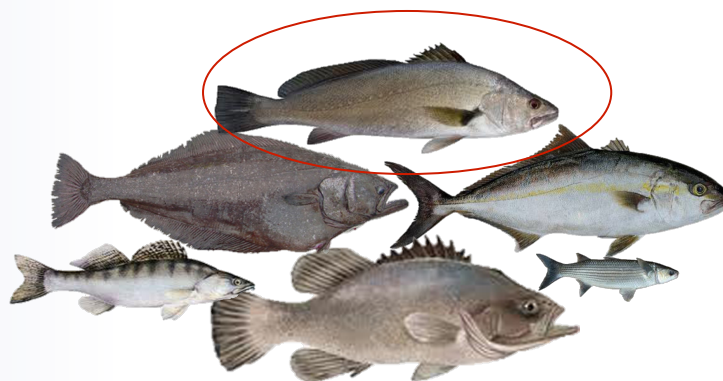


# WP 20: Grow out Husbandry Meagre

The study of feeding behavior of meagre to develop rearing technologies.

**Ioannis Papadakis**, Hellenic Centre for Marine Research, Greece (HCMR)

**Neil Duncan**, Institut de Recerca I Tecnologia Agroalimentaries, Spain (IRTA)



**To acquire the necessary information for the development of appropriate feeding methodologies for cage culture of meagre, in order to maximize the performance.**

- **Feeding behavior.**
- **Specific biological rhythms.**

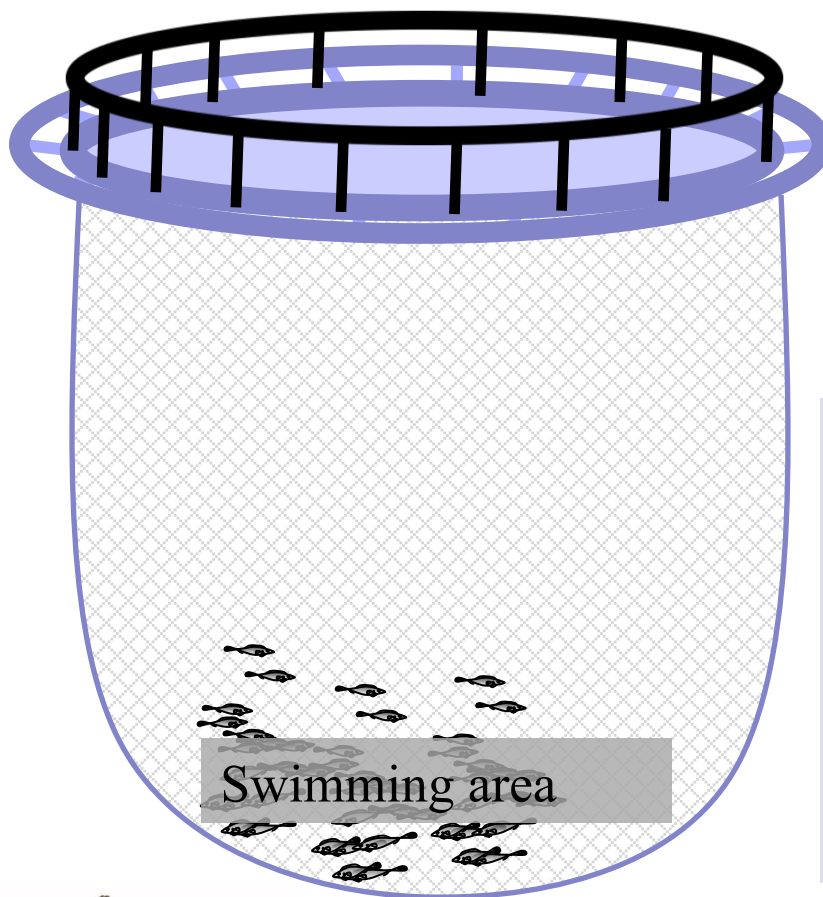
**The above information have to be harmonized with the rearing- feeding methodologies used.**



- 1. The effect of different stimuli on meagre feeding behavior (HCMR).**
- 2. Comparison of programmed and auto-demand type feeding in tanks (IRTA).**
- 3. Test of different feeding methods on growth performance and feeding behavior of meagre (HCMR).**



# 1. The effect of different stimuli on meagre feeding behavior (Introduction)



**In nature meagre inhabit areas close to the sea bottom.**

**Related to:**

- **Mouth position.**
- **Slow swimming activity.**
- **Visual system (2D vision).**

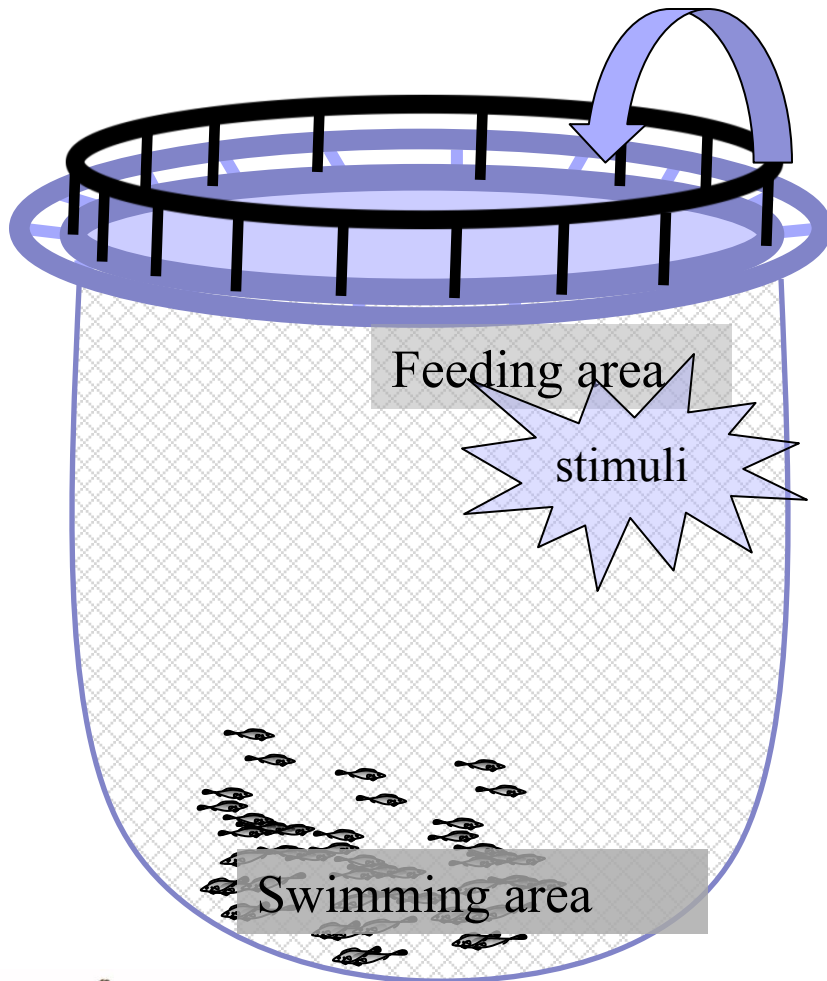
**In farming cages fish express the same behavioral pattern inhabiting the lower section of the cage.**

**Modification by:**

- **Light conditions**
- **Availability of food**



# 1. The effect of different stimuli on meagre feeding behavior (Introduction)



## Objectives

Develop a feeding method for cage farming, attracting the population to a **specific feeding area**, where management will be more effective.

The methodology is based on three steps:

1. “**Stimulus**” for the feeding time
2. “**Attraction**” to the feeding area
3. Actual “**Feeding**”



# 1. The effect of different stimuli on meagre feeding behavior (Materials and methods)

**The stimuli used rely on  
*vision and mechanoreception.***

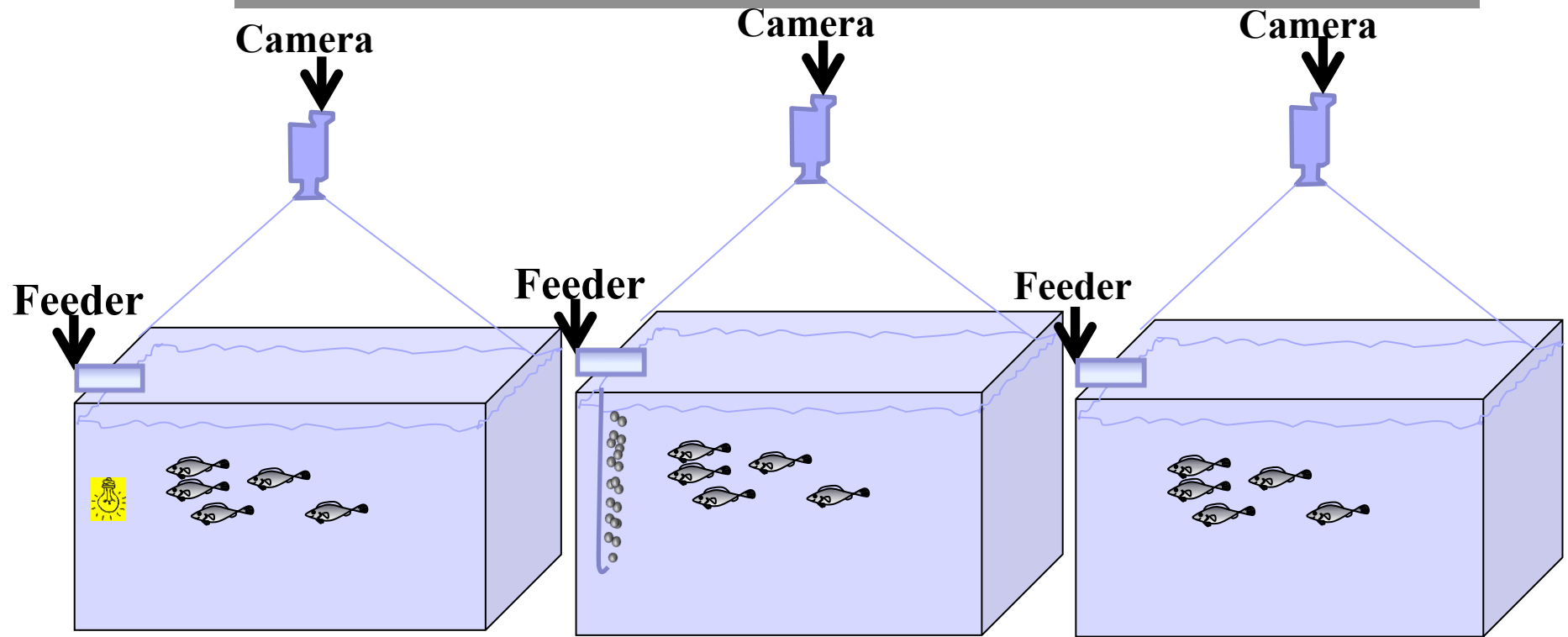
## Stimuli

## Sensory system

- **Light (fading)** → **Vision**
- **Air bubbles** → **Mechanoreception and vision**

**The effect of stimuli on feeding behavior of meagre in natural light conditions.**





**Light**  
❖ light in the water column.

**Bubbles**  
❖ air bubbles in the water column.

**Control**  
Feeding without stimuli.

**Experimental conditions:**

- a) 5 m<sup>3</sup> outdoor tanks
- b) Initial fish weight (636 ± 56g)
- c) 10 individuals in each tank



# 1. The effect of different stimuli on meagre feeding behavior (Materials and methods)

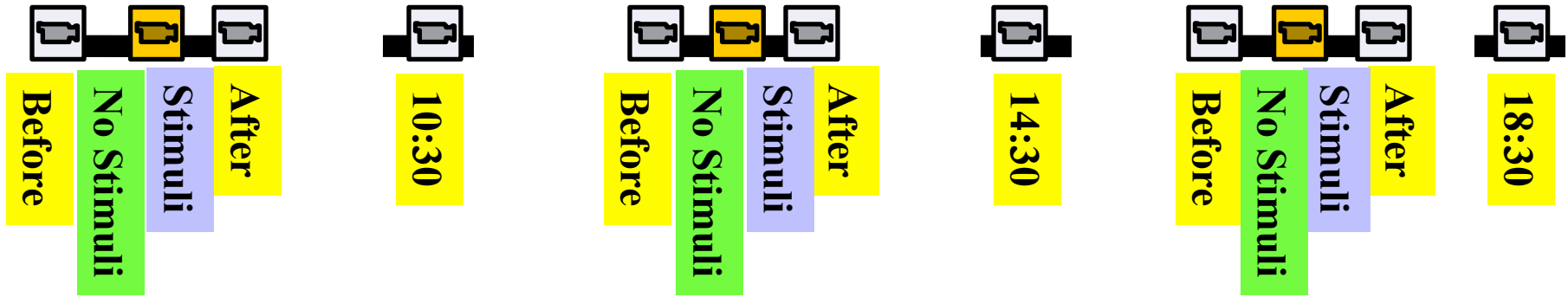
Schematic representation of recording periods during the day and analysis of stimuli

Day length

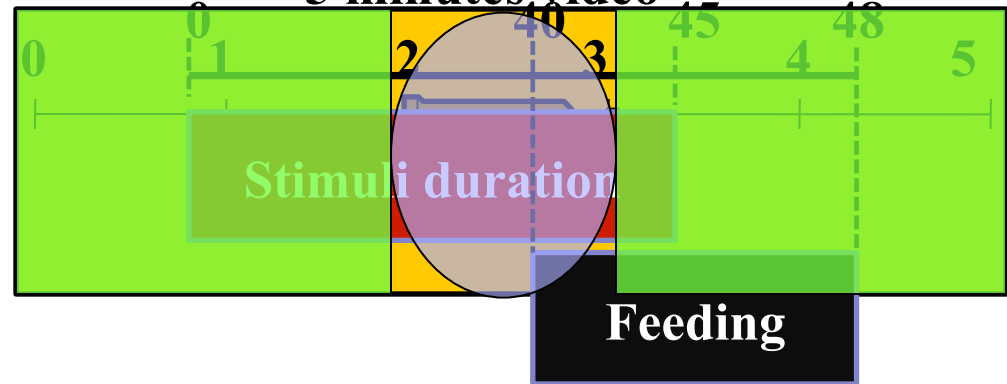
07:30

12:30

18:30



Time (sec)  
5 minutes video



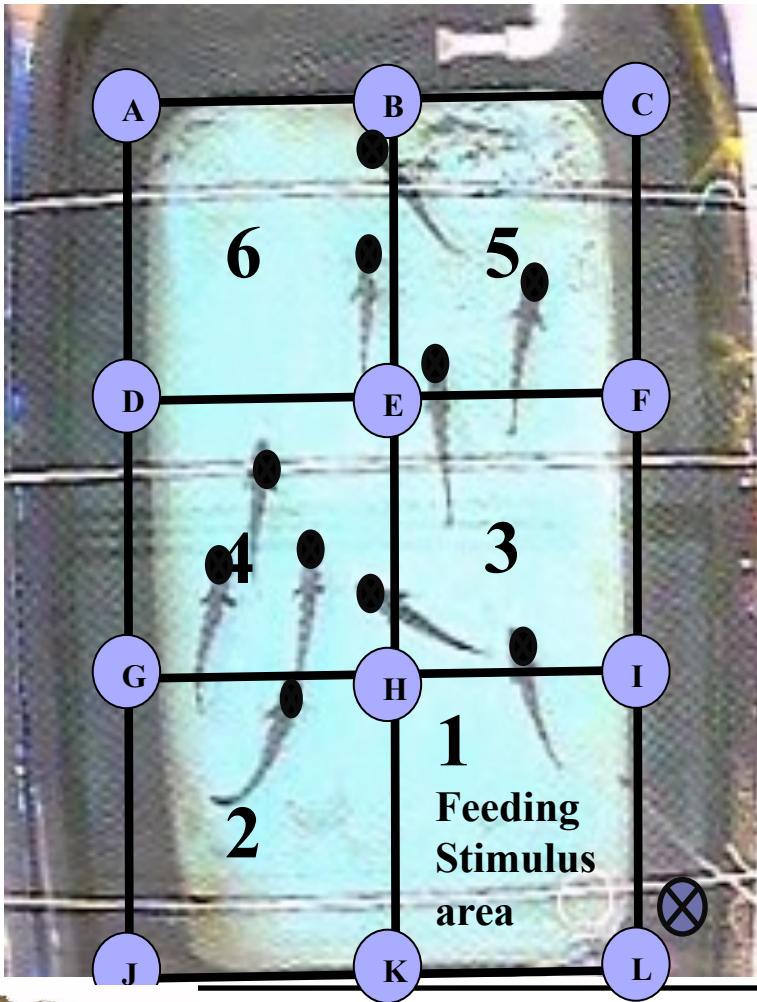
- Feeding time
- Recording periods
- 5 minutes video
- 5 minutes video stimuli + feeding





# 1. The effect of different stimuli on meagre feeding behavior (Materials and methods)

## Analysis with Image j



Number of area	Number of fish in Each area	% distribution of the fish in each area
1	0	0 %
2	1	10 %
3	1	10 %
4	4	40 %
5	2	20 %
6	2	20 %



Place of feeder and stimuli

● Place of head of the fish

# 1. The effect of different stimuli on meagre feeding behavior

## Results- periods without stimuli

(3) 10:30



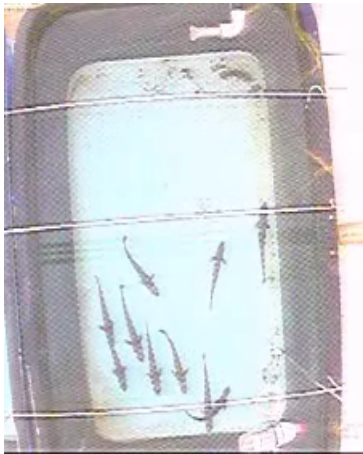
(4) 12:30 (noon)



(5) 15:30



(1) 07:30 (morning)



(2) 18:30 (afternoon)



❖ **Light conditions affect the behavior of meagre.**

➤ **Meagre during the morning and the afternoon (low light intensity) moved continually and were distributed in all the areas of the tank.**

➤ **During the other periods of the day (high light intensity), they prefer to inhabit the dusky areas of the tank.**

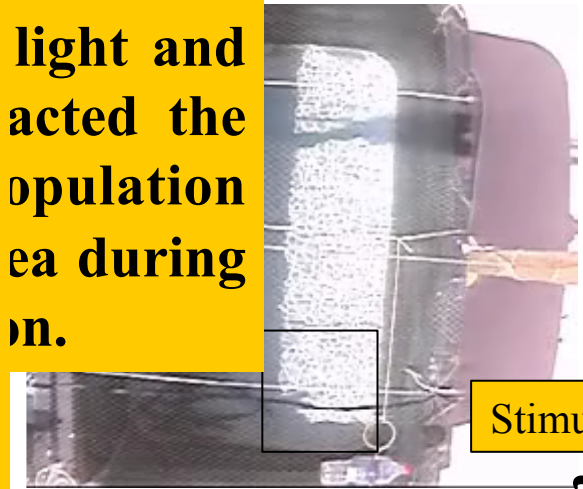


Time (hours)



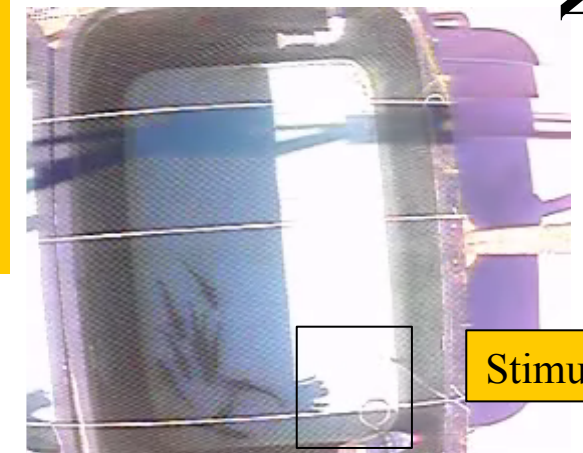
Sun light intensity &gt; 1,000 lux

Sun light intensity &lt; 30,000 lux

**Light stimulus****Light stimulus****Stimuli**

➤ The stimulus of air light and bubbles attracted the experimental population to the feeding area during its implementation, more than the light.

➤ The sun light intensity overlapped the light stimulus intensity and the stimulus became not visible.

**Air bubbles stimulus****Stimuli****Air bubbles stimulus****Stimuli****Morning and afternoon****Noon**

- Light conditions affect the behavior of meagre.
- Meagre without direct sunlight (morning and afternoon) present higher motility than during direct exposure (noon).
- During noon (direct sun light exposure) fish prefer to inhabit dusky areas of the tank.
- Meagre is able to learn and remember specific stimuli that are associated with feeding.
- Meagre responded to air bubbles very quickly (from the second day of application).
- Meagre responded to the light stimulus only without direct sunlight. **Inability to see the stimulus**
- Both air bubbles and light or combinations of them can be used in an industrial setting, as they can be manufactured, implemented and managed easily with existing technologies in sea cages.



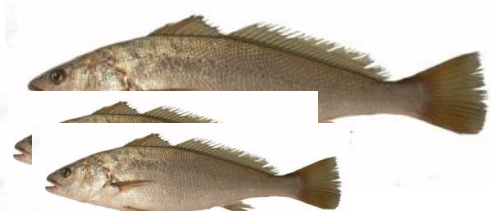
- **The effect of different stimuli on meagre feeding behavior (HCMR).**
- **Comparison of programmed and auto-demand type feeding in tanks (IRTA).**
- **Test of different feeding methods on growth performance and feeding behavior of meagre (HCMR).**

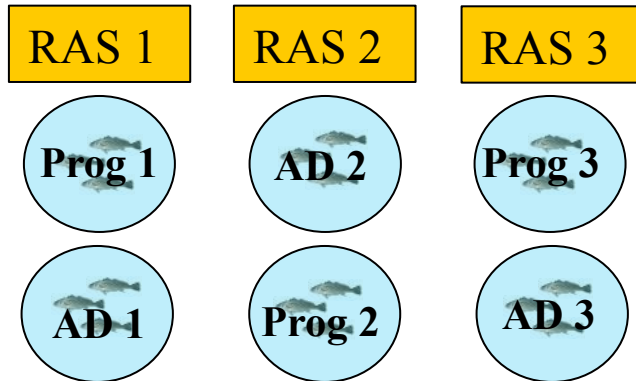


### Objective:

**To compare programmed automatic feeding with auto-demand feeding in tanks.**

**The conditions that were used simulated the cage rearing conditions (temperature and photoperiod) and programmed automated feeding followed the cage feeding practices.**





### Recirculation system (RAS)

Started 4th October 2016 → 6th September 2017

Fish 50g at start, all fish trained to auto-demand  
200 → 75 fish per tank

Natural photoperiod

Simulated cage culture temperature

### Programmed feeding (Prog) –

- Feeding rate from feeding tables
- Program similar to cage feeding periods
- 50-100g = 3 x 1 hour feeding periods
- 100-300g = 2 x 1 hour feeding periods

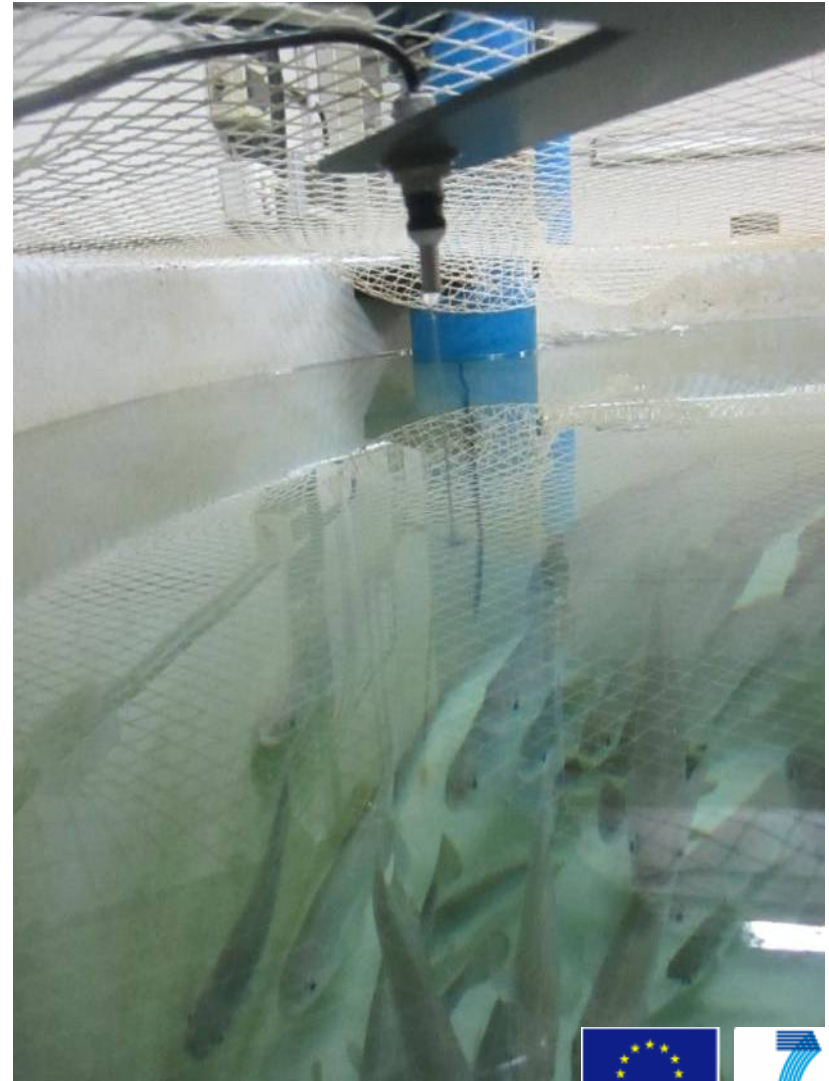
### Auto-demand (AD) feeding –

- Pendulum to demand feed
- 5g feed per demand
- Register of time of demand



**Methods**

**Auto-demand or self-feeding systems**



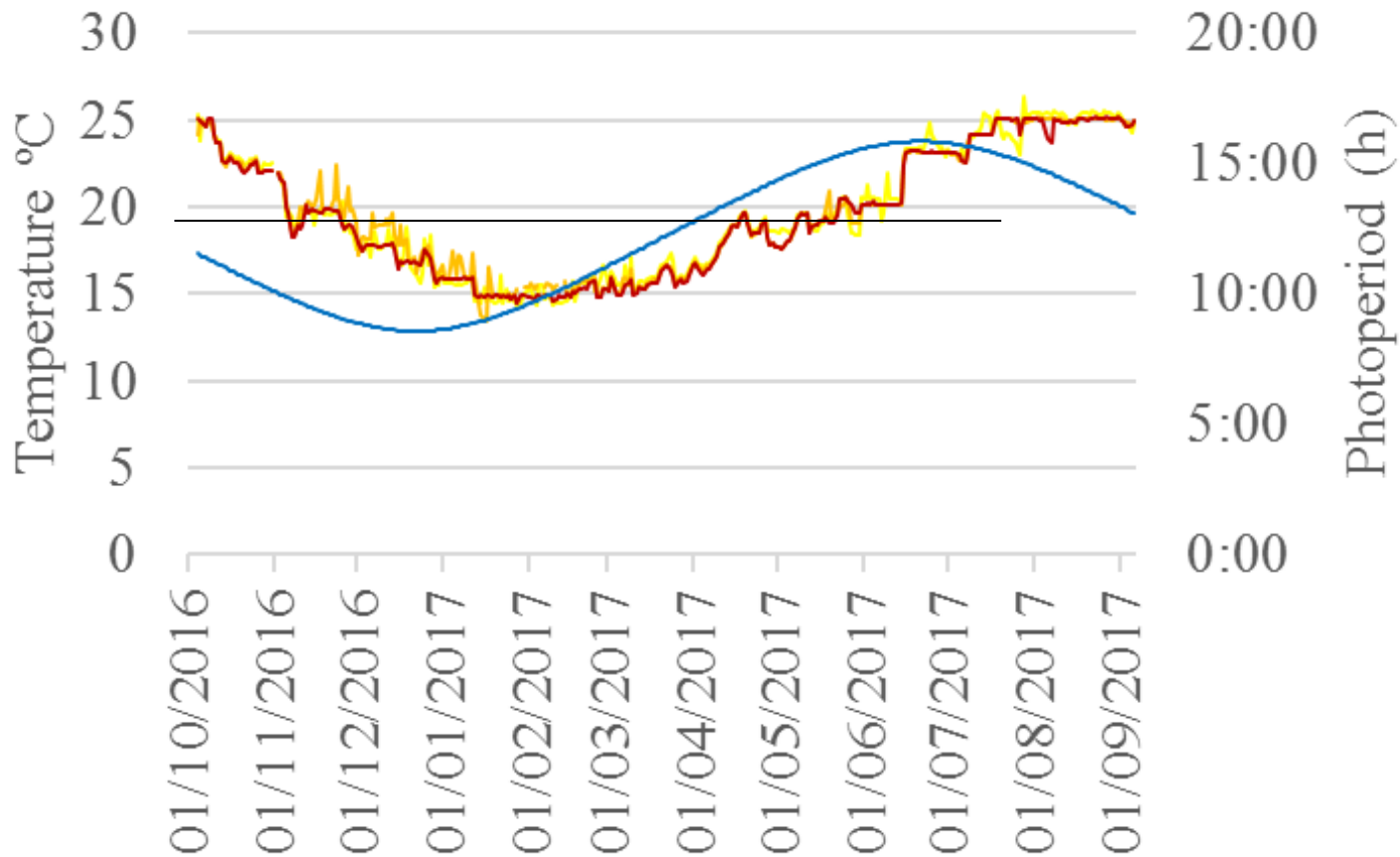


### Data registered

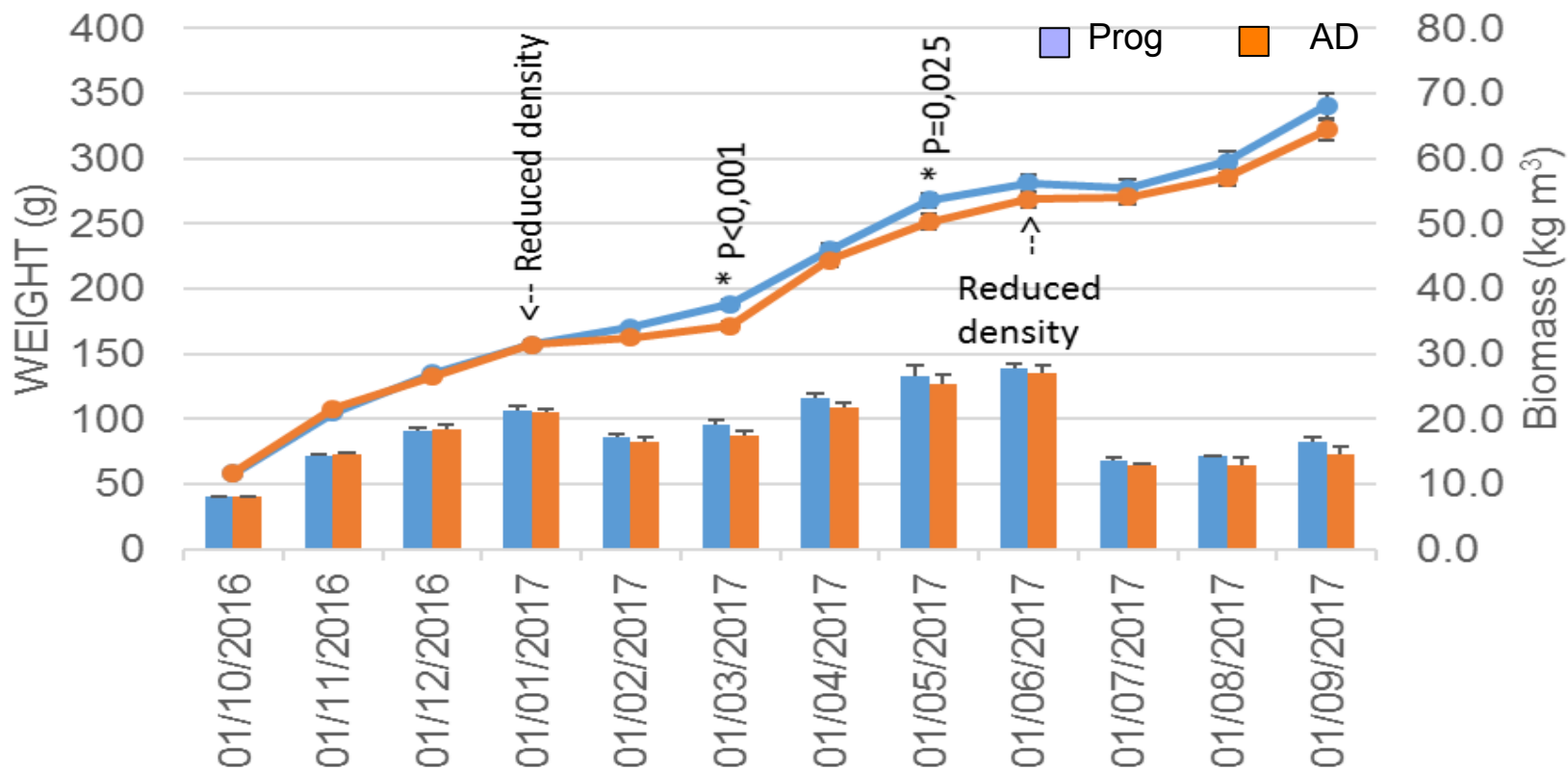
- **Activity with two movement sensors**
  - **Upper 20 cm below the surface**
  - **Bottom 80 cm from surface (20 cm from bottom)**
- **Growth**
- **Size frequency in population**
- **Fin condition**
- **Feed conversion ratio**
- **Timing of demand feeding – feeding pattern**



### Environmental conditions



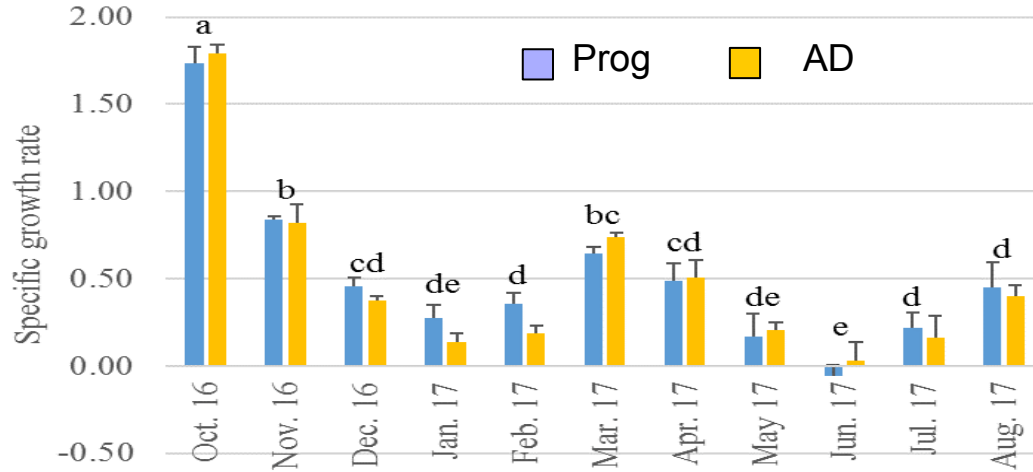
### Growth performance



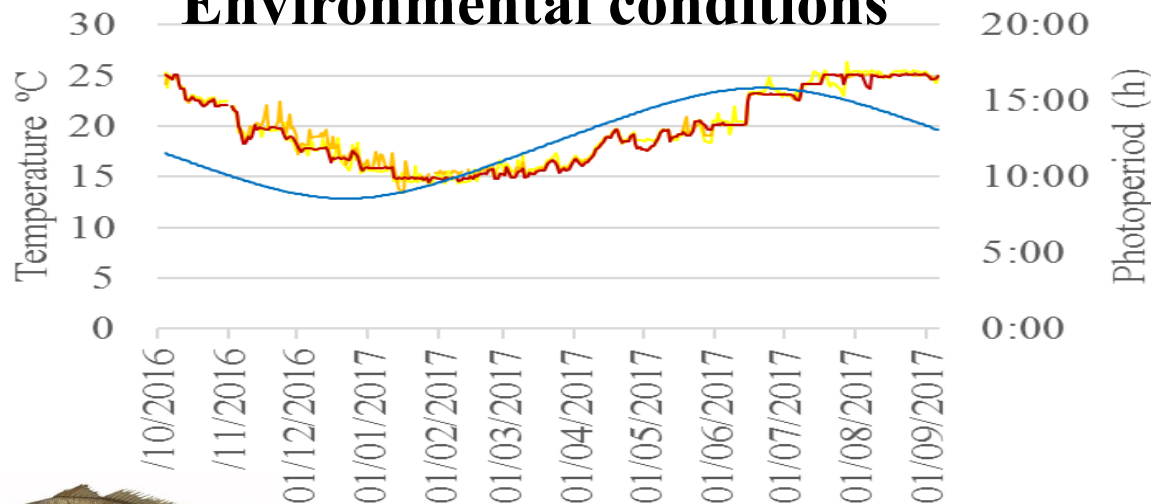
❖ Growth between the two feeding methods was similar.



### Specific growth rate



### Environmental conditions

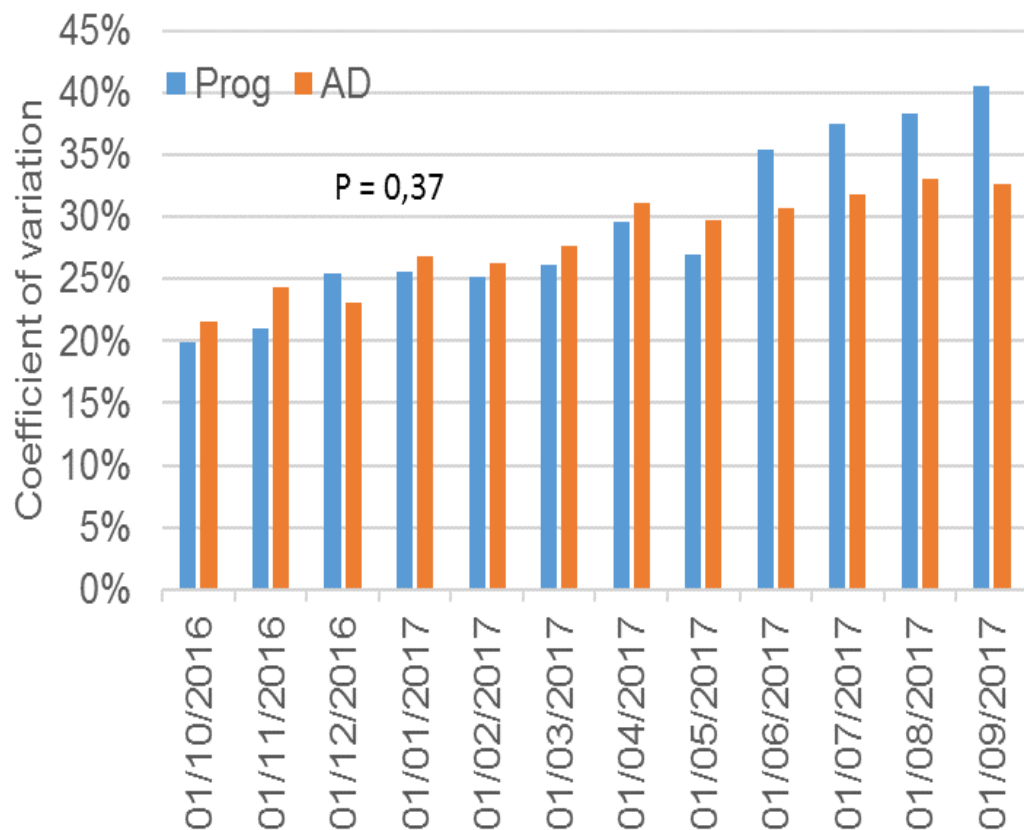


- ❖ There were no significant differences in specific growth rate (SGR) between fish fed with the two feeding systems
- ❖ The growth of the fish in the two feeding systems exhibited a similar pattern over the year.
- ❖ The SGR was affected from the Temperature – Size.



### Growth – Size variation - Coefficient of variation (CV)

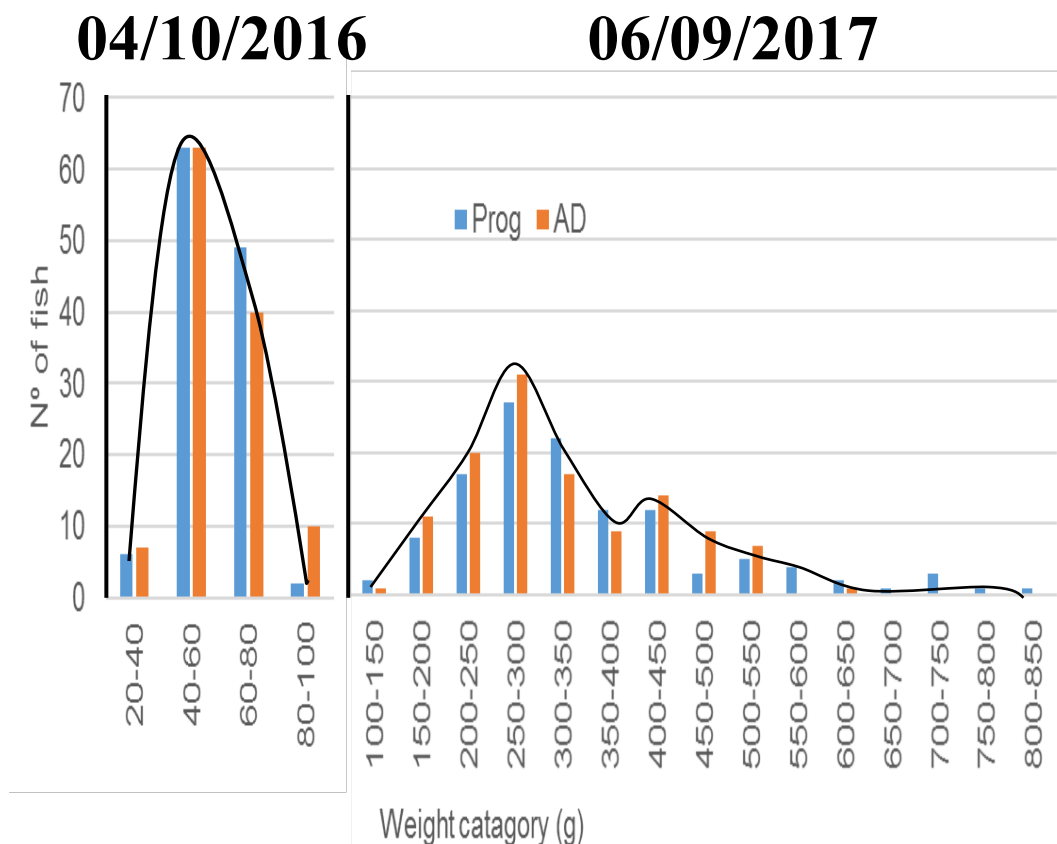
The extent of variability in relation to the mean of the population



❖ The size distributions and coefficient of variation were similar between the fish populations fed with the two feeding systems, programmed and auto-demand



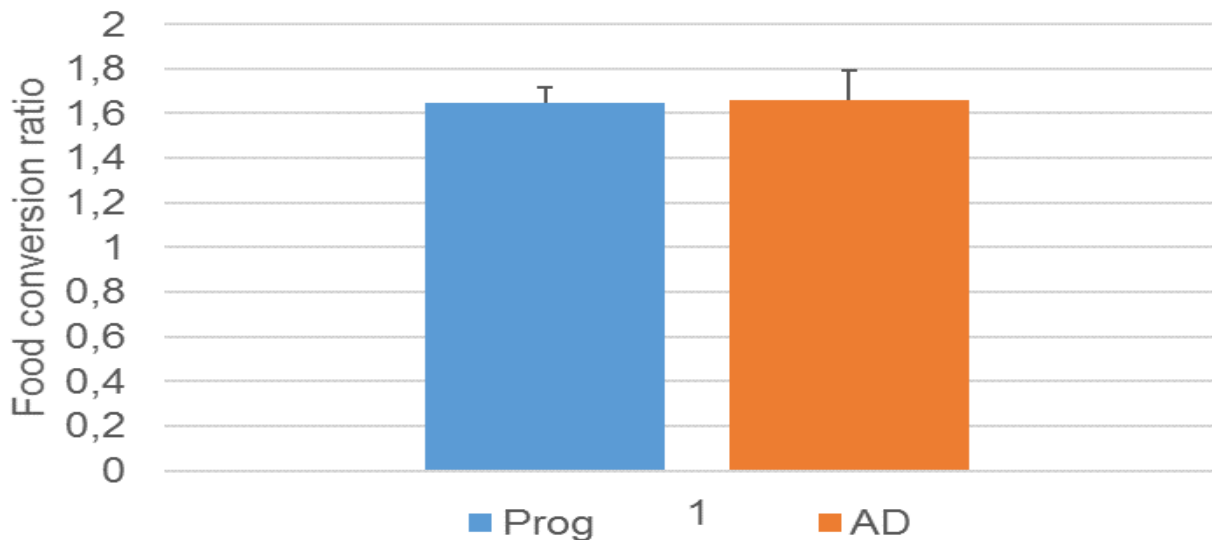
**Size variation: Number of fish in size weight (g) category,  
sample of 120 fish**



- ❖ The size variation in the tank changed over the experiment.
- ❖ Initially the size distribution was normal.
- ❖ As the experiment progressed, the size distribution became positively skewed towards a few large fish.



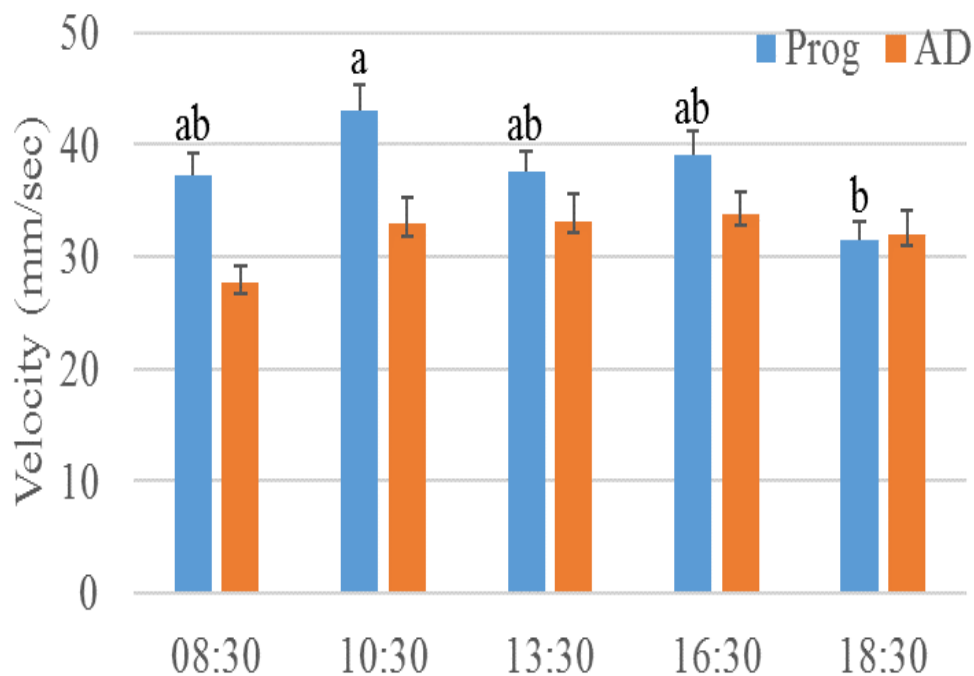
### Feed Conversion Ratio (FCR)



- ❖ There were no differences in FCR between fish feed with the two feeding systems, programmed and auto-demand.



## Mean swimming velocity (mm/sec) August n = 72



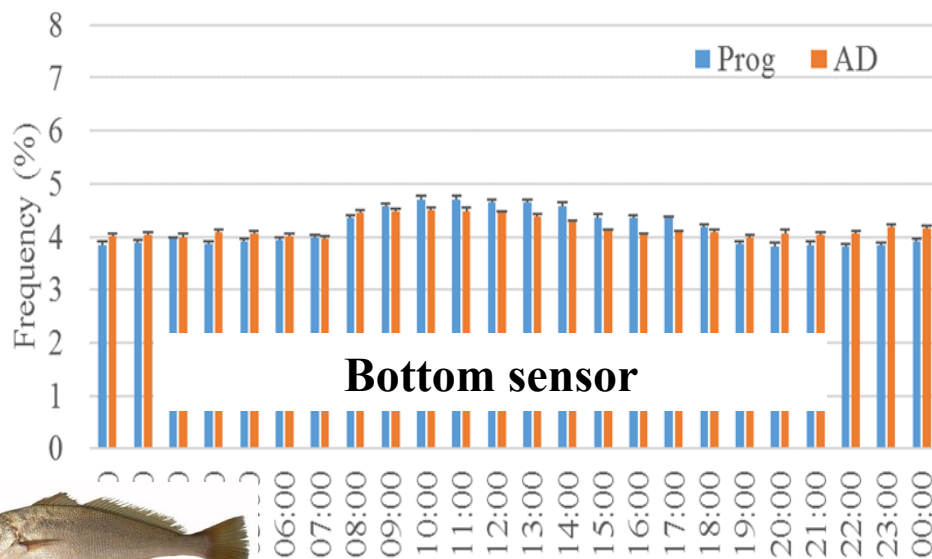
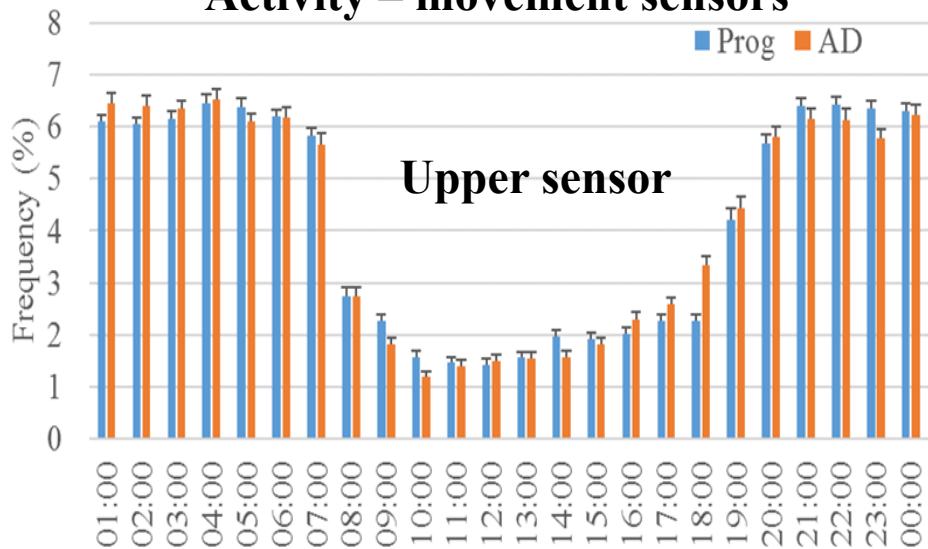
- ❖ The fish in the auto-demand feeding system had lower swimming velocity than fish in the programmed feeding system.
- ❖ This appeared to be related to feeding and availability of feed.
- The fish in the auto-demand feeding system had feed availability at all times
- The fish in the programmed feeding system had higher swimming speeds in response to hunger and periodic feed delivery.





### Behaviour

#### Activity – movement sensors

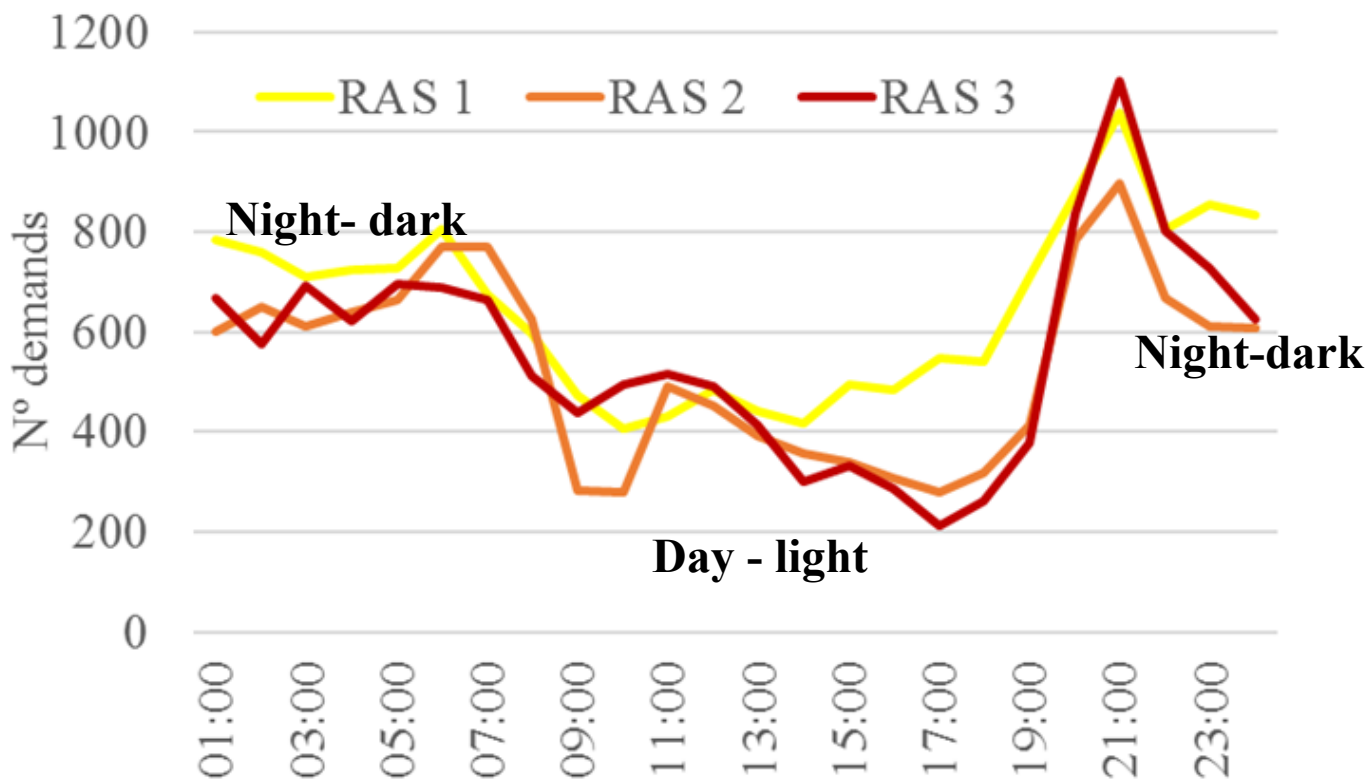


- ❖ The meagre did not exhibit aggressive behaviour.
- ❖ The sensors at the surface (20 cm below the surface) and bottom (20 cm above the bottom) showed a clear change in behaviour during the day and night.
- ❖ The fish clearly stayed lower in the tank during the day and rose to the surface to fill the whole tank during the night.



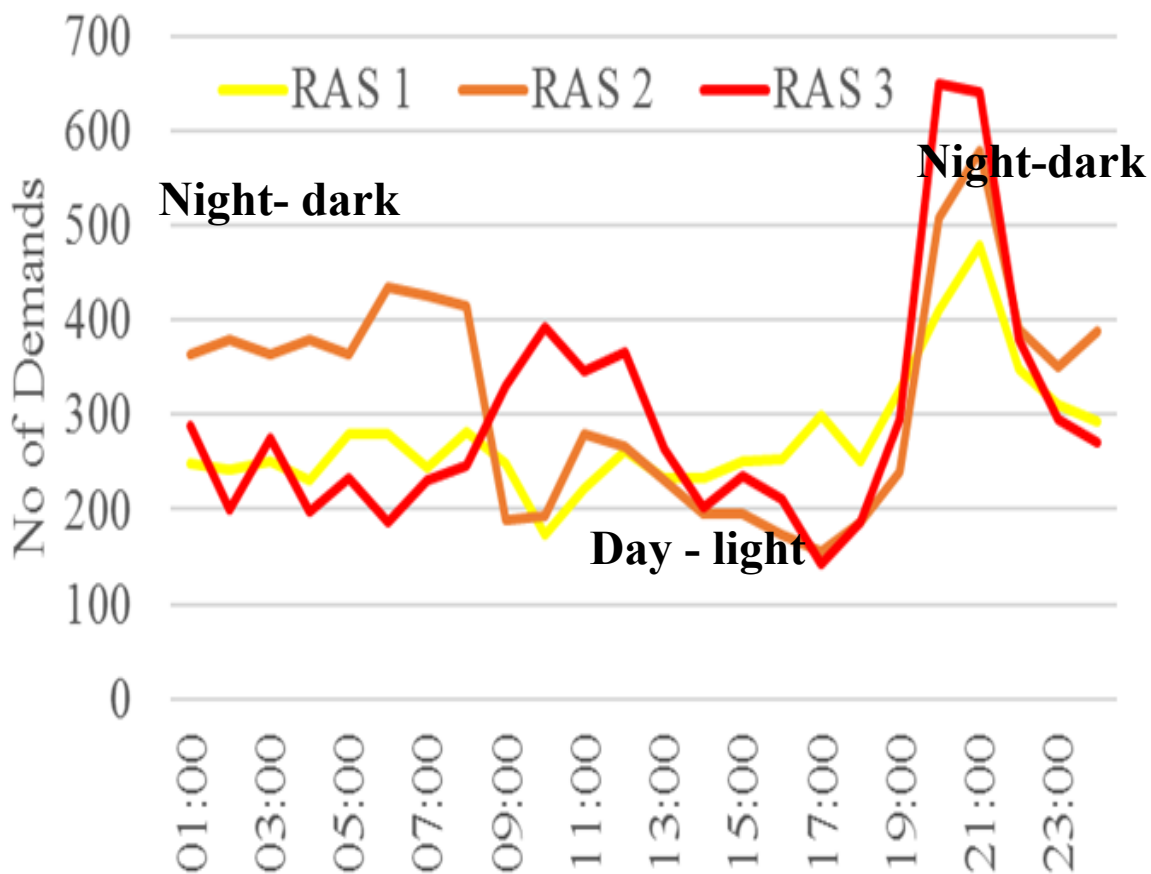
**Behaviour – feeding activity – feeding pattern**

**Cumulative demands per hour for feed during all the year**



### Behaviour – feeding activity – feeding pattern

#### Cumulative demands per hour for feed 4 Oct – 21 April

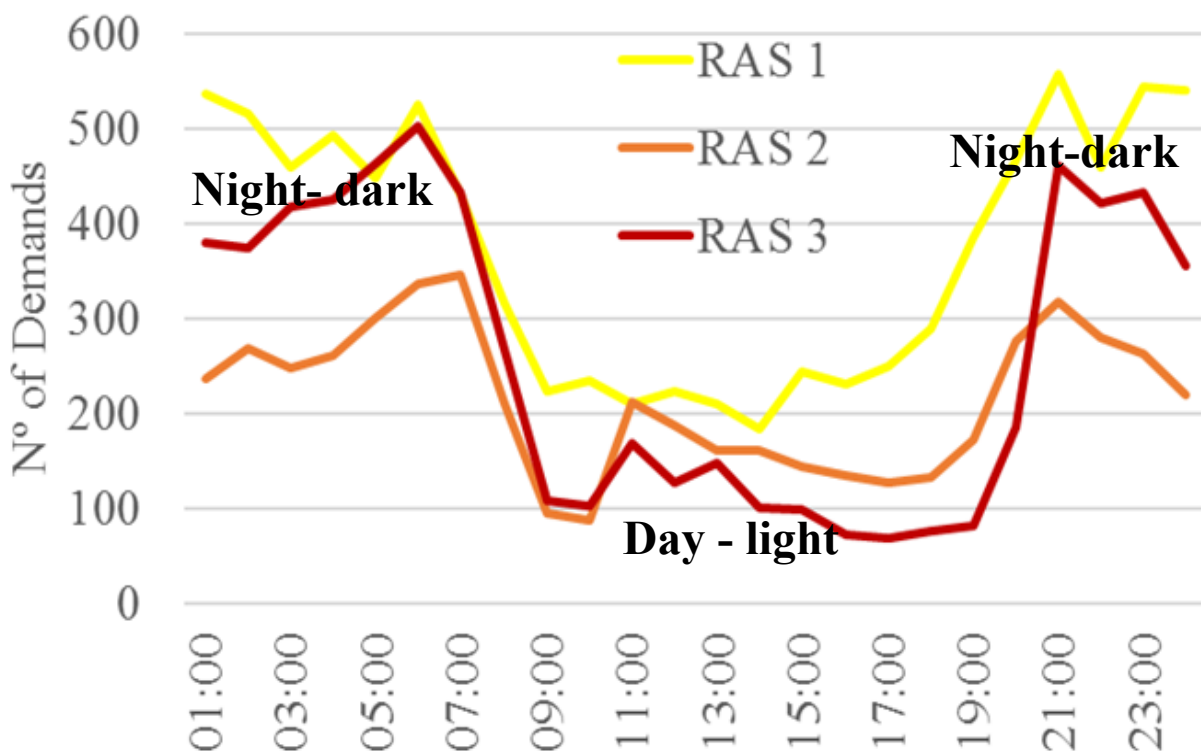


- ❖ The pattern of feeding during the night appeared to change from the first part of the experiment to the second part of the experiment.
- ❖ During the period Oct. 2016 to April 2017, more feed was demand in the first part of the night from 19:00 to 22:00.



### Behaviour – feeding activity – feeding pattern

### Cumulative demands per hour for feed during 22 April – 6 Sept



**During the period from April 2017 to Sept. 2017 the higher demand was the entire night period 20:00 to 08:00**

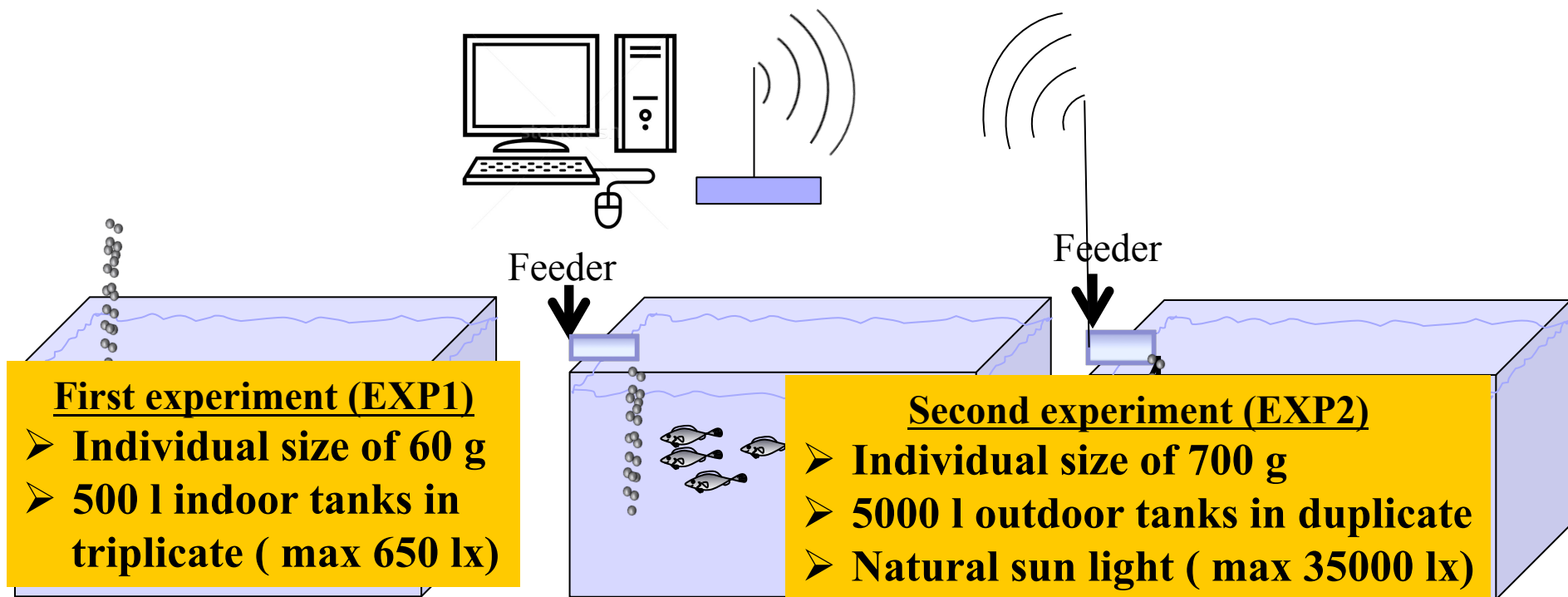


- **Grow out practices of 2 – 3 feeding periods during the day light hours gives the same growth, FCR and size variation as demand feeding.**
- **Comparing parameters between programmed feeding and auto-demand feeding:**
  - **No difference in growth**
  - **Similar size variation**
  - **No difference in FCR**
- **Feeding during the entire 24 hours cycle including during the night.**
- **Higher levels of feeding during the night.**
- **Meagre rise to fill all the water column during the night and stay deeper in the tank during the day.**



- **The effect of different stimuli on meagre feeding behavior (HCMR).**
- **Comparison of programmed and auto-demand type feeding in tanks (IRTA).**
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❖ **Hand feeding**

Feeding ad libidum

(08:00, 12:30 and 16:30)

❖ **Scheduled feeding with electric feeder.**

Activated three times per day  
(08:00, 12:30 and 16:30)

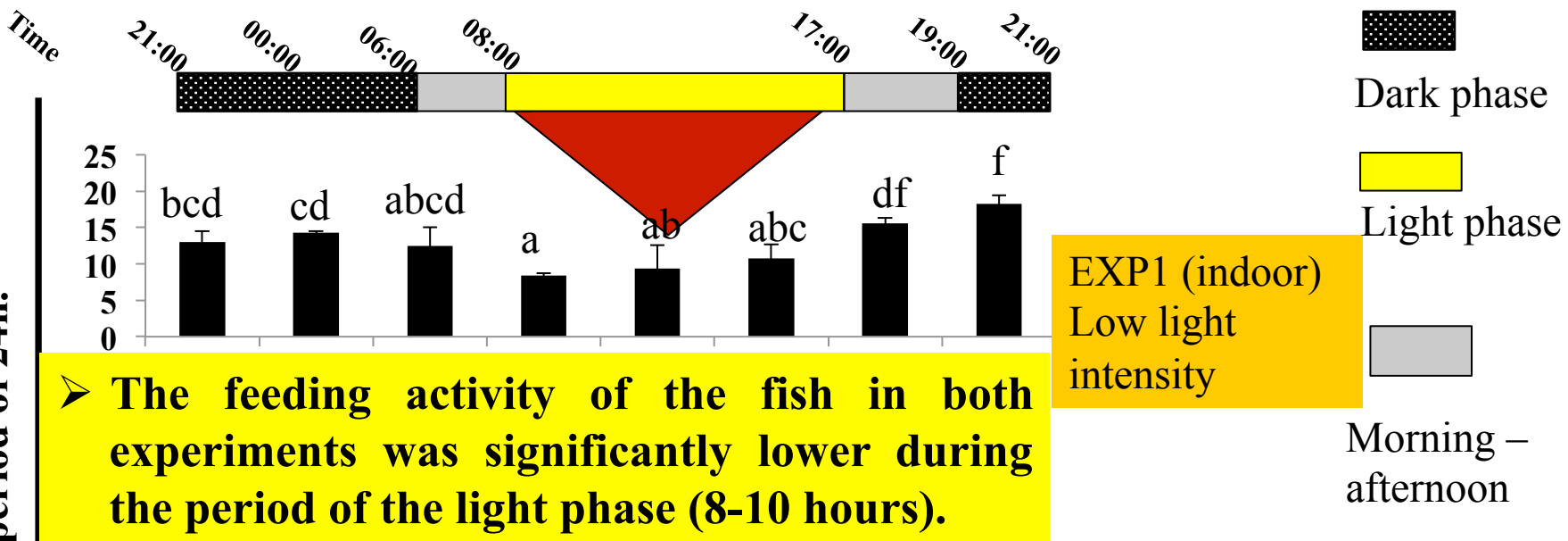
❖ **Self-feeder**

Activated by fish

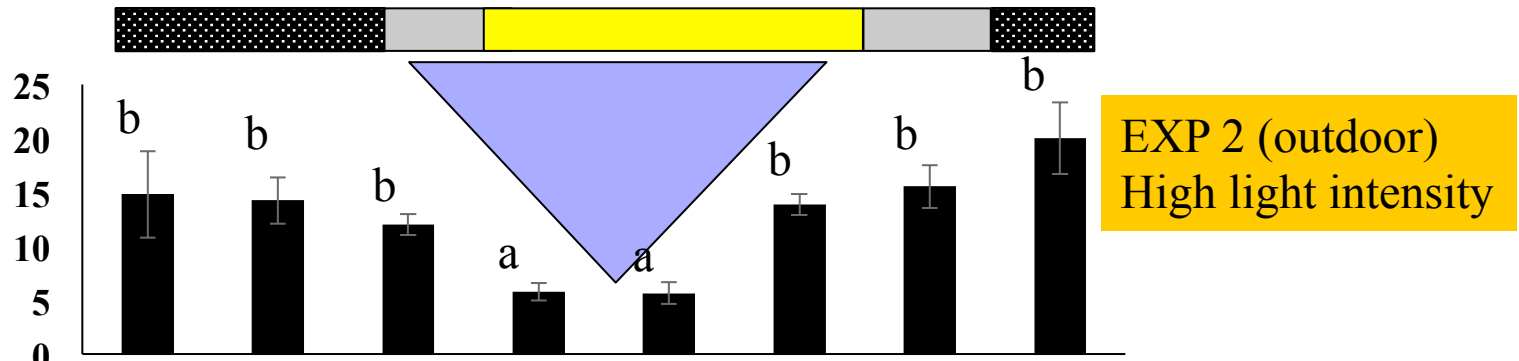


### 3. Test of different feeding methods (Results-feeding activity)

Distribution (%) of the self feeder activations in the period of 24h.



➤ The feeding activity of the fish in both experiments was significantly lower during the period of the light phase (8-10 hours).



➤ This phenomenon was more intense in outdoor tanks, which were exposed to direct sunlight and the intensity of light was much higher.

Periods of the day





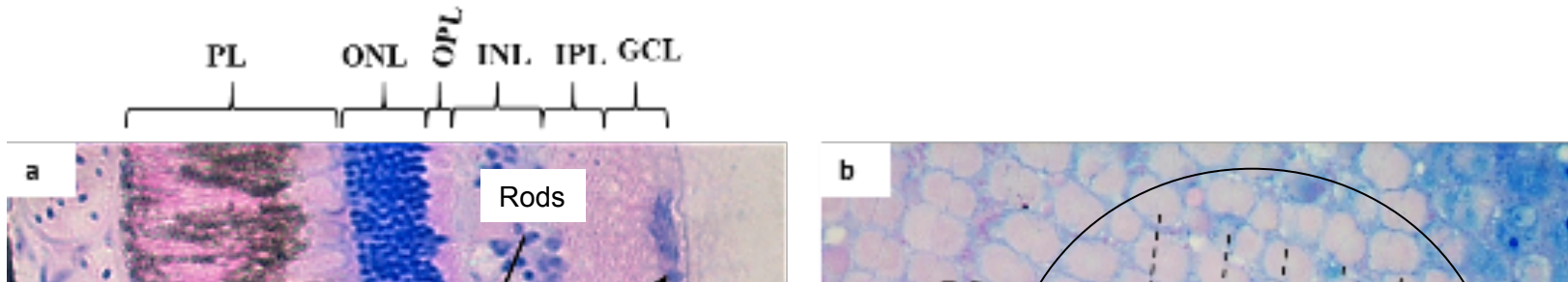
**Two main questions were extracted from all the above information.**

- ❖ Why do meagre exhibit high feeding activity under low light intensity?**
- ❖ Why was feeding activity reduced for 8-10 hours?**

**Further analyses were performed and additional deliverables were produced.**

- Histological analysis on the retina of the meagre eye.**
- Gastric Evacuation Rates of the meagre.**





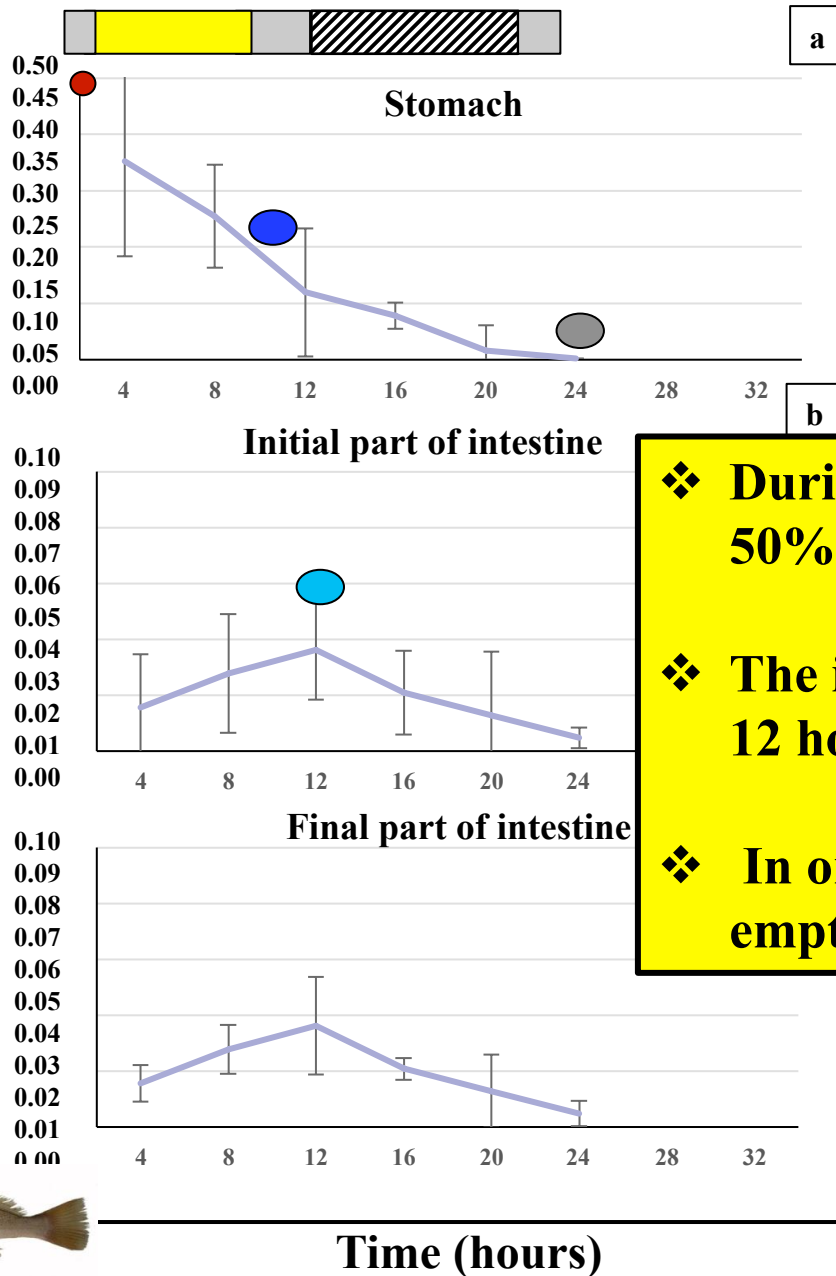
- ❖ The arrangement of rods (RN) is connected with the high nocturnal ability of meagre.
- Schooling behavior.
- The perception in two dimensions.

❑ The previous explains:

- ❑ The previous explains: Why meagre tend to reduce the feeding activity under high light intensities.
- Why meagre tends to wait for the feed to drop to their level of swimming, rather than actively swim to the surface as soon as feeding begins.



% dry food in the digestive canal per fish body weight



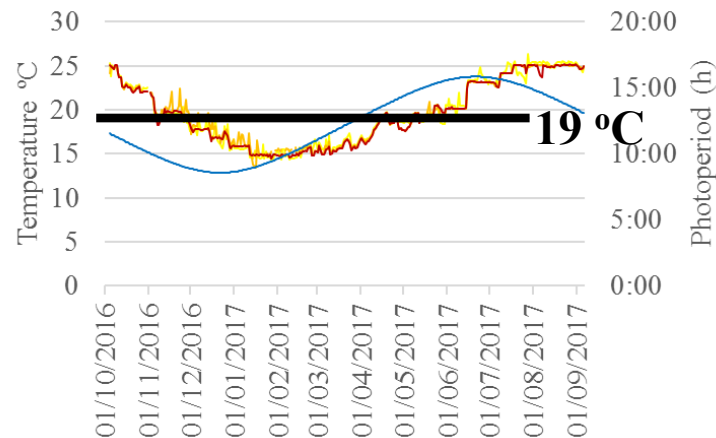
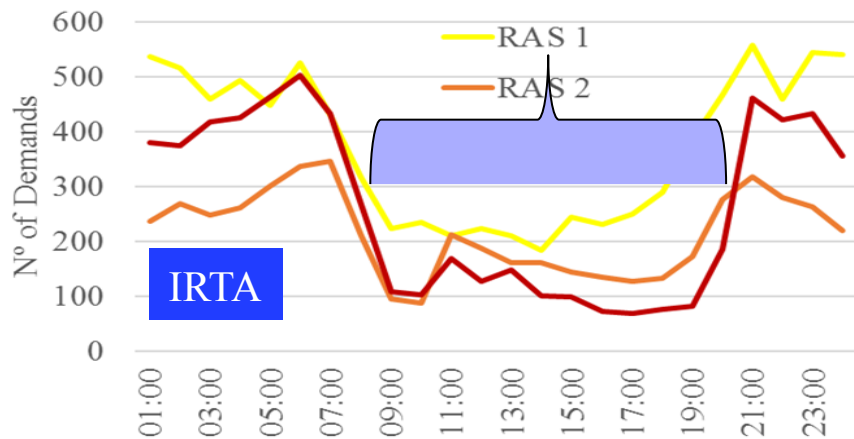
Gastric evacuation rates of:  
 a) stomach,  
 b) initial part of intestine,  
 c) final part of intestine.

● Force Feeding with pellets (0.5 % of the fish body weight)

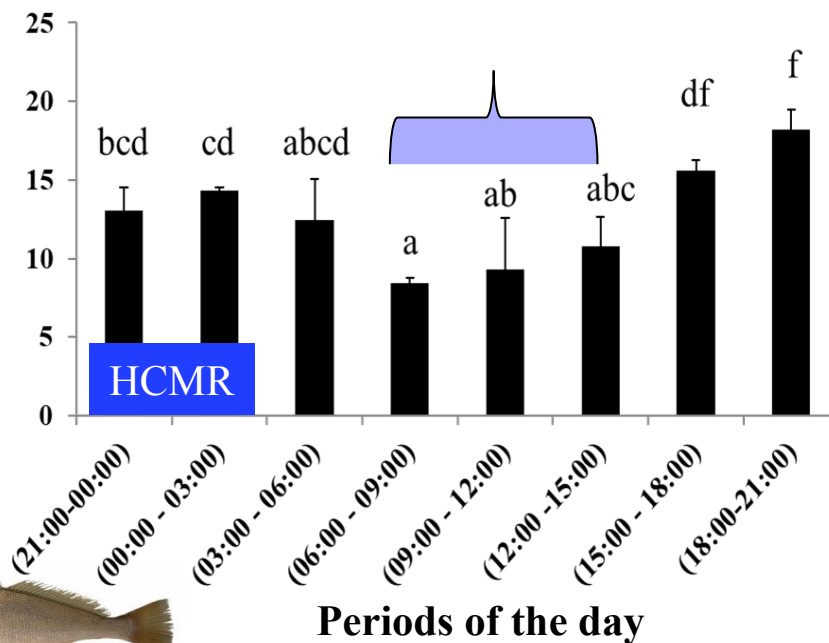
- ❖ During the first 8 hours, the stomach lost 50% of the initial amount of food. ●
- ❖ The intestine reaches its maximum filling 12 hours after the forced feeding. ●
- ❖ In order the digestive canal to become empty required 24 hours. ●

Light phase  
 Morning – afternoon





Distribution (%) of the self feeder activations in the period of 24h.



**At 19 °C, refeeding activity was observed 8 hours after the previous feeding activity.**

**The fish act for refeeding when the stomach content is lower than 50% from the previous feeding.**

**\*\*\*A basic information to consider for the development of feeding methodology.**



**From the experiments related with stimuli and the methodologies of feeding is clearly indicated that:**

- ❖ In order to develop a feeding methodology or to optimize the feeding protocols in rearing conditions, we have to take in consideration the special characteristics of the main systems that are associated with feeding behavior that are, the digestive and visual system.**
- ❖ The feeding method for meagre can be based on the use of various stimuli (light or air bubbles) in order to attract the rearing population to the specific feeding area.**
- ❖ The shadowing of the sea cages is proposed as an additional process that will increase the effectiveness of an automated feeding system for meagre.**
- ❖ The development of a combinational, programmed feeding method with using various types of stimuli, is considered as the most appropriate feeding methodology.**



**Ioannis Papadakis (HCMR)**  
*papad@hcmr.gr*

**Nikos Papandroulakis (HCMR)**

**Constantinos C. Mylonas (HCMR)**

**Manolis Vasilakis (HCMR)**

**Alkioni Sfendouraki,**  
BSc student Biology Department,  
University of Crete (UoC)

**Veronica Camporesi,** BSc student  
(University of Bologna)

**Karamanlidis Dimitris,**  
MSc Student (UoC)

**Theodor Stevens,** BSc student  
(Rijksuniversiteit Groningen)

**Neil Duncan, (IRTA)**  
*Neil.Duncan@irta.cat*

**Alicia Estevez, (IRTA)**

**Ana Roque, (IRTA)**

**Elvira Fatsini, (IRTA)**

**Jordi Comas, (IRTA)**

**Gracias por su atención**  
**El fin**  
**Σας ευχαριστούμε για την**  
**προσοχή σας**  
**Thank you for your attention**

