AQUA EXCEL 3.0
AQUAculture infrastructures for EXCELlence in European fish research 3.0

Deliverable 21.1

Analysis of access provided by Wageningen Research performance Infrastructure: types and users

Version 2

WP 21
Deliverable 21.1
Lead Beneficiary: WR
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Executive Summary

Objectives

WR offered one infrastructure which includes independent units for research on fish performance, all suited for long and short term experiments with new or established species in late-larval, juvenile or grow-out phase. Swim tunnels and a number of different independent tailor made RAS were used. The infrastructure was set to investigate fish performance at the level of swimming physiology, endurance, metabolism, oxygen consumption, activity monitoring, and heart rate monitoring. This combination of read-out parameters allows for a detailed analysis of physiological fish performance under different swimming conditions.

Main Results:

Three TNA projects were carried out at the WR facilities. In general, the TNAs investigated swimming performance and physiological response and adaptation to different swim speeds, related to production levels. Three fish species were used (European eel, European seabass, yellowtail kingfish), and each project had specific goals, protocols and tools that were used, such as heart rate sensors and/or activity monitoring. The TNA guests were trained to set-up the study, with objectives, background, associated protocol, and were trained in the use of the technologies during the study.
TNA's:
PID: 36176 – Swimming Performance and Heart Rate of Eels During Sexual Maturation. species used; European eel (*Anguilla anguilla*).
60 units of access; One person trained; Gökhan Tunçelli

PID: 29879 – Proof of concept demonstration of a novel electronic tagging and tracking tool in fish. Species used: yellowtail kingfish (*Seriola lalandi*)
44 units of access; two persons trained: Amund Skjellstad and Eirik Svendsen

PID: 23949 – Heart rate, acceleration, oxygen consumption and swimming behaviour of European seabass (*Dicentrarchus labrax*) during increasing exercise and stress loads.
54 units of access; one person trained: Joaquim Tomàs-Ferrer

Authors/Teams involved:

For WR, scientific supervision was done by Arjan Palstra and Wout Abbink. Additional supporting staff to facilitate the stay of the TNA guests was involved, as was staff at the animal facilities.

Wageningen Research (Nl): Arjan Palstra, Wout Abbink
NTNU/Sintef Ocean (No): Eirik Svendsen, Amund Skjellstad
IMEDEA-CSIC (Sp): Joaquim Tomàs-Ferrer, Pablo Arechavala Lopez
Istanbul University faculty of aquatic sciences (Tu); Devrim Memiş , Gökhan Tunçelli

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1. Overview of TNA users projects realized WR RAS - Fish Performance

1.1.1. Installation (short description of each installation in the local INFRA)

The infrastructure included independent units for research on fish performance, all suited for long and short term experiments with new or established species in late-larval, juvenile or grow-out phase; a swim carousel and swim tunnels, and a number of different independent RAS, with various options on the number and size of the tanks, depending on the proposition of the TNA user. All RAS are temperature controlled and suitable for fresh water and seawater, and equipped with mechanical and bio-filtration units. Filter modules can be exchanged to meet the specific needs of the end-user, such as UV-disinfection, ozone treatment, up-flow filtration, de-nitrification etc. The swim tunnels are tools to define optimal hydraulic conditions, and exercise physiology and swimming protocols. Oxygen consumption and activity monitoring were included. In addition, heart rate and acceleration sensors were implanted in the fish for detailed analysis of swimming physiology. The systems are suitable for both fresh and seawater, and fish in different stages of development (fingerlings, juvenile, grow-out) can be studied in short and long term studies.

The swim tunnel with sensor implanted seabass

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1.1.2. User projects

Min. quantity of access units to be provided according the DoA: 116 (160 was the initial number, but after revision it was decreased to 116)
Total number of access units (sum of access units in the table): 158

Installation number	Installation code	Project title	Project acronym	Description about the experiment	Host Coordinator and name of guest user	Already used installation (Yes/No)	Nature of the access unit*	Number of used access units during the project, and dates	(Potential) paper	How many people was trained by this procedure ?	Affiliation and country of guest institute
29	WR RAS-Fish performance	Swimming Performance and Heart Rate of Eels During Sexual Maturation	SILVEREELSWIM	Eels were implanted with a heart rate sensor and subjected to a swimming exercise experiment in swim tunnels	Wout Abbink (WR), and Gökhan Tunçelli	no	system week	60; 01/03/25 - 30/06/25	yes, but the TNA is still in progress during the writing of this report	1	Istanbul University, Turkey
29	WR RAS-Fish performance	Heart rate, acceleration, oxygen consumption and swimming behaviour of European seabass (*Dicentrarchus labrax*) during increasing exercise and stress loads	ACTIVEBASS	seabass were exposed to a swimming exercise experiment in swim tunnels	Wout Abbink (WR), and Joaquim Tomàs-Ferrer	no	system week	54; 04/09/23 – 12/10/23	yes, as part of the PhD of the TNA user, in preparation	1	CSIC, Spain
29	WR RAS-Fish performance	Proof of concept demonstration of a novel electronic tagging and tracking tool in fish	RACE TAG	yellowtail kingfish were implanted with a novel heart rate sensor that was developed and	Wout Abbink (WR), and Amund Skjellstad	no	system week	44; 02/09/24 – 04/10/24	yes, in preparation	1	Sintef Ocean, Norway

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				tested in salmon, and needed validation in a second species							

** Access units describe how accesses are calculated, typically 1 day x 1 pot, 1 season x 1 microplot, etc …*

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2. TNA projects

2.1.1. TNA projects description

PID: 36176 – Swimming Performance and Heart Rate of Eels During Sexual Maturation
Gökhan Tunçelli
Acronym: SILVEREELSWIM
European eels were implanted with a heart rate sensor, and subjected to a maturation protocol (not the scope of the TNA). During this 12 week period, the fish were exposed to a swimming exercise protocol three times, at week 1, week 6 and week 12. Respective control fish that did not have the sensor implanted were also used. During the swim trial, oxygen consumption was measured.
This TNA is still ongoing at the time of writing of this report. The first series of swimming trials (week 1) was successful. Fish were exposed to 0, 0.2, 0.4, 0.6 and 0.8 m/s for one hour at each speed. Further results are expected after the following two swimming exercises, and subsequent analyses of data.
The results will be published in a peer reviewed journal.

PID: 29879 – Proof of concept demonstration of a novel electronic tagging and tracking tool in fish
Eirik Svendsen and Amund Skjellstad
Acronym: RACE TAG
Yellowtail kingfish were implanted with a novel heart rate and activity sensor that was originally developed and tested in salmon, and needed validation in a second fish species from a different environment (warmer water) than salmon, and a different swimming behaviour (very active swimmer). After implantation surgery, the fish were allowed to recover for two weeks, after which the fish were exposed to an exercise swimming protocol of 0, 0.2, 0.4, 0.6, 0.8, 1.0 m/s for one hour per speed. Respective control fish that did not have the sensor implanted were also used. During the swim trial, oxygen consumption was measured, and swimming performance was monitored by video analyses.
The sensor appeared to function well in the novel species. There was no mortality and the read-out was good. Detailed analyses are still ongoing, but the functioning of the sensor is as good as it is in salmon.
The results will be published in a peer reviewed journal.

PID: 23949 – Heart rate, acceleration, oxygen consumption and swimming behaviour of European seabass (*Dicentrarchus labrax*) during increasing exercise and stress loads
Joaquim Tomàs-Ferrer
Acronym: ACTIVEBASS
European seabass were implanted with a heart rate sensor and subjected to a exercise swimming protocol. Fish were subjected to 0, 0.2, 0.4, 0.6, 0.8 and 1.0 m/s for one hour at each speed. In addition, after the swim trials, the fish were exposed to a standardized stress challenge to monitor acceleration and heart rate.
During the swim trial, oxygen consumption was measured, and swimming performance was monitored by video analyses. Heart rate and acceleration was recorded by the sensor. The results showed that the sensor functioned well in the seabass, and that for instance there was a strong significant relation between activity and heart rate, pointing to successful recording of the heart rate and acceleration of the sensor in the fish. Further results are given below (2.1.2)
The results will be published in a peer reviewed journal

2.1.2. Selection of One exemplary project

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PID: 23949 – Heart rate, acceleration, oxygen consumption and swimming behaviour of European seabass (*Dicentrarchus labrax*) during increasing exercise and stress loads

The aim of this study was to provide a comprehensive understanding of the evaluation of welfare states of European sea bass by assessing the behavioural and physiological response through implanted bio-loggers at increasing swimming speeds and during a stress challenge tests.

During the swimming challenge tests, the findings reveal a significant positive correlation of oxygen consumption with heart rate (R^2 = 0.56, $p < 0.001$) and with acceleration (R^2 = 0.76, $p < 0.001$). In addition, acceleration values recorded by the bio-loggers were strongly correlated with head and tail beat frequency (R^2 = 0.69 and R^2 = 0.70 respectively; $p < 0.001$), thereby validating heart rate and acceleration as reliable proxies for energy expenditure in seabass. During the stress challenge tests, heart rate increased progressively with each subsequent stressing event, whereas QRS-wave amplitude and acceleration peaked with stress but decreased in-between stress induction steps. Data obtained in this study enabled the assessment of physiological and behavioural responses of European seabass subjected to swim and stress challenge tests, as well as the characterization of four welfare individual states based on those seabass responses. The findings of this study highlight the potential value and validated the use of bio-loggers as a tool for monitoring fish welfare.

One of the seabass with the sensor implanted, two weeks after surgery.

3. Reflection on results of the TNA programme

As WR, we are positive about the TNAs that we have done during AQUAEXCEL, AQUAEXCEL^{2020}, and AQUAEXCEL3.0. We have acquired new knowledge, have established new scientific relationships with individuals and knowledge institutes. We have received enthusiastic guests from many countries with different backgrounds.
For further access programmes, limiting overhead and administrative burden should stay a focus point, although we realise that this is also a necessary aspect of TNA programs.

4. References

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Work Participants				

Lead Beneficiary	WR
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06.05.2025		Wout Abbink	Third revision
06.05.2025		Marc Vandeputte	Changes accepted

[1]Dissemination level (DELETE ACCORDINGLY): **PU:** Public, **CO:** Confidential, only for members of the consortium (including the Commission Services), set out in Model Grant Agreement, **CL:** Classified, information as referred to in Commission Decision 2001/844/EC

[2] Nature of deliverable (DELETE ACCORDINGLY): **R:** Report, **DEM:** Demonstration, pilot, prototype, plan design, **DEC:** Website, patent filing, market studies, press & media, videos, **Other:** Software, technical diagram, etc., **Ethics:** Ethics deliverable

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