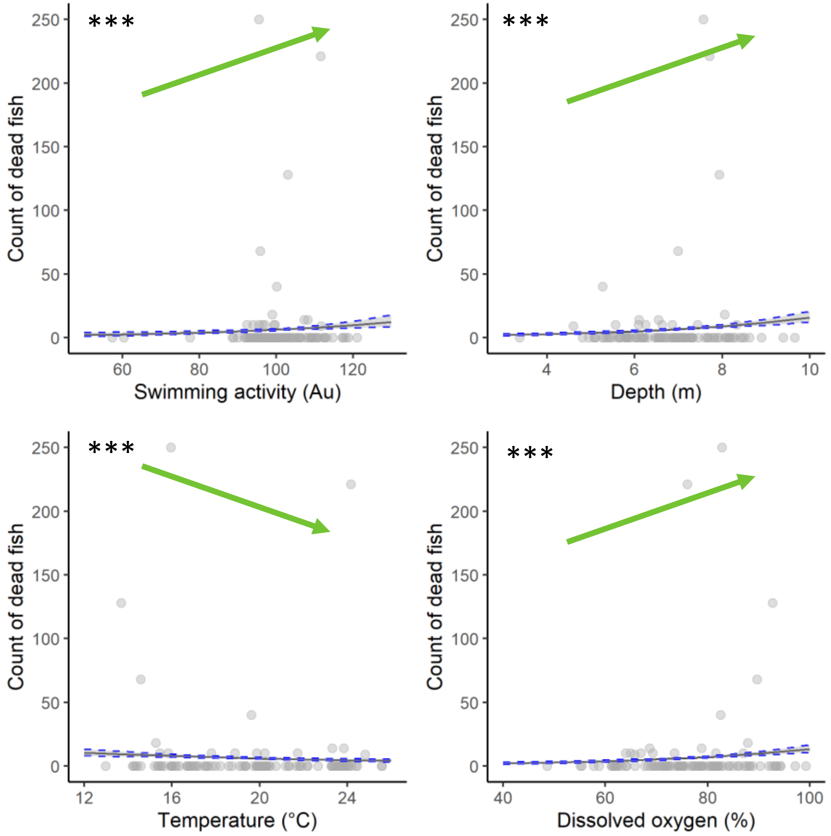
- **Conclusion:**
- Weight gained by fish is affected by temperature and DO
- Tendency for significant effects of swimming activity and depth (recorded using accelerometer tags)
- No effects of feed given

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Modelling KPI| Mortality**



Mortality ~ Swimming activity + Depth + Temperature + DO



Fixed effects	Estimate	Std. error	P value
(Intercept)	-3.551228	0.516575	<0.001 (***)
Swimming activity	0.023056	0.006318	<0.001 (***)
Depth	0.289137	0.041496	<0.001 (***)
Temperature	-0.067844	0.17736	<0.001 (***)
Dissolved oxygen	0.031898	0.004681	<0.001 (***)

- **Conclusion:**
- Mortality is affected by temperature and DO
- Mortality is affected by swimming activity and depth (recorded using accelerometer tags)

4.4. Study 2 – Real-time monitoring of environmental and physiological parameters

- **Conclusions from the study 2**

Take home messages:

- **Predicting growth performance and mortality** of sea bass using physiological and environment parameters of interest gathered by wireless sensors **is very promising for the future**.
- It is, however, important to note that models and predictions have **to be enhanced by including more parameters such as species, salinity, turbidity, water current, mass**.
- Including those parameters in a model would represent huge work, i.e., monitoring fish from key farmed species from the minimum size to be implanted with sensor to harvest, in different cages from the same location (to serve as replicates) and in different areas with different environmental conditions (e.g. temperature, DO, salinity, turbidity, water current) to improve the models and forecasts.

➔ After that futit would be possible to remotely asses health and welfare of fish in real-time based on the outure work, puts given by the physiological sensors implanted in sentinel fish calibrated with the environmental conditions and fish physiology, and adapt the management practices if necessary.

Summary

FUTURE EUAQUA

5. Conclusions and perspectives

A real-time wireless communication system

Water quality

Fish health & welfare

Growth performances

Environmental gains

Economic gains

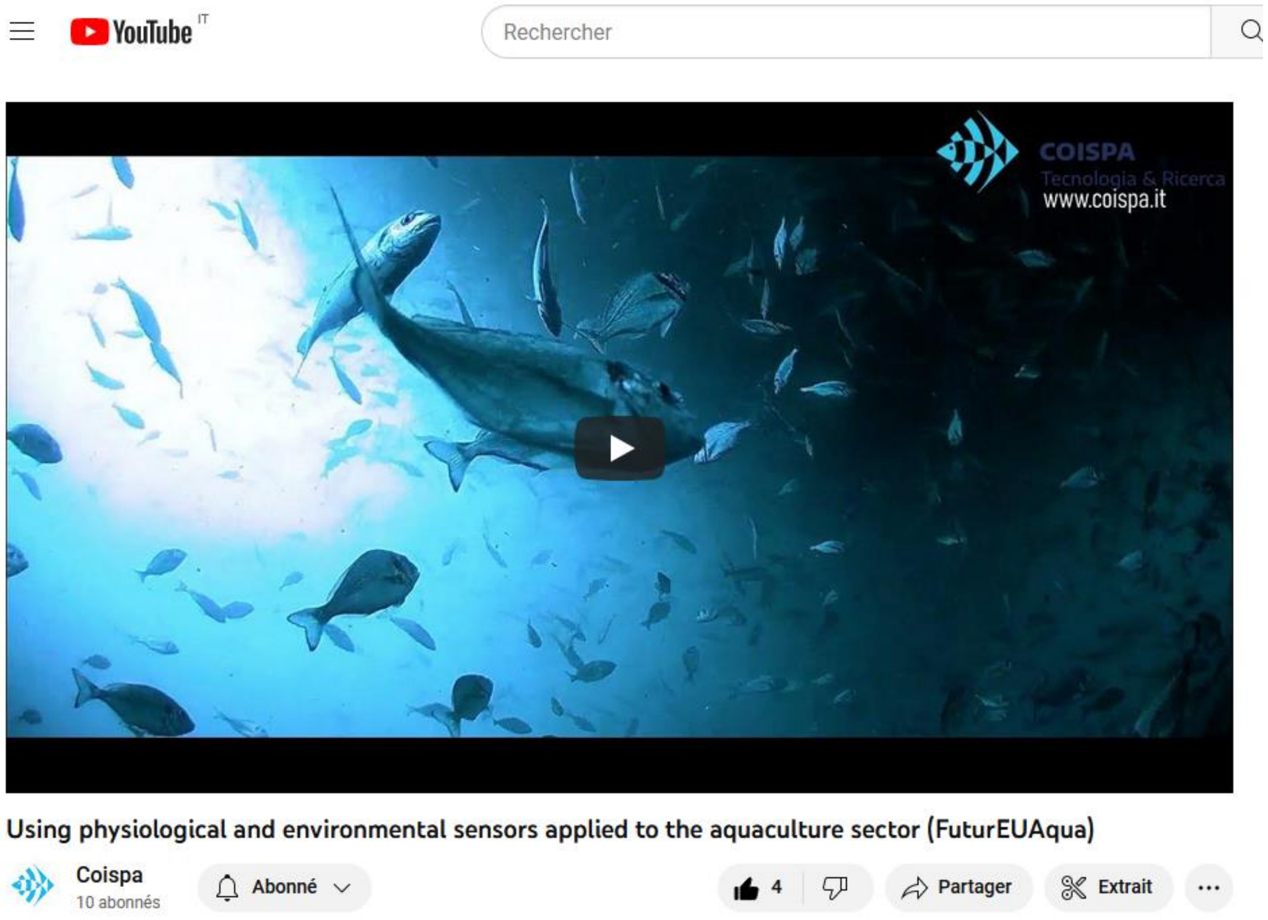
Take home messages

- **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."

5. Conclusions and perspectives

Video summarizing how work on physiological/environmental sensors in FutureEUAqua



https://www.youtube.com/watch?v=tZGZ9bRmwJ8&t=11s

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 (AVRAMAR / Kefalonia Fisheries SA)
- Coordination
  - Åsa Maria O. Espmark (Nofima) - Asa.Espmark@Nofima.no
- Organization
  - Stefan holler (Naturland) - S.Holler@naturland.de

FUTURE EUAQUA

Thanks for your attention, questions ?

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

COISPA Tecnologia & Ricerca