Klaipeda University
Marine Research Institute

aqua VIP

Interreg South Baltic

EUROPEAN UNION

European Regional Development Fund

Saltwater RAS: some biological, technical and economic aspects of brackish, marine and geothermal water applications

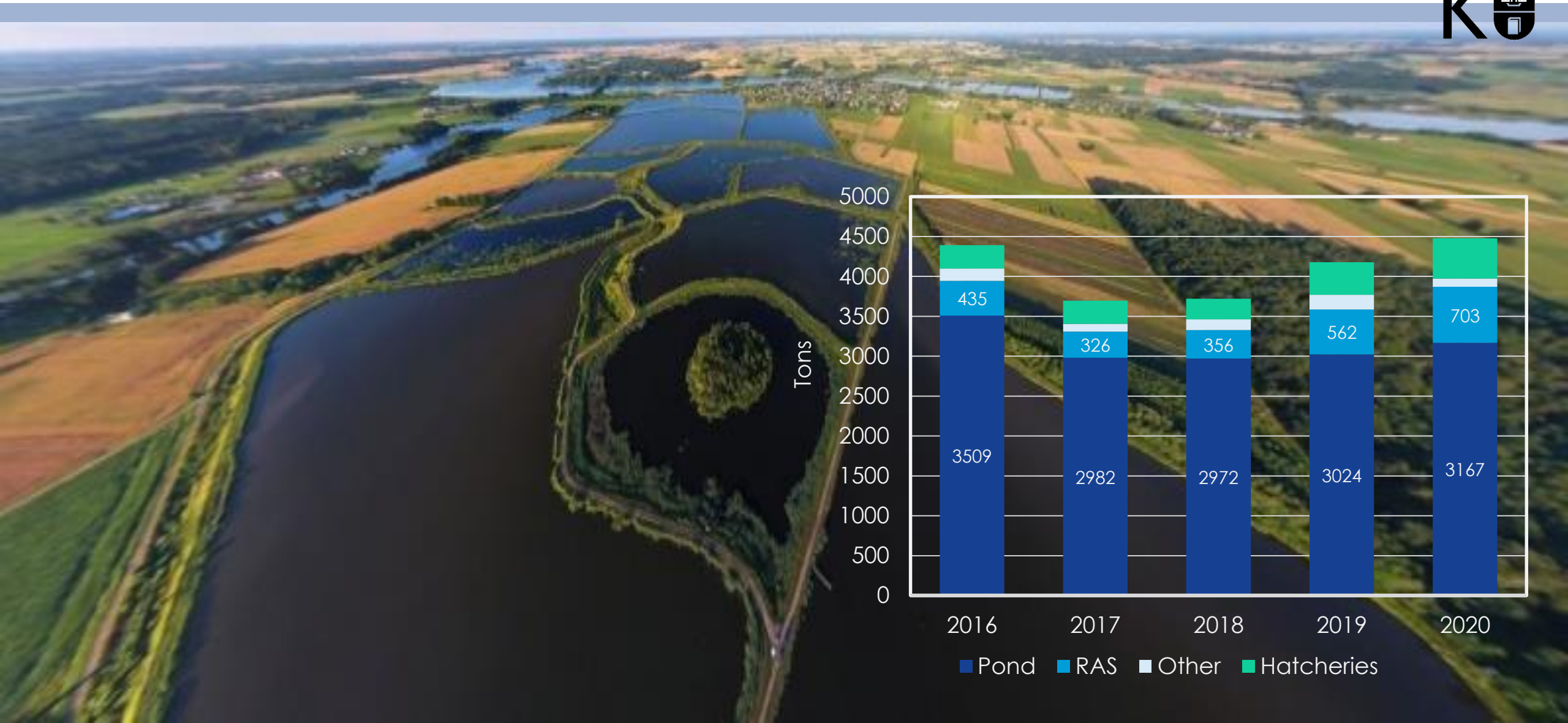
Nerijus Nika, Klaipeda University

PLAN OF THE PRESENTATION

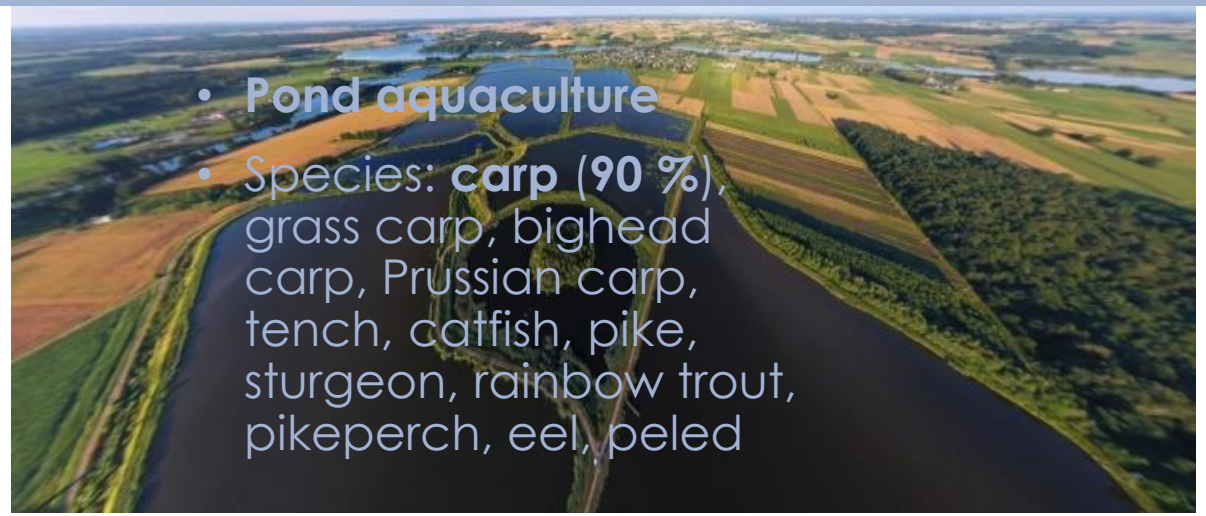
- Introduction / Why saltwater RAS?
- Marine RAS for shrimp cultivation
- Geothermal water application potential
- Freshwater fish cultivation in brackish RAS

- **WHY SALTWATER/MARINE RAS?**

LITHUANIAN AQUACULTURE - FRESHWATER

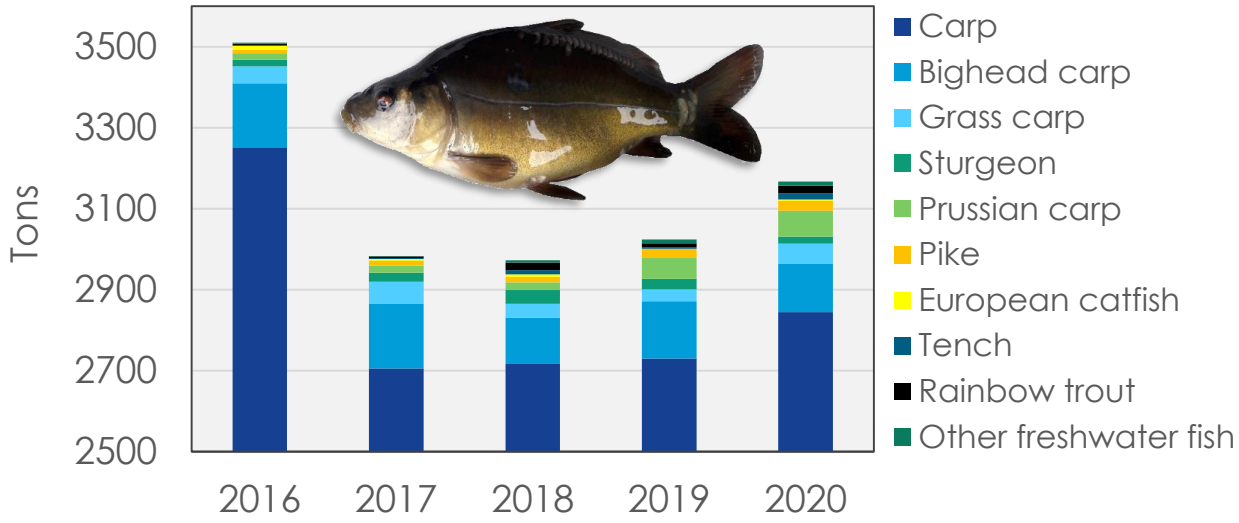


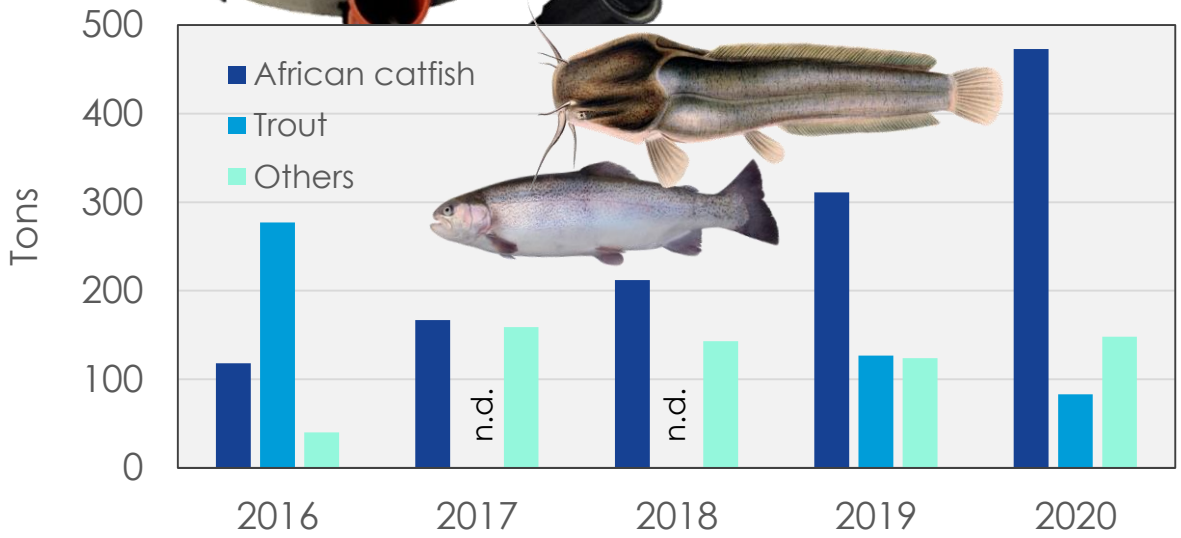
LITHUANIAN AQUACULTURE - FRESHWATER



- **Pond aquaculture**
- Species: **carp (90 %)**, grass carp, bighead carp, Prussian carp, tench, catfish, pike, sturgeon, rainbow trout, pikeperch, eel, peled

- **RAS aquaculture**
- Species: rainbow trout, African catfish, eel, sturgeon, Arctic charr, whiteleg shrimp, tilapia





DEVELOPMENT OF THE SECTOR

- **National Aquaculture Sector Development Plan 2014-2020 (next 2021-2027)**
- Innovative aquaculture – one of priorities in **Klaipeda Economic Development Strategy 2030**
- Potential of the sector directly depends on skilled personal

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ŠILUTĖS PROFESINIO MOKYMO CENTRAS

VYTAUTAS MAGNUS UNIVERSITY
MCMXXII

- Other scientific facilities:
  - **State Hatcheries of Fisheries Service under the MoA**
  - **Nature Research Center**
- Associations

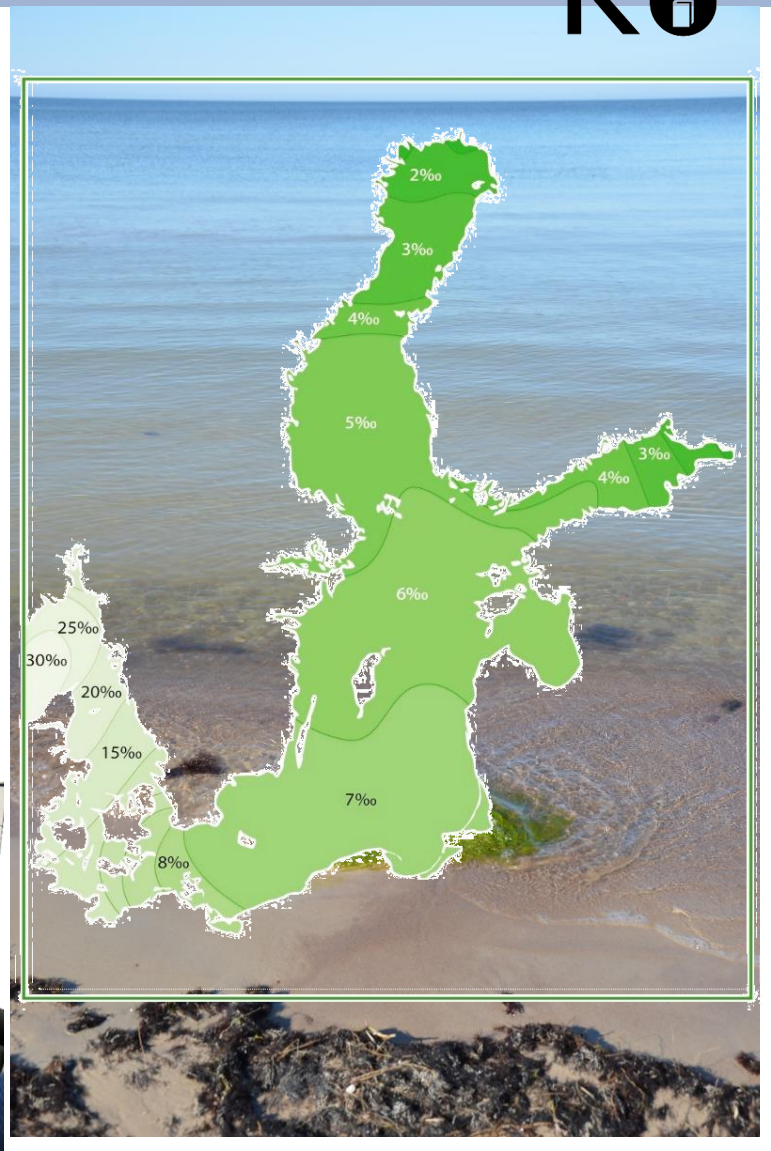
NACIONALINĖ AKVAKULTŪROS IR ŽUVŲ PRODUKTŲ GAMINTOJŲ ASOCIACIJA

alternatyvios akvakultūros asociacija

MARINE AQUACULTURE IN LITHUANIA?

- **Low salinity of the central Baltic Sea for the algae and mussel farming**

- **Challenges for fish mariculture in Lithuanian marine waters:**
  - Exposed coast - rough hydrological conditions and short wave period
  - Low salinity
  - Other environmental constraints
    - **High eutrophication and commitments to Helcom**
    - **Bioinvasions**



Solution – land-based marine aquaculture!

AQUACULTURE IN KU

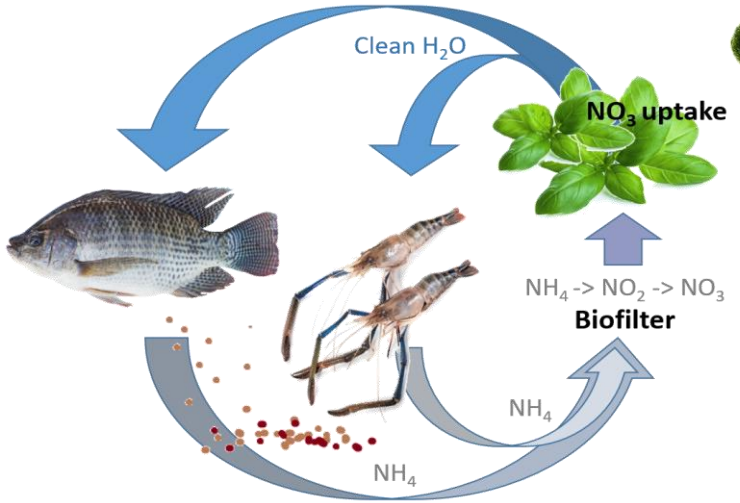
- **Fishery and Aquaculture Laboratory** – new infrastructure for aquaculture experiments, development of unique competences and student trainning
- **Aquaculture Competence Center** established in collaboration with Klaipeda Science and Technology Park
- **Aquaculture Research** based on KU high competences in aquatic ecology, hydrobiology, chemistry, also on close collaboration with other scientific institutions, aquaculture and biotechnology businesses.

AQUACULTURE RESEARCH IN

- ***Marine recirculating aquaculture technologies***
  - Marine RAS and shrimp production competences
  - Geothermal water and energy application solutions
  - Brackish water potential for freshwater fish cultivation

- ***Probiotics in aquaculture***
  - Effects on fish and functioning of aquaculture systems
  - Patogenic microorganisms control efficiency
  - Application methodologies

- ***Aquaponics***
  - Developement of integrated multi-trophic system concept (fish, freshwater shrimp and vegetables)



POTENTIAL OF MARINE RAS

- Deficit of fresh water
- Off-shore marine aquaculture goes on land
- The segment of marine sea food generates higher added value
- Freshwater fish growth in brackish conditions may have some advantages
  - Food availability
  - Diseases and parasites
  - Osmoregulatory energetic expenditures

MARINE RAS FOR SHRIMP CULTIVATION (LITHUANIAN EXPERIENCE)

With contribution of Gintautas Narvilas and Jonas Lelys (KU)

Aquaculture Competence Center
(Klaipeda University and Kaipeda
Science and Technology Park

KLAIPĖDOS MOKSLO IR
TECHNOLOGIJŲ PARKAS

LOCAL
OCEAN
VANDENYNO GĖRYBĖS

FIRST SHRIMP RAS IN LITHUANIA

- Pilot infrastructure created within **InnoAquaTech** project.
- RAS for *L. vannamei* shrimp cultivation integrated with renewable energy sources at KU Business Incubator
- The goal is to acquire shrimp cultivation knowledge and to optimize growth technology for local conditions.

KLAIPĖDOS MOKSLO IR TECHNOLOGIJŲ PARKAS

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InnoAquaTech

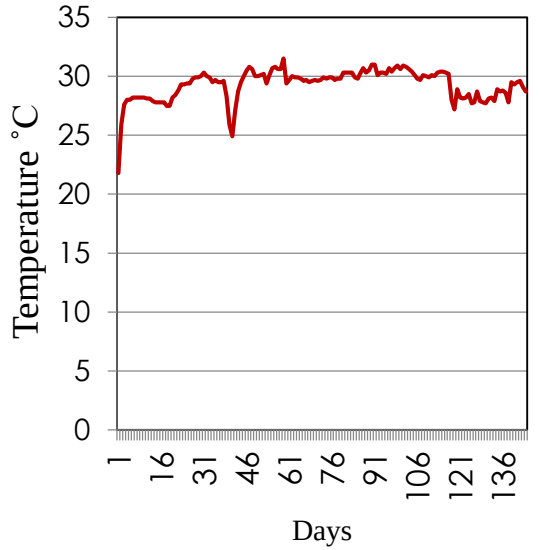
GENERAL PARAMETERS OF THE SYSTEM:

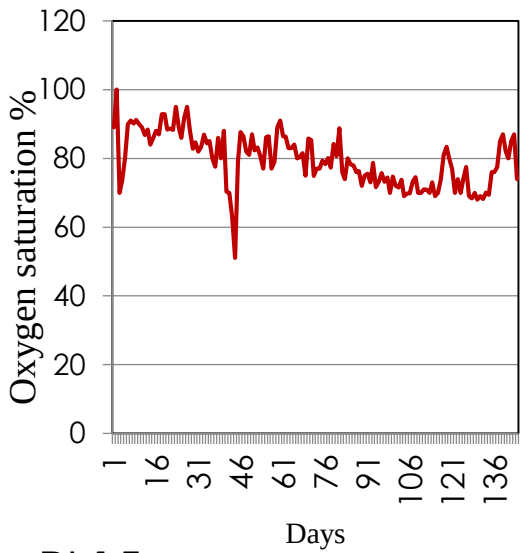
- Artificial saltwater RAS
- Uses solar energy
- Unique to LT – denitrification filter
- System setup in two rooms
- Water volume – ~40 m^3
- Daily water loss – ~2 % (so far)
- 8 rearing tanks, surface area – ~29 m^2
- Max yield/cycle ~145 kg (5kg/m^2)
- Electricity consumption – 5 kW/month

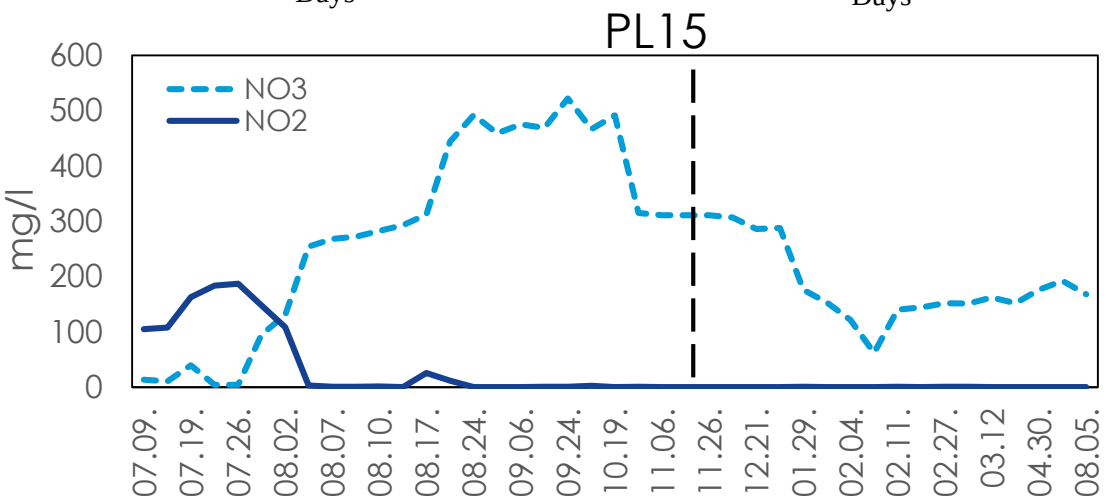
- Drum filter
- Biological filter
- Sump
- Protein skimmer
- Denitrification filter
- Oxygenation cone
- Heater
- UV
- Monitoring and control system
- Salt water preparation system

WATER QUALITY IN RAS

- Temperature – 28.5 (28-30)°C
- Salinity – 15-16 ppt
- Oxygen – 70-90%, some drops to 40-50%
- pH – 7,6-8,1
- Mn – 351 µg/l; Fe – 70 µg/l;
- NH_4 – 0.04 mg/l (some short increases to 0.32-0.85 mg/l)
- Good nitrification, problems with denitrification
- Some increase in algae and nematode growth followed by ozonizer failure

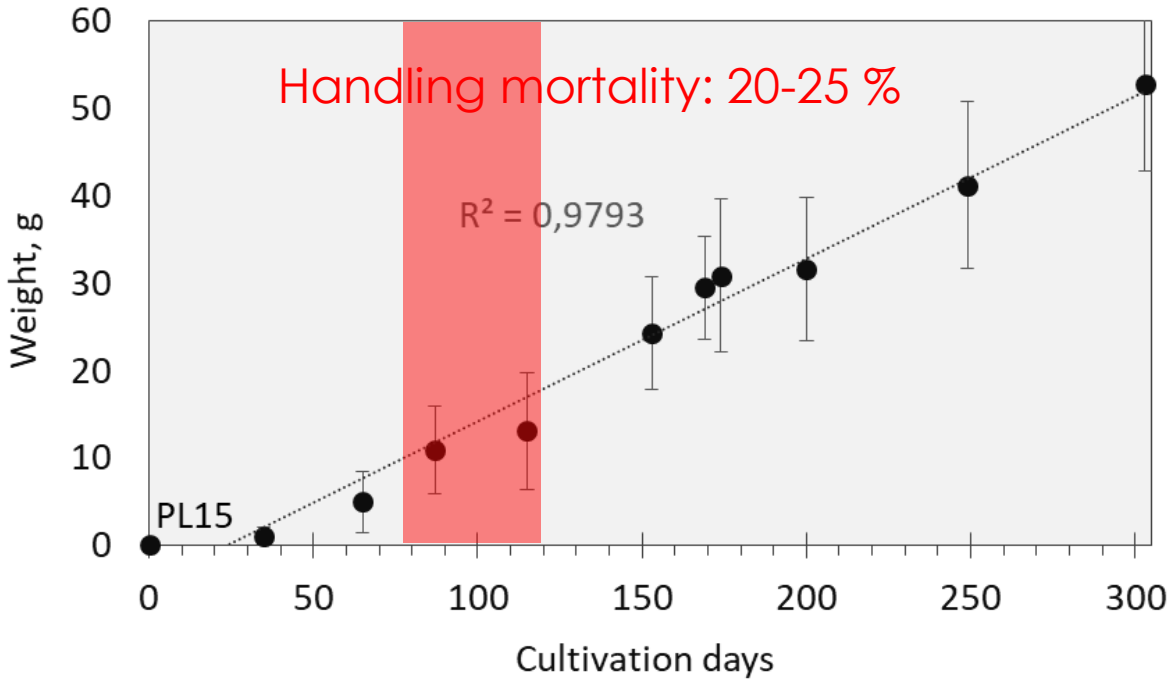






FIRST RESULTS OF GROWING *L. VANNAMEI*

- Very poor transportation survival – ~50 % of 15 000 PL15
- Canibalism observed
- Distributed into 5 tanks (1000 ind. per tank)
- Growth to the market size took 5 months and average size was 24.3±6.4 g (up to 40 g)
- Stocking density 2,5-3 kg/m^2
- Total harvest 80 kg
- FCR – 1,9-2,0

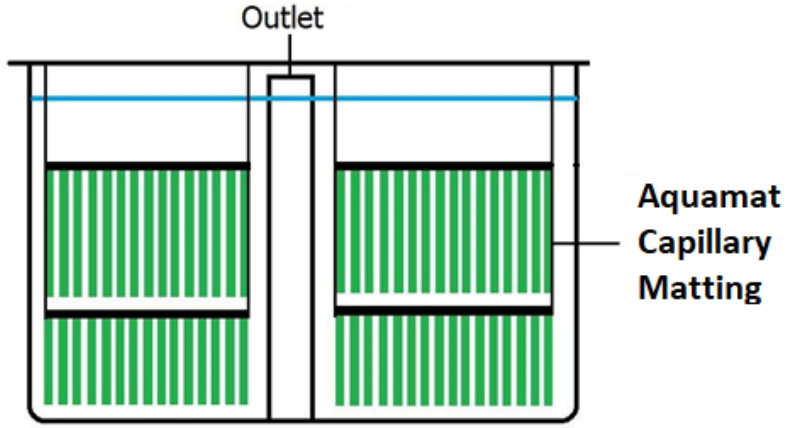


Feeding manually x4/day
Growth rate 0.18 g/day
Mortality ~65 %
Cannibalism observed
Jumping issue

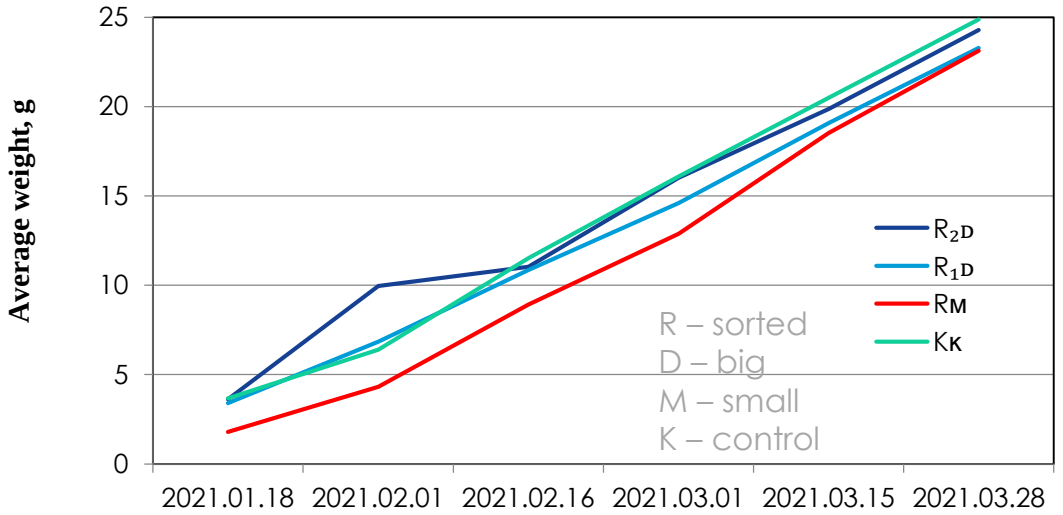
FIRST HARVEST

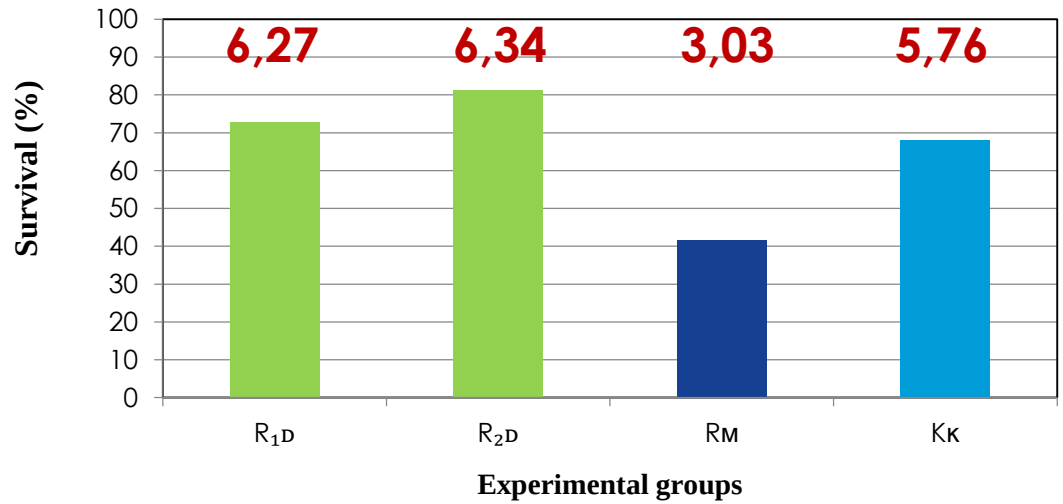
FURTHER TECHNOLOGY OPTIMIZATION TASKS

- Denitrification filter performance
- Water quality optimization
- Feeding management
- Reduce mortality – improve production
- Diseases?
- Unequal growth rate during first months
- Shrimp tank design – extra surface area



TECHNOLOGY OPTIMIZATION – IMPROVED GROWTH





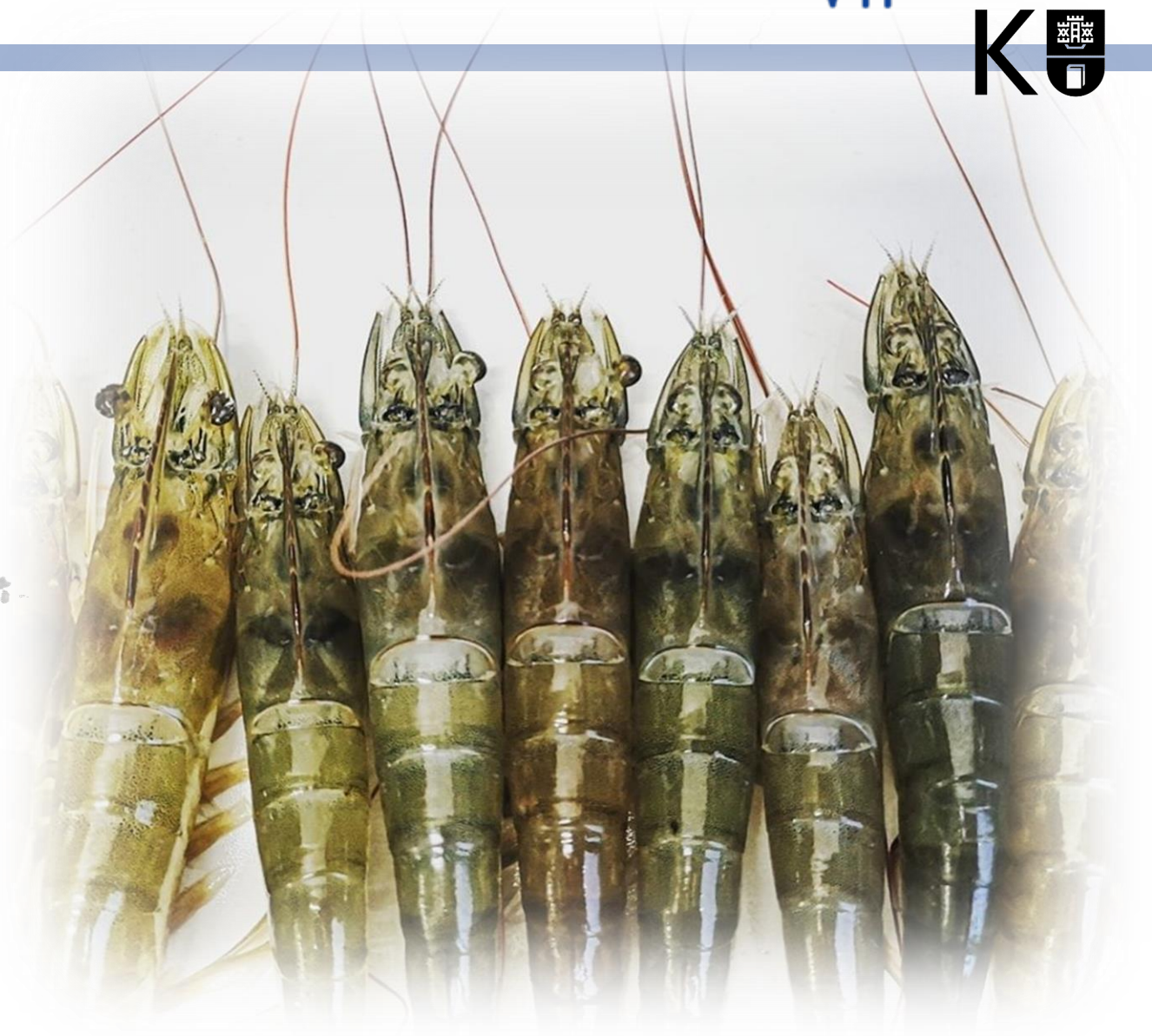
- Sorting experiment, feeding management
- High growth rate sustained – market size in 4 months
- High mortality and compensatory growth in a group of small ones
- But only the harvested biomass matter!

ECONOMIC PERFORMANCE OF SHRIMP RAS?

- **Fresh shrimp is a luxury product**
- **The production is costly**
- **What are the OPerating EXpences?**

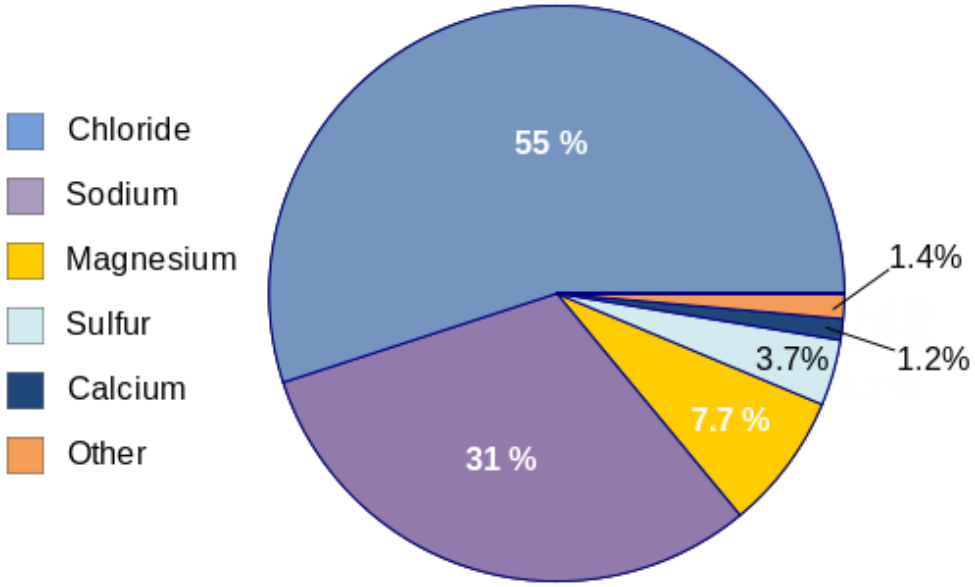
- **Heating was not as crucial as it was thought initially**
- **High operational costs for salt**

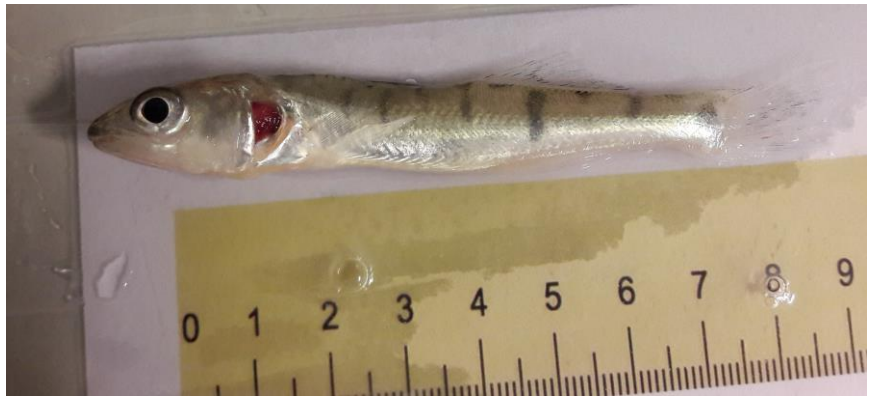
- **Solutions (that we are dealing with)**:
- Low cost salt mixture LCSM: (Na, Mg, Ca, K chlorides, Mg sulphate) (Galkanda-Arachchige et al., 2020)
- Geothermal brine



WATER ELEMENTAL COMPOSITION IMPORTANCE

- Natural seawater contains virtually every element known on Earth.
- Macroelements, microelements (<1 mg/L) and trace elements
- Trace elements like **Sr**, Fe, Zn, Mn, Mo and others are necessary for normal growth of marine organisms
- Element deficiency (or toxicity by excess of element) may cause:
  - Reduced growth
  - Anemia
  - Cataract
  - Mineral deficiency in bones
  - Increased mortality
  - Anorexia
  - Fin necrosis
  - Short body dwarfism
  - Other skeletal deformations





GEOTHERMAL AQUACULTURE

- „Traditional“ purpose – to heat the water to optimal temperatures **(13-30 °C)** for cultivated organisms
  - Regulating temperature could increase growth of aquacultured organisms by 50-100 %.
  - Heat exchanger technology or direct use
- Leading countries: China, USA, Iceland, France, Hungary, Italy, Israel, New Zealand and others
- Species: tilapia, salmon, trouts, bass, catfish, sturgeon, shrimps, lobsters, microalgae etc.
- Very much related to aquaponics technology – to heat greenhouses.
- Environmental and marketing aspects – clean, green energy (CO_2 zero emission), low environmental impact, sustainable production


Home › Crops › Research into the Combination of Geothermal Heat, Lettuce Cultivation and Fish Farming...

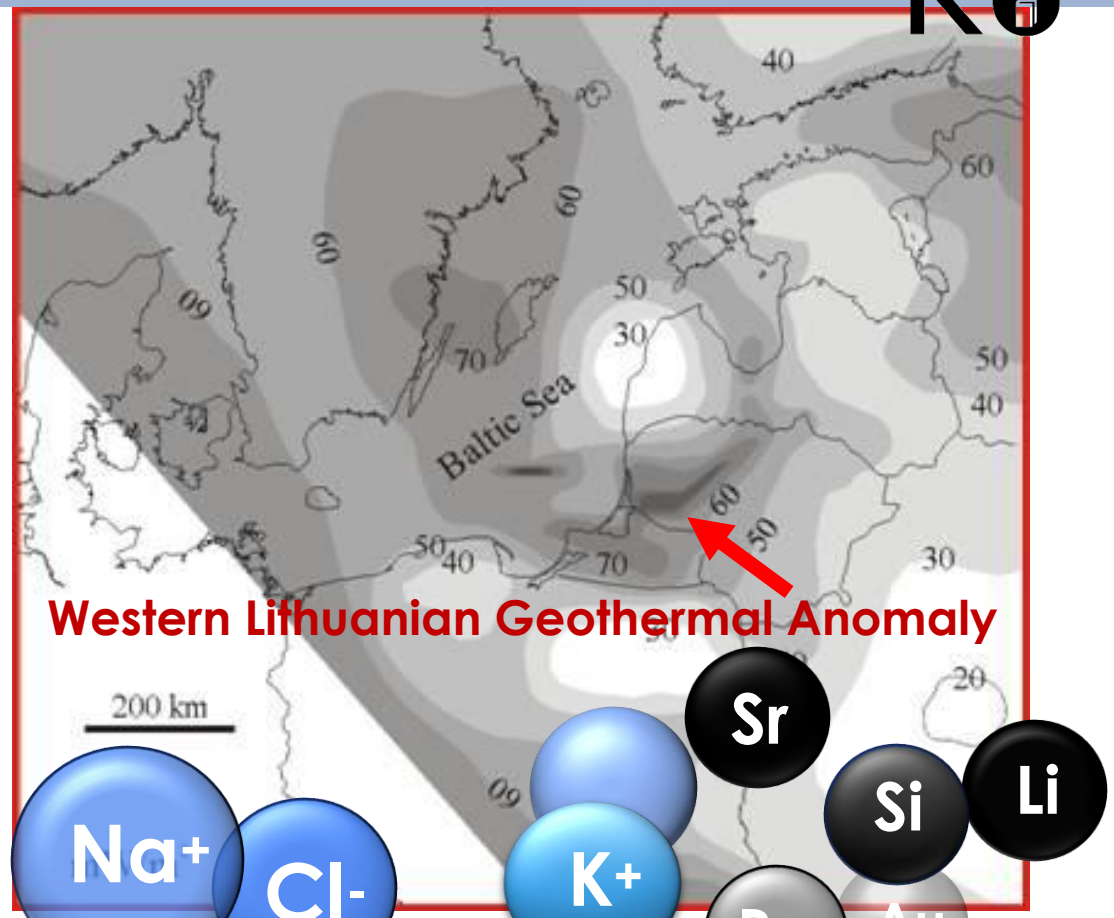
Crops Lettuce Technology Research News

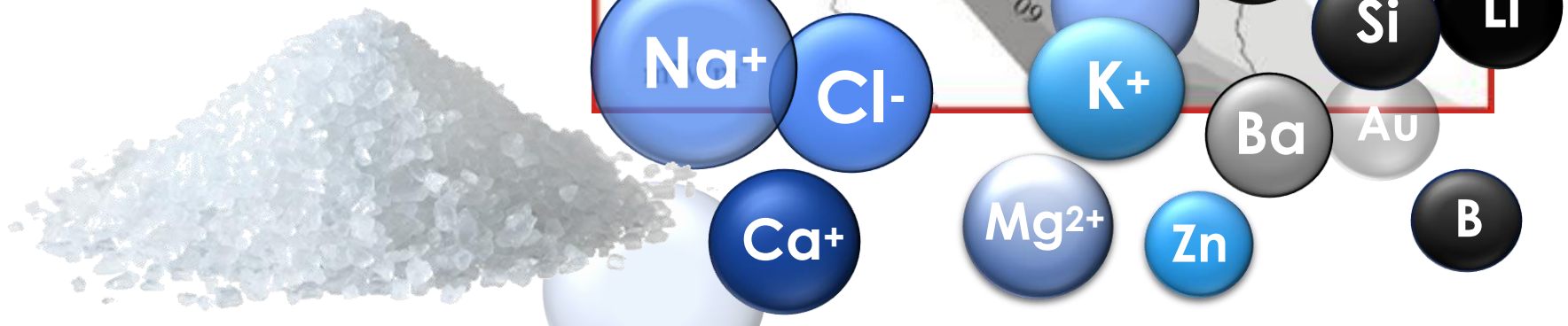
Research into the Combination of Geothermal Heat, Lettuce Cultivation and Fish Farming Started

By European Seed - October 30, 2019 250 0

GEOTHERMAL SOLUTION FOR WATER SALTING?

- Geothermal brine seems nice solution
- Western Lithuanian resources (110 g/L) from 1300 m deep Cambrian aquifer, which is highly rich in sodium, calcium, magnesium and other, including trace, elements.
- Geothermal water closely resembles marine water composition
- Some trace elements of concern are present at higher concentrations



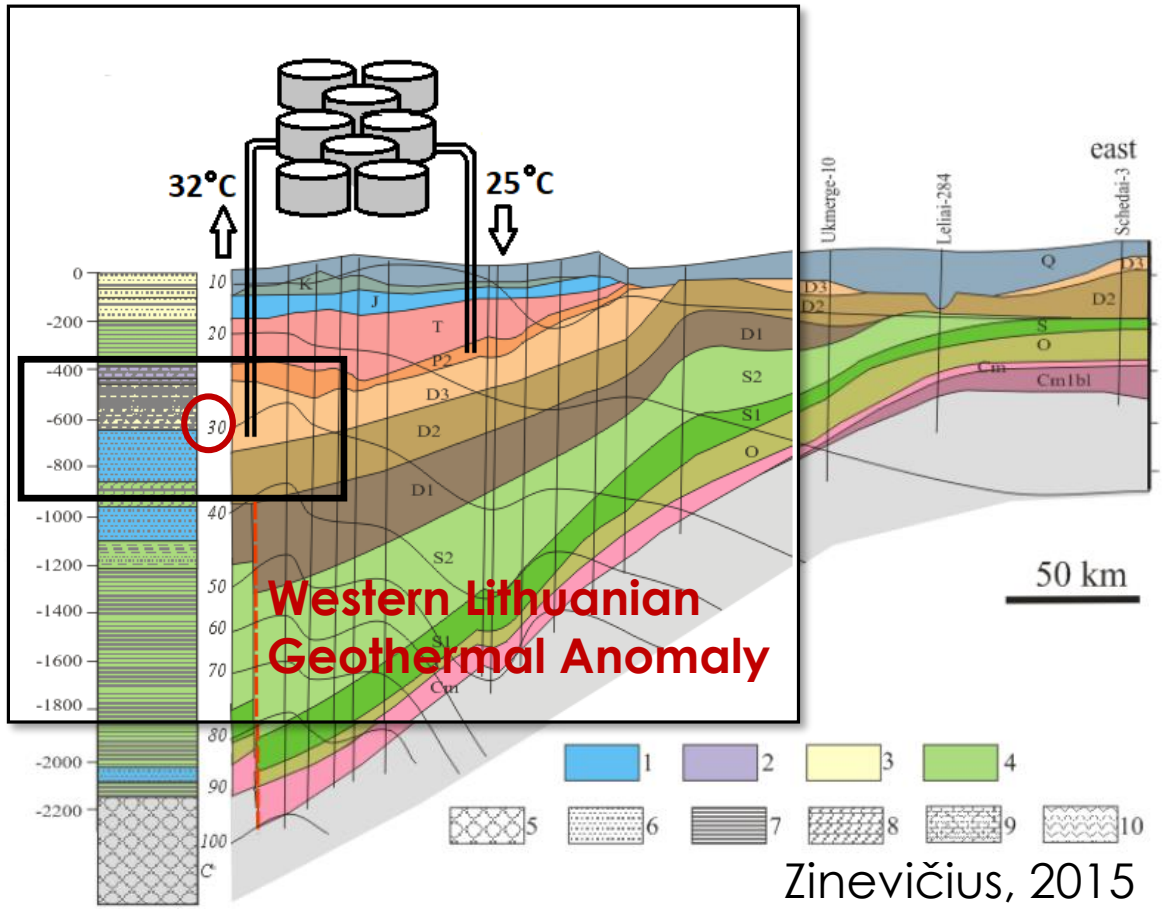


GEOTHERMAL APPLICATION: DIRECT?

- Concept of direct use of geothermal water with right temperature and right mineralization is rarely implemented in practice

JURASSIC SALMON

- Direct use of geothermal water from the large and shallow Upper-Middle Devonian aquifer containing 15-35 g/L salts and 20-30°C temperature.
  - Technical aspects
  - ***Legal aspects***



Zinevičius, 2015

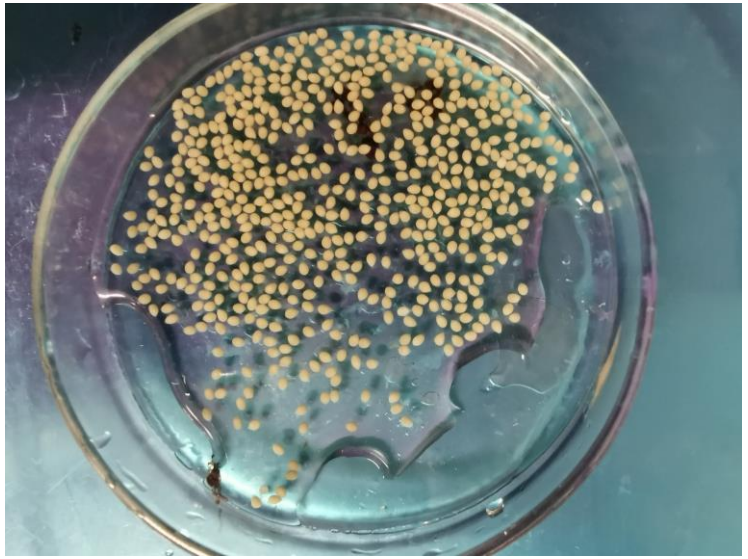
FRESHWATER FISH CULTIVATION IN BRACKISH RAS

With contribution of Gerda Petreikytė, Gintautas Narvilas and Marius Diadyk (KU)

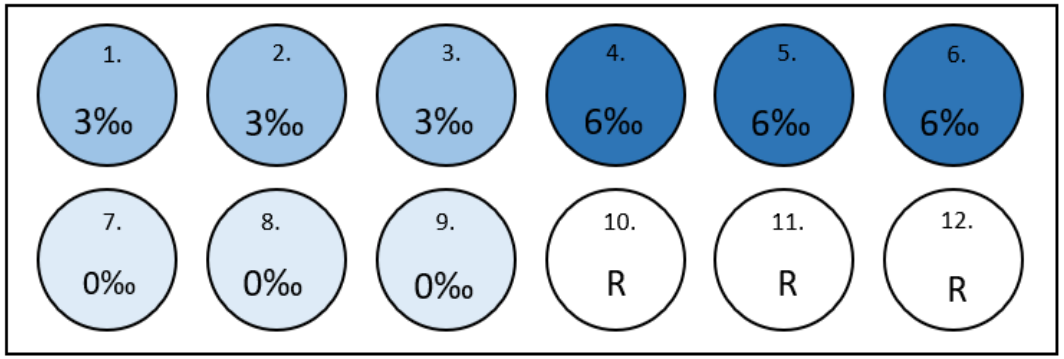
CULTIVATION OF TILAPIA IN BRACKISH CONDITIONS

- It is known that certain species show better growth performance in marine/brackish water than freshwater
- Mostly this was evident for representatives of Perciformes

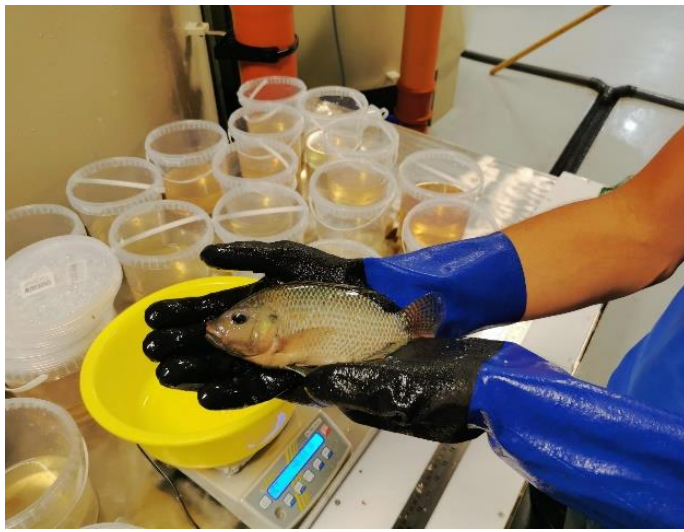
- Nile tilapia (*Oreochromis niloticus*)
  - Eurihaline species
  - One of most popular aquacultured species



STRUCTURE OF THE EXPERIMENT

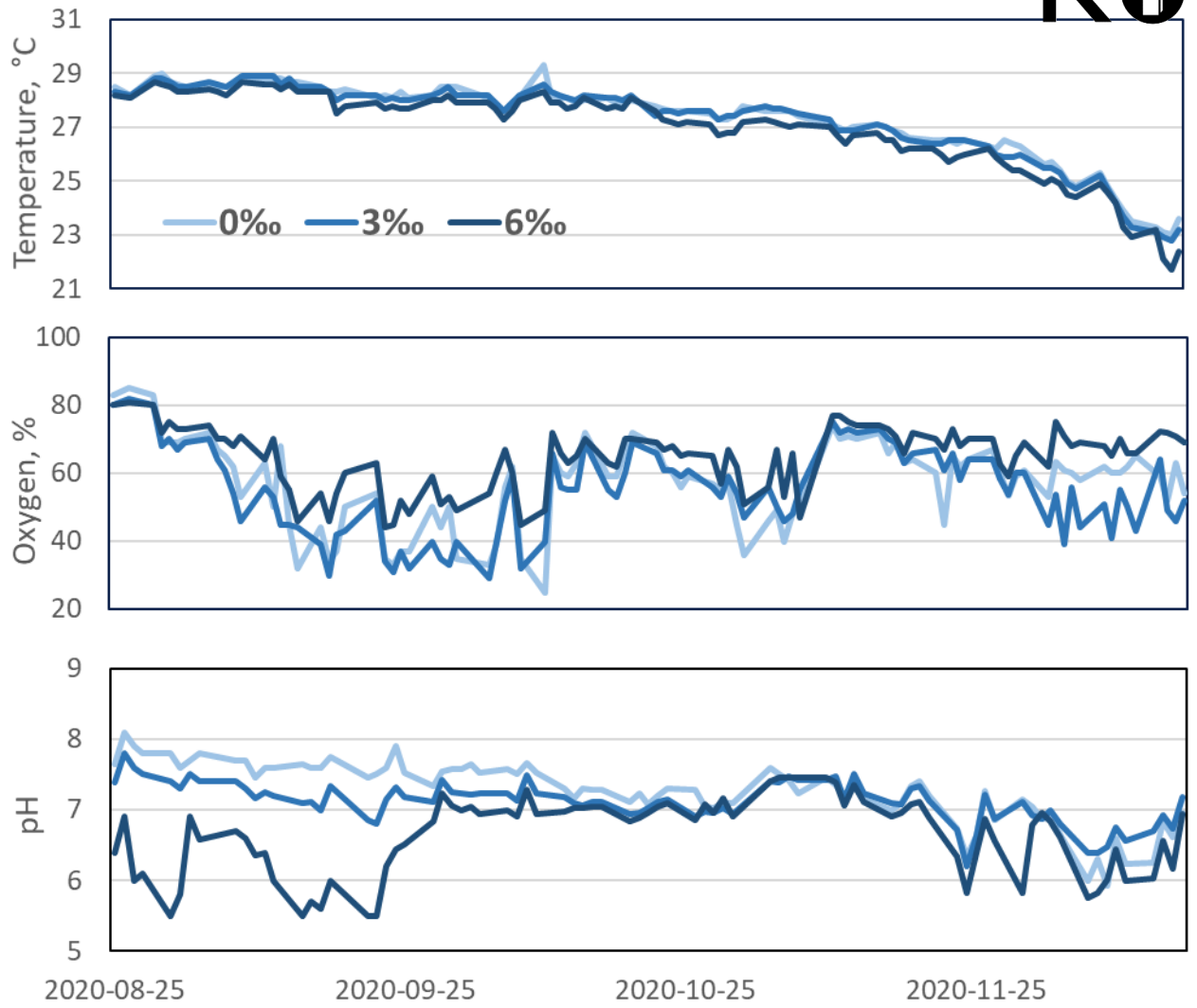


- 3 RAS (8 m^3 each) x3 replicate tanks
- Experiment time – 4 months
- Water quality, survival, growth, harvested biomass, reproduction patterns, osmoregulatory physiology, meat quality tested



SYSTEM PERFORMANCE

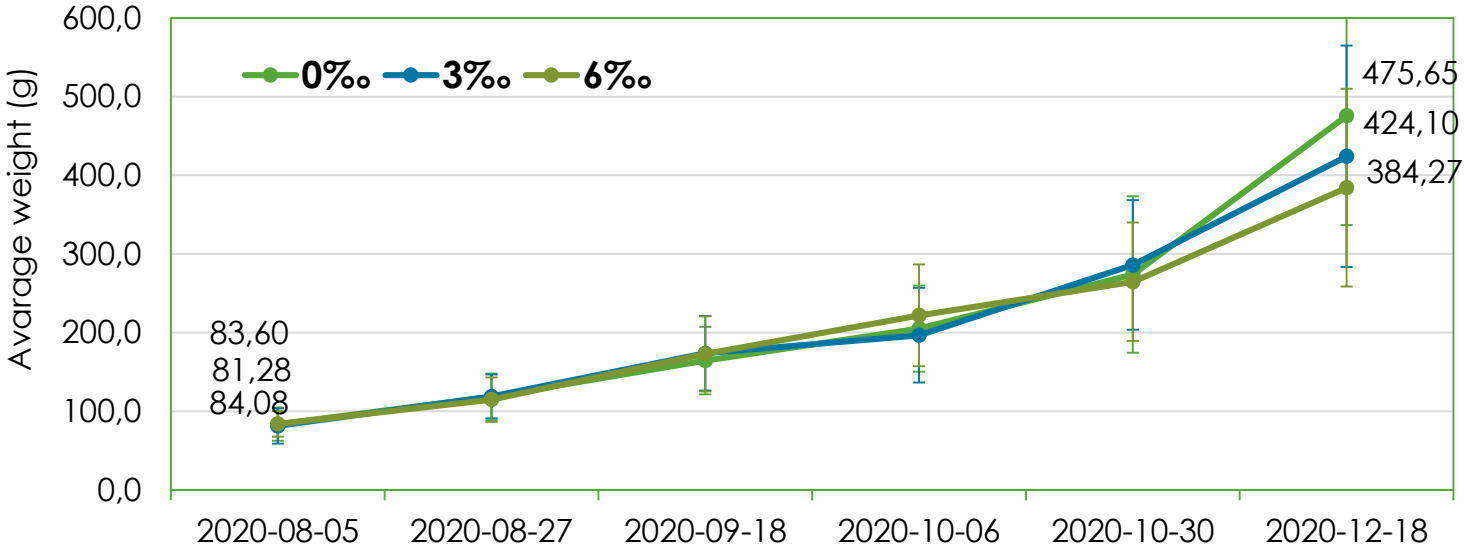
- Basic water parameters trends were similar...
- ...while water quality was hard to keep the same in all salinities under the standard freshwater RAS technology

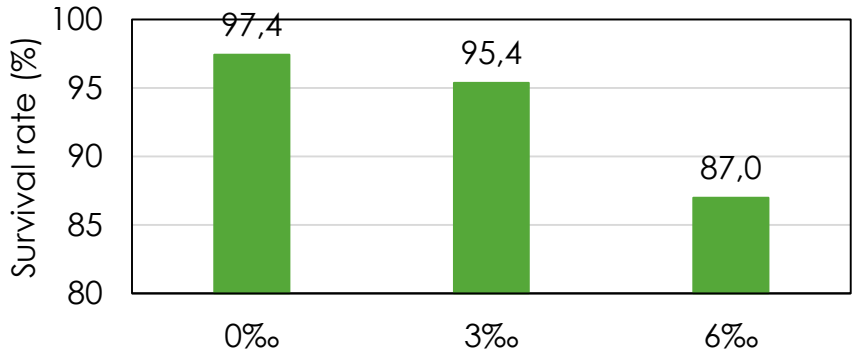


EFFECT OF SALINITY ON GROWTH and SURVIVAL

- Brackish water had no significant effect on growth rate of tilapia.
- The growth rate was similar in all treatments
- The lowest survival was observed in the brackish water conditions

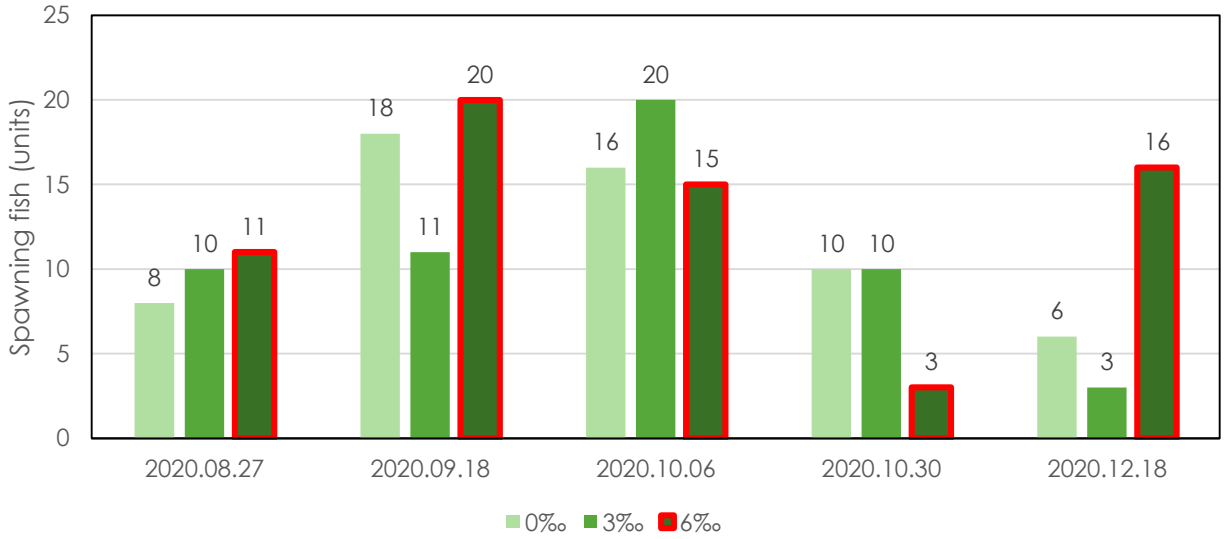
This could be the side effect of deteriorated water quality in 6ppt system

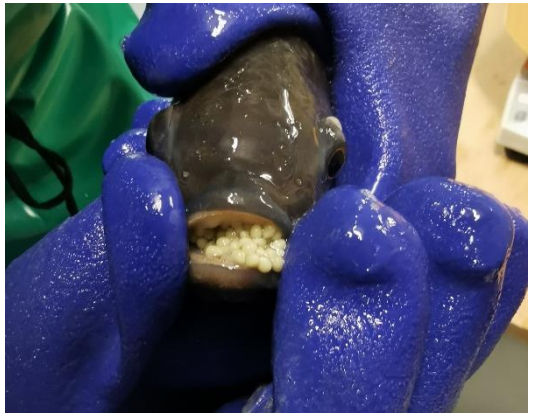


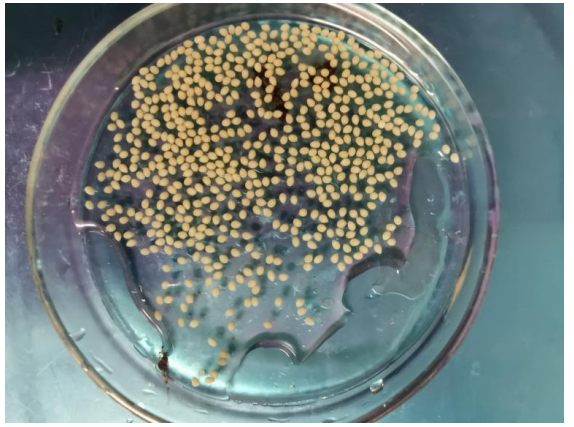


REPRODUCTIVE TRAITS

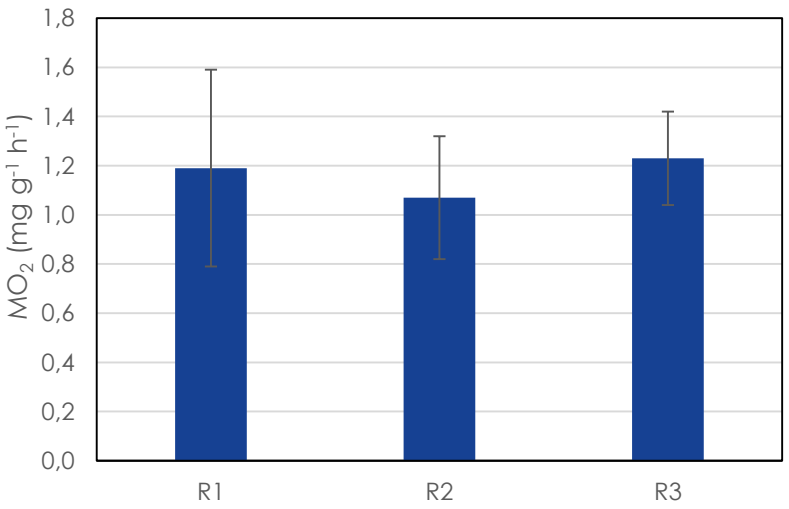
- Sex of Tilapia was determined by painting papilla.
- Spawning females were identified by having brood (eggs or larvae) in the mouth
- The spawning fish were most common in 6 ppt RAS system

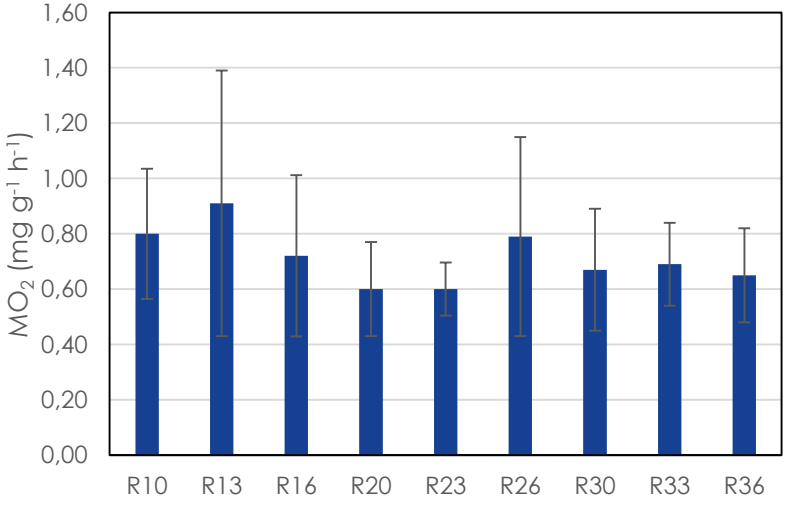




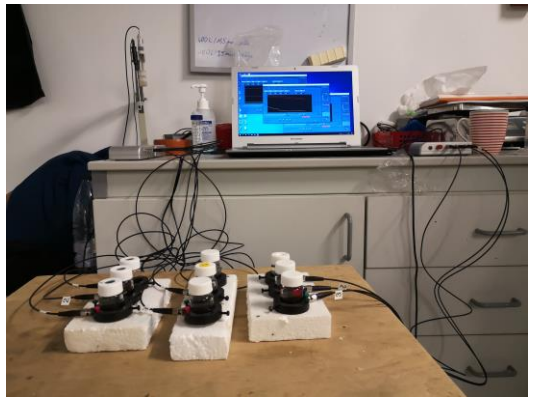


SALINITY DOESN'T MATTER FOR JUVENILES TOO?



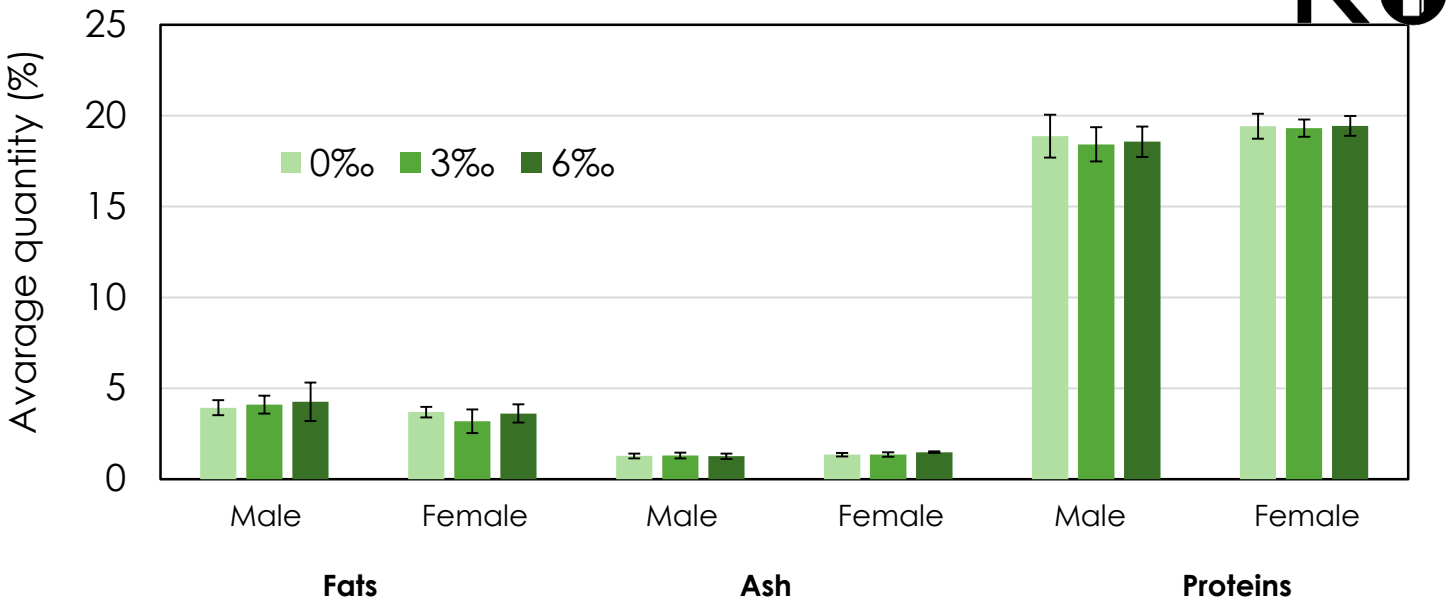


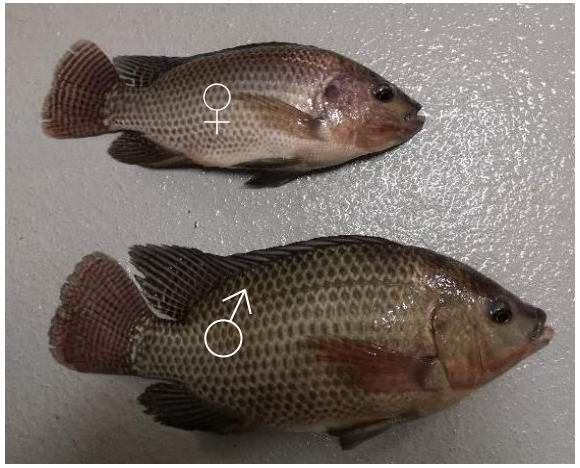
No osmoregulatory stress were detected for tilapia juveniles by measuring SMR



SO MAYBE SALINITY MATTERS FOR CONSUMERS???

- No differences in meat quality (fat, protein, ash, dry matter water content, water binding activity, pH) were detected for males and females of tilapia
- Nor for different salinity treatments





Salinity effect was determined for organoleptic parameters - smell and taste which were better in fish reared in brackish water, compared to muddy taste of freshwater system fish.

NEW AQUAVIP EXPERIMENT WITH GEOTHERMAL BRINE

- Rainbow trout grow-out (from 100g to 1kg)
- 3x3 experimental groups with 6 ppt salinity of different origin:
  - ***Baltic Sea water***
  - ***LCSM***
  - ***Geothermal brine***
- Estimation of growth performance, physiology, survival, ***bioaccumulation***

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Thank You!

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