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Klaipeda University

# AQUALOOP PILOT PROTOCOL

## *"FISHVISA – Fish-Shrimp-Vegetables Integrated System of Aquaponics to showcase circular economy principles in RAS"*

**September 2026**






**AquaLoop** - *Aquaculture expert floor for circular economy practice,* Interreg South Baltic
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# I. INTRODUCTION

The transition to circular aquaculture in the South Baltic region is essential for addressing key environmental, economic, and social challenges. By promoting more efficient resource use, reducing waste, and closing nutrient loops, circular aquaculture contributes to the green transition while supporting regional resilience and competitiveness. It is fully aligned with European sustainability objectives and regional policy frameworks, providing a pathway towards a more sustainable and resource-efficient aquaculture sector.

The **AquaLoop - *Aquaculture expert floor for circular economy practice* Interreg South Baltic** project aimed to develop, promote, and support the implementation of circular aquaculture in the South Baltic region, with a particular focus on nutrient loop closure and the valorisation of aquaculture by-products to foster responsible production and consumption.

To achieve these objectives, the project developed and demonstrated innovative circular aquaculture solutions while strengthening the capacities of current and future professionals, businesses, and consumers to support the sector's transition. The consortium brought together universities, municipalities, industry associations, and SMEs, creating a strong partnership that combined research, education, stakeholder engagement, and practical industry application. This multidisciplinary approach was fundamental to developing and implementing circular economy solutions that can be effectively adopted in practice.

A key element of the project's approach was the close cooperation between partners in the joint development of tailored solutions to strengthen human resource capacities. This was achieved through the design and implementation of **three cross-border pilots** within the range of activities jointly called **PilotLoops**, which tested innovative methods and tools while demonstrating practical approaches to circular aquaculture under real-life conditions in the South Baltic region.

## I.1. PilotLoops – Circular aquaculture South Baltic pilots

Three pilots tested and demonstrated innovative production methods aimed at reducing waste and water use, while generating valuable by-products and lowering environmental impacts. The work involved in-depth analysis and close cooperation with associated partners, enabling the exchange of data and practical solutions and supporting testing from lab to farm scale. This collaboration was supported by the use of commercially relevant technologies and enabled a continuous exchange of data and solutions. In addition, the project delivered jointly developed protocols to support further uptake by enterprises. These outputs also provided important input for the project's training and support activities, helping to ensure that the results could be effectively applied in practice.

**AquaLoop Pilot 1 – TARAS - *Testing Algae Applications in Re-circulating Aquaculture Systems (RAS) to improve aquaculture circularity potential in the SB region***. Coordinating partner: University of Gdańsk (PL). The aim of the pilot was to further develop technology on cultivation of shrimps and specific strains of microalgae, for RAS facilities, processing water purification, while producing high-value algal biomass, and to demonstrate applications of the biomass produced.

- **AquaLoop Pilot 2 - NEMATIC - *Increasing the nutrient efficiency of commercial aquaculture through increased application of circular economy concepts.*** Coordinating partner: University of Rostock (DE). The idea of the pilot was to research and test the unused residues from fish production. Specifically, the biochemical composition of the gonads, livers and skins of African catfish (*Clarias gariepinus*), rainbow trout (Oncorhynchus mykiss) and pikeperch (*Sander lucioperca*) will be investigated, and possible and practical potential paths of utilization will be tested.

- **AquaLoop PILOT 3 – FISHVISA – Development of the Fish-Shrimp-Vegetables Integrated System of Aquaponics to showcase the potential of circular economy principles in RAS.**

Coordinating partner: Klaipeda University (LT). The pilot developed and tested a small glasshouse aquaponics system combining freshwater fish, crayfish and vegetables. Fish side streams were investigated as a food resource for crustaceans, while plants used dissolved nutrients circulating through the system. The work assessed sludge management and organism production and supported practical training in circular aquaculture.

## I.2. FISHVISA pilot – background and aim

FISHVISA – Development of the Fish-Shrimp-Vegetables Integrated System of Aquaponics to showcase the potential of circular economy principles in RAS – was implemented by the Fisheries and Aquaculture Laboratory of the Marine Research Institute at Klaipeda University, Lithuania. The pilot investigated whether adding a freshwater crustacean compartment to aquaponics could improve the use of particulate aquaculture side streams while maintaining fish and vegetable production.

Conventional aquaponics combines fed fish with plants that use dissolved nutrients circulating through a water treatment system. FISHVISA added a complementary function: crustaceans were expected to consume fish faeces and uneaten feed before the remaining solids were removed mechanically. This offered a practical way to test whether a side stream normally treated as waste could support another cultured organism and reduce the solids load passing through the system.

The pilot addressed three linked questions: whether crayfish consume aquaponic sludge, whether their presence reduces the amount of collectable sludge leaving the crustacean tank, and whether sludge-based feeding supports crustacean growth. Fish and plant growth, water quality and operational performance were monitored alongside these questions. The choice of freshwater species reflected regional relevance,

access to stocking material and the need to operate fish, crustaceans and plants within a shared temperature regime.

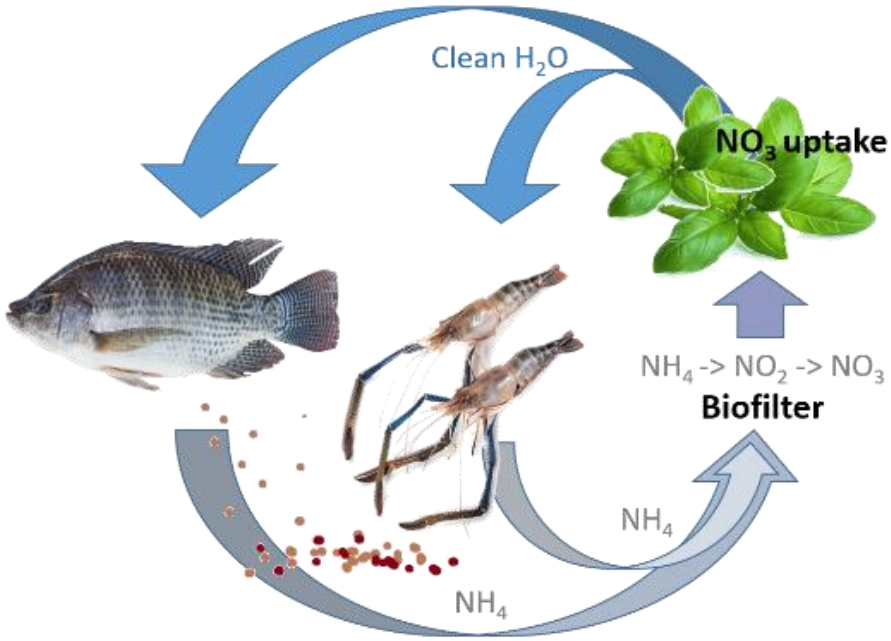



**Fig. 1.** FISHVISA concept scheme.

The principal result was that sludge handling and crustacean production must be evaluated separately. The cold-water trout–noble crayfish–lettuce trials indicated a reduction in collectable sludge, but no consistent increase in crayfish biomass. In the cool-water sturgeon–narrow-claw crayfish–basil trials, sludge reduction was small and variable, while crayfish biomass declined. Separate feeding trials confirmed sludge ingestion and showed modest growth on dried sludge. These findings support further optimisation of the crustacean compartment rather than a claim that a fully productive, zero-waste system has been demonstrated.

The specific objectives of the FISHVISA pilot were:

- to adapt and operate a glasshouse aquaponics facility as a freshwater multi-trophic demonstration system;
- to compare fish–plant cultivation with fish–crayfish–plant cultivation through successive production cycles;
- to monitor water quality, organism growth and collectable solids at the fish and crayfish outlets;
- to investigate sludge ingestion and growth in complementary crayfish feeding experiments;
- to translate pilot activities and results into practical training for school youth, university students and aquaculture professionals.

# II. FISHVISA PILOT IMPLEMENTATION

## II.1. Pilot facility and system configuration

The FISHVISA facility was established in a 19 m² glasshouse at the Fisheries and Aquaculture Laboratory in Kopgalis, Klaipeda. Its approximate total system volume was 3.5

m³. Existing aquaponics infrastructure was prepared and adapted during the first project periods, followed by experimental operation, monitoring and demonstrations throughout the project.

The installation comprised a fish tank, a separate crustacean tank, a sedimentator, a mechanical backwash filter, a biological filter, a water reservoir and three plant beds containing expanded clay. Water recirculation, aeration, pH control, supplementary LED lighting and glasshouse climate control supported operation. A Senect monitoring system was included in the pilot configuration presented at the AquaLoop final conference.

The technical description in the FISHVISA-based coursework identifies a fish tank of approximately 1.1 m³, a 0.4 m³ crayfish tank, a 0.34 m³ biofilter, a 0.34 m³ reservoir and three plant beds of approximately 0.23 m³ each. Each plant bed provided about 0.6 m² of planting area. These are nominal component capacities; their sum is not a measurement of actual operating water volume because plant beds contain substrate and tanks are not necessarily filled to nominal capacity.

Two circulation pumps were described, each rated at 65 W with a nominal capacity of 9,000 L $h^{-1}$. These are equipment ratings, not verified flow measurements through the crayfish tank. Aeration was supplied to the fish tank, biofilter and plant beds. Plastic pipe shelters, approximately 50 mm in diameter, were provided in the crayfish compartment. The mechanical filter was identified as EconoBead EB-40 in the coursework description.

Supplementary lighting and temperature management were important because seasonal glasshouse conditions influenced the selection and timing of species combinations. Sun-screen installation was included among the infrastructure adjustments discussed during project implementation. The facility therefore served both as an experimental installation and as an accessible demonstration platform for circular aquaculture.





**Fig. 1.** FISHVISA glasshouse and principal system components.

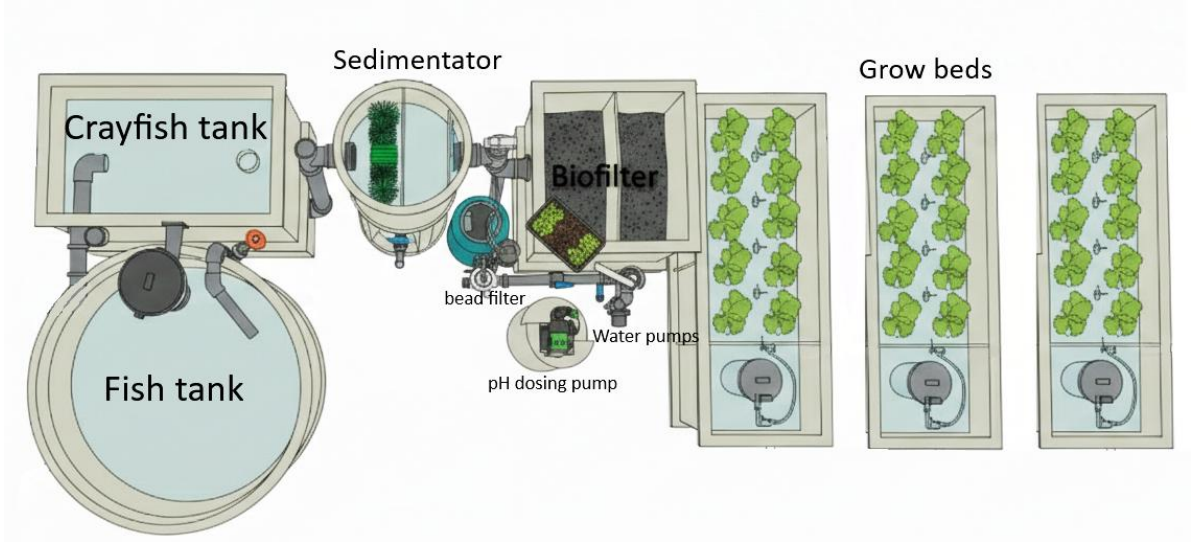



**Fig. 2.** Layout and water circulation in the FISHVISA aquaponics system.

## II.2. Species selection and implementation sequence

The initial warm-water concept combined Nile tilapia, Australian red-claw crayfish and vegetables. Tilapia were supplied through cooperation with the Swedish project partner, while Australian red-claw crayfish were obtained from Latvia in April 2024. A technical accident resulted in the loss of the tilapia stock during preliminary testing. The experimental sequence was consequently adjusted, beginning with a cold-water combination before progressing to cool-water and, later, warm-water operation.

The main cold-water experimental combination was rainbow trout (Oncorhynchus mykiss), noble crayfish (Astacus astacus) and lettuce (Lactuca sativa). The subsequent cool-water combination comprised Siberian sturgeon (Acipenser baerii), narrow-claw crayfish (Astacus leptodactylus, as named in the project materials) and basil (Ocimum basilicum). Early planning documents use some inconsistent common or scientific names; the species assignments here follow the final-conference presentation and the later experimental descriptions.

In July 2026, the fish tank was stocked with African catfish (Clarias gariepinus) and operated with basil. Small stocks of giant freshwater prawn (Macrobrachium rosenbergii) and Australian red-claw crayfish (Cherax quadricarinatus) were procured as candidates for subsequent warm-water integration and TrainingLoop activities. Their acquisition is documented, but a completed comparative warm-water crustacean trial is not reported in the supplied materials.

**Table 1.** Implementation sequence and status of FISHVISA species combinations.

| Stage | Species combination | Documented implementation |
|---|---|---|
| Preparation and commissioning | Rainbow trout with vegetables and herbs | System preparation and testing during 2023–2024; warm-water tilapia trial interrupted by a technical accident. |
| Cold-water trials | Rainbow trout, noble crayfish and lettuce; fish–lettuce controls | Three fish–lettuce control cycles, followed by three cycles with crayfish; principal experimental work in 2024–2025. |
| Cool-water trials | Siberian sturgeon, narrow-claw crayfish and basil; fish–basil controls | Three crayfish-integrated cycles reported in PR5; fish–basil operation continued in PR6. Some detailed cycle records remain incomplete or inconsistent. |
| Warm-water continuation | African catfish and basil; candidate prawns and red-claw crayfish | African catfish–basil operation launched in July 2026. Crustacean integration and comparative performance require further testing. |

The temperature bands presented in the final-conference experimental plan were 16–20 °C for the cold-water combination, 20–24 °C for the cool-water combination and approximately 25 °C for the intended warm-water combination. These describe the experimental design rather than continuous measured conditions for every cycle. The available sturgeon-cycle measurements averaged approximately 20 °C.

## II.3. Experimental design and monitoring

FISHVISA was evaluated through successive cultivation cycles in one shared pilot installation. Fish–plant cycles without crayfish provided an operational reference, followed by cycles in which crayfish were added between fish production and downstream solids treatment. This design allowed practical comparisons over time, but did not provide independent, simultaneously operated replicate systems.

For the cold-water combination, three trout–lettuce cycles were completed from September 2024 to January 2025, followed by three cycles including noble crayfish. The reported cycle duration was 28–40 days, with the initial control cycles lasting approximately 32–35 days. Lettuce varieties included Gelbus, Dark roden and Aficion. Approximately 19–20 seedlings were planted per bed, giving around 60 plants across the three beds at nominal stocking.

The final-conference presentation reports a fish-density range of approximately 20–50 kg $m^{-3}$, or around 40 fish per tank, for the trout trials. Some earlier progress materials label fish density in kg $m^{-2}$; this conflicts with the later volumetric notation. The exact stocking biomasses and operating tank volumes should be confirmed before using

these values as a prescriptive stocking protocol. An early crayfish-integrated cycle was described as 15 noble crayfish in the 0.4 $m^3$ compartment.

For the cool-water combination, nominal fish density was approximately 10–15 kg $m^{-3}$. Narrow-claw crayfish were stocked at approximately 40 individuals per tank, corresponding to a reported bottom-area density of 52 individuals $m^{-2}$. Basil was normally planted at 20 seedlings per bed, although actual numbers varied between cycles. Cultivation periods of approximately 30–35 days were used in the project summaries.

Fish and crayfish were weighed and counted at the beginning and end of cultivation cycles. Length measurements were also included in the monitoring plan. Recorded performance indicators included biomass, individual weight, survival, feed input and, where complete records were available, feed conversion and specific growth rate. Plants were assessed using height, weight, leaf number and visual condition; basil harvest measurements in the coursework also included root length and root biomass.

Water monitoring covered temperature, dissolved oxygen and pH, together with ammonium, nitrite, nitrate, phosphate, magnesium, calcium, potassium and iron. The coursework describes spectrophotometric measurements using a Hanna Iris instrument, with nitrogen compounds and phosphate generally measured twice weekly and additional mineral parameters weekly. Alkalinity was measured using a Salifert KH/Alk test kit. Sampling frequency and completeness varied in the available records.

Sludge was periodically collected at the fish-tank and crayfish-tank outlets. The coursework describes a 200 µm filter bag and a 24-hour collection period. Collected sludge was weighed to compare the material entering and leaving the crayfish compartment. These measurements quantify collectable sludge under the stated collection conditions; no consistent dry-matter correction is supplied for the full dataset.

For matched sampling periods, apparent sludge reduction can be expressed as $E = 100 \times (M_{fish} - M_{crayfish}) / M_{fish}$, where $M_{fish}$ and $M_{crayfish}$ are the sludge masses collected at the respective outlets. A negative result means that more collectable solids were measured after the crayfish compartment. It must not be automatically set to zero or interpreted as evidence of ingestion.

Specific growth rate is expressed as $SGR = 100 \times [\ln(W_{final}) - \ln(W_{initial})] / t$, where t is the number of days and the weights must refer to comparable individuals or consistently defined biomass. Survival is $100 \times N_{final} / N_{initial}$. Feed conversion ratio requires feed input divided by biomass gain, with stock changes and mortalities accounted for. Indicators are not recalculated here when dates, animal identity or biomass accounting are incomplete.

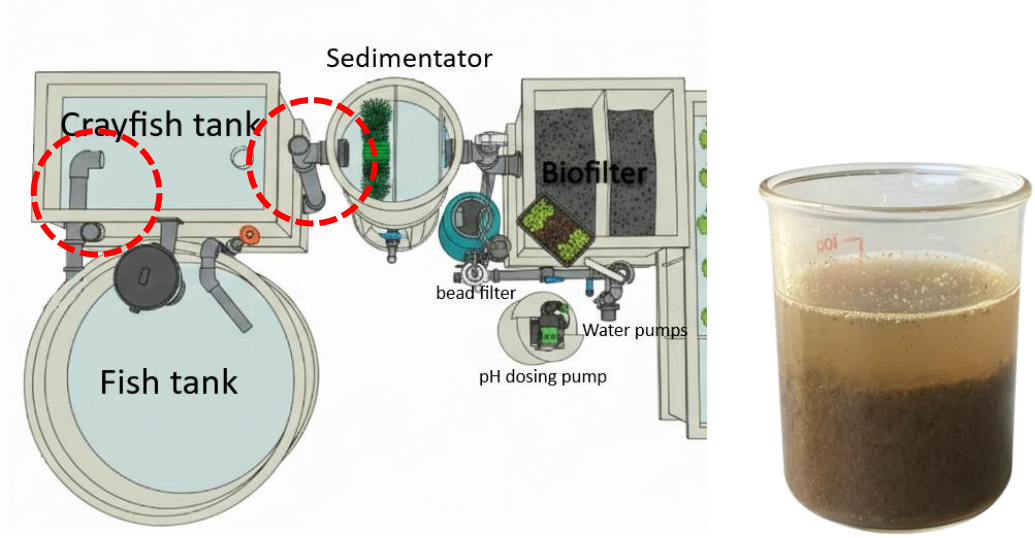



**Fig. 3.** Monitoring and sludge collection in the FISHVISA pilot.

## II.4. Cold-water trials with rainbow trout noble crayfish and lettuce

The cold-water trials demonstrated that rainbow trout and lettuce could be cultivated in the glasshouse aquaponics system, both before and after adding crayfish. The three initial fish–lettuce control cycles provided the first operational reference. PR3 and the April 2025 progress presentation report average production of approximately 7.9 kg of lettuce and 8.2 kg of fish per cycle. These are reported project-summary values; the underlying cycle-level trout records were not included among the supplied spreadsheets, so their calculation basis cannot be independently reconstructed here.

The subsequent three crayfish-integrated cycles tested whether noble crayfish could use fish faeces and uneaten feed without receiving supplementary feed. The final-conference presentation reports trout growth of approximately 0.3% day$^{-1}$ SGR. Lettuce continued to grow successfully. PR4 reports approximately 15 kg of plant biomass during this stage, but does not specify sufficiently clearly whether this is a per-cycle or pooled value; it is therefore not used as a directly comparable yield against the 7.9 kg control-stage value.

Collected sludge leaving the fish tank was greater than the amount leaving the crayfish tank. The project's principal interpretation, reported in PR4 and the final-conference presentation, was that noble crayfish contributed to approximately 40% reduction in collectable sludge. The presentation also contains a 57% annotation within a figure, without enough textual context to establish its aggregation basis. Approximately 40% is retained as the narrative summary rather than combining the two percentages.

This result indicates a potentially useful solids-handling function under the tested conditions. It does not demonstrate that all missing sludge was converted into crayfish biomass: settling within the tank, fragmentation, mineralisation and sampling differences could also contribute to the outlet difference. The absence of a complete solids and nutrient mass balance limits attribution of the observed reduction to ingestion alone.

Crayfish did not show consistent growth on the available in-system diet, and biomass losses were reported. The cold-water experiment therefore met the practical objective

of demonstrating fish and lettuce cultivation and indicated a sludge-management benefit, but did not establish a commercially productive crayfish crop supported solely by fish side streams.

[INSERT PHOTO / FIGURE HERE]

**Fig. 4.** Cold-water FISHVISA combination of rainbow trout noble crayfish and lettuce. Insert photographs of the stocked fish tank, crayfish compartment and lettuce beds during a documented trial cycle.

[INSERT PHOTO / FIGURE HERE]

**Fig. 5.** Collectable sludge in the cold-water trials. Insert the verified trout–noble crayfish sludge comparison graph. Confirm the cycle values, wet or dry mass basis, units, error bars and the distinction between the approximately 40% summary and the 57% annotation before insertion.

## II.5. Cool-water trials with Siberian sturgeon narrow-claw crayfish and basil

The cool-water experiment extended the FISHVISA concept to Siberian sturgeon and basil. Three crayfish-integrated cycles were reported as completed in PR5, followed by sturgeon–basil cultivation without crayfish during PR6. At the time of the final conference in February 2026, two integrated cycles had been completed and a third was ongoing. This reflects the reporting date of the presentation rather than the final status of project implementation.

The available evidence comprises the final-conference summary, a working spreadsheet, a short results document and the later coursework by Vaclovas Jazdauskas. These materials agree on successful basil cultivation and limited crayfish performance, but some cycle dates, stock counts and biomass values do not agree. Results from different versions are therefore identified explicitly rather than silently merged.

**Fish and plant performance**

The final-conference presentation reports sturgeon SGR of approximately 0.6% day$^{-1}$. The working spreadsheet documents one completed fish record with seven sturgeon, initial biomass of 10.0 kg, final biomass of 11.8 kg and survival of 100%. It records 3.432 kg of feed and an FCR of approximately 1.89 for that record. Its first cycle has no final fish-performance values, and the accompanying short document flags fish mortality during that stage.

The later coursework contains a different three-cycle biomass series: 14.9 to 14.9 kg, 11.8 to 13.48 kg and 13.9 to 14.47 kg. These records support growth during at least

part of the experimental programme, but they cannot be aligned confidently with every spreadsheet cycle. They are not used here to calculate a pooled growth rate or a definitive treatment effect. [TO CONFIRM: reconcile fish transfers, mortalities, cycle dates and final stock records before approving a final fish-performance table.]

Basil grew successfully in the system. The working spreadsheet provides complete harvest records for two cycles, with total plant biomass of 7.688 kg from 60 plants and 7.361 kg from 47 plants. Mean individual final weights were 128.15 ± 42.39 g and 156.64 ± 87.78 g, respectively, using the individual measurements and sample standard deviations. The mean harvest biomass across these two cycles was approximately 7.52 kg, close to the 7.51 kg reported in the final-conference presentation. The table retains the spreadsheet summary totals; summing the individual weights gives 7,689.0 and 7,361.9 g, respectively, a small aggregation difference requiring reconciliation in the final dataset.

**Table 2.** Basil production in the two cycles with complete harvest records.

| **Indicator** | **Cycle 1** | **Cycle 2** |
|---|---|---|
| Number of measured plants | 60 | 47 |
| Initial total plant biomass g | 38.76 | 29.50 |
| Final total plant biomass g | 7,688 | 7,361 |
| Mean initial individual weight g | 0.646 | 0.628 |
| Mean final individual weight g ± SD | 128.15 ± 42.39 | 156.64 ± 87.78 |
| Net increase in total plant biomass g | 7,649.24 | 7,331.50 |

The larger individual plants in the second cycle occurred with fewer plants in the beds. This is a possible density-related explanation, not an experimentally isolated density effect. Harvest values refer to the recorded plant biomass; a separate marketable shoot yield is not consistently distinguished from total plant mass. The third cycle has initial plant weights in the supplied spreadsheet but no complete final harvest record and is therefore excluded from this quantitative comparison.

The coursework extends the plant analysis to root biomass, with roots commonly accounting for approximately 25–50% of total plant weight. This supports a description of substantial root development in the expanded-clay substrate. Root weight alone does not quantify nutrient uptake or nitrogen and phosphorus recovery, which would require tissue composition and a system mass balance.

[INSERT PHOTO / FIGURE HERE]

**Fig. 6.** Basil growth and harvest in the cool-water FISHVISA trials. Insert photographs of basil seedlings, established plants and measured harvests. If a root-to-total biomass plot is included from the coursework, verify its dataset, cycle labels and statistical test first.

**Crayfish performance**

Both the working records and the later coursework show losses in total narrow-claw crayfish biomass. In the two complete working-spreadsheet records, biomass changed from 1,234.9 to 1,086.1 g and from 1,086.1 to 1,069.1 g. Counts changed from 40 to 35 and from 35 to 34 individuals, corresponding to survival of 87.5% and 97.1%. Small increases in mean survivor weight did not compensate for mortality.

The coursework reports a separate consolidated three-cycle series, reproduced below as provisional coursework results. It must be reconciled with the working spreadsheet before the series is treated as a single final experimental dataset. The first final biomass is interpreted as 1,169.0 g from the reported difference of −65.9 g; the coursework cell itself contains a mixed-unit entry of "1,169".

**Table 3.** Provisional narrow-claw crayfish results reported in the FISHVISA-based coursework.

| **Indicator** | **Cycle 1** | **Cycle 2** | **Cycle 3** |
|---|---|---|---|
| Initial number | 40 | 40 | 40 |
| Final number | 38 | 36 | 37 |
| Survival % calculated from counts | 95.0 | 90.0 | 92.5 |
| Initial total biomass g | 1,234.9 | 1,211.0 | 1,137.7 |
| Final total biomass g | 1,169.0* | 1,103.0 | 1,051.6 |
| Change in total biomass g | −65.9 | −108.0 | −86.1 |

*Unit interpretation described above; final confirmation is required. These values belong to the coursework series and are not substituted for the different counts and weights in the working spreadsheet. Both series nevertheless support the same operational conclusion: the tested in-system feeding and stocking conditions did not produce a net increase in crayfish biomass.

Mortality, competition for food and shelters, and sludge accumulation were identified as possible constraints in the coursework discussion. These were not isolated experimentally and should be treated as explanations requiring further testing. The results support adjustment of stocking density, tank layout, solids retention and feeding strategy before expecting crayfish production as an additional crop.

**Sludge collection results**

The final-conference presentation and PR5 describe only a small or inconsistent sludge-management effect in the sturgeon–narrow-claw crayfish combination. The working spreadsheet summarises approximately 132.5 g per 24 h after fish and 115.0 g after crayfish at one feeding level, and 135.0 g versus 144.4 g at a higher feeding level. These are recorded outlet summaries; differences in feed entries and sampling alignment prevent their interpretation as a controlled feeding-rate response.

The coursework presents five paired sludge collections of 120/130, 105/35, 130/105, 85/90 and 95/95 g after the fish/crayfish tanks, respectively. Their means are 107.0 ± 18.23 g and 91.0 ± 34.89 g. The mean difference is 16 g per collection, or approximately 15.0% when expressed as the difference between the two mean outlet masses relative to the fish outlet.

For these five pairs, the differences vary from −10 to +70 g. Three pairs show no positive reduction, and the average difference is strongly influenced by one collection. These observations do not establish a consistent crayfish effect. The 15.0% ratio of means is also different from the mean of the five individual percentage reductions and must be labelled accordingly if plotted.

In addition, retained material can accumulate in the crayfish tank and be released later. Outlet mass differences are therefore an apparent solids-reduction indicator rather than direct measurements of ingestion, digestion or nutrient recovery. The cool-water trial did not demonstrate reliable replacement of mechanical solids removal by narrow-claw crayfish.

[INSERT PHOTO / FIGURE HERE]

**Fig. 7.** Sludge collected at the fish and crayfish outlets in the cool-water trials. Insert a graph of the five paired coursework collections, retaining negative differences. Identify these as a separate dataset from the working-spreadsheet feeding-level summaries and specify the collection duration and mass basis.

## II.6. Water quality and system performance

The cool-water spreadsheet records oxygenated water throughout the sampled periods. Cycle means for dissolved oxygen ranged from approximately 8.2 to 8.9 mg $L^{-1}$, with oxygen saturation means of about 91–100%. Mean temperature remained close to 20 °C, while mean pH decreased from approximately 7.56 in the first recorded cycle to 6.95 in the third.

**Table 4.** Water-quality summaries for the recorded sturgeon–basil cycles mean ± SD.

| **Parameter** | **Cycle 1** | **Cycle 2** | **Cycle 3** |
|---|---|---|---|
| Dissolved oxygen mg $L^{-1}$ | 8.90 ± 0.70 | 8.50 ± 0.60 | 8.22 ± 0.19 |
| Oxygen saturation % | 99.6 ± 5.6 | 94.4 ± 3.7 | 90.6 ± 1.2 |

| Parameter | Cycle 1 | Cycle 2 | Cycle 3 |
|---|---|---|---|
| Temperature °C | 20.40 ± 0.90 | 20.20 ± 1.41 | 19.92 ± 0.46 |
| pH | 7.56 ± 0.20 | 7.38 ± 0.30 | 6.95 ± 0.05 |
| $NH_4$ as labelled mg $L^{-1}$ | 1.63 ± 1.36 | 0.38 ± 0.09 | 0.36 ± 0.10 |
| $NO_2$ as labelled mg $L^{-1}$ | 0.26 ± 0.16 | 0.11 ± 0.04 | 0.31 ± 0.13 |
| $NO_3$ as labelled mg $L^{-1}$ | 40.50 ± 30.78 | 28.45 ± 10.55 | 37.89 ± 21.32 |
| $PO_4$ as labelled mg $L^{-1}$ | 31.20 ± 8.97 | 20.78 ± 12.87 | 17.64 ± 2.30 |

The table follows the supplied summary values and parameter labels. The analytical reporting basis, for example $NH_4$ versus $NH_4$-N and $PO_4$ versus $PO_4$-P, should be confirmed against the instrument methods before comparison with external thresholds or nutrient budgets. Sample numbers differ among parameters, and cycle boundaries for some records are marked as uncertain in the spreadsheet. The summaries describe the observations and are not proof of optimal conditions throughout cultivation.

Ammonium was highest and most variable in the first recorded cycle; the underlying measurements include a maximum of 3.86 mg $L^{-1}$ under the spreadsheet's $NH_4$ label. Nitrite was measurable in all cycles. These findings indicate the need to follow biofilter performance, feeding load and pH alongside oxygen. Well-oxygenated water alone does not establish that all water-quality requirements have been met.

The nutrient records also show changes in mineral availability. Reported cycle means were approximately 9–11.7 mg $L^{-1}$ for magnesium, 30–145 mg $L^{-1}$ for calcium, 58–131 mg $L^{-1}$ for potassium and 0.16–0.28 mg $L^{-1}$ for iron. Some cycle values are based on very few measurements. Their practical significance is that plant nutrition and fish welfare must be managed together, using verified methods and a documented supplementation regime where needed.

Fish and plants were maintained successfully during substantial parts of the pilot, but the available sequential-cycle observations do not establish statistical equivalence between systems with and without crayfish. No complete nitrogen, phosphorus, dry-solids, water-use or energy balance is available. Consequently, the pilot demonstrates operational feasibility and identifies management constraints, while quantitative claims about overall resource savings or environmental benefits remain to be verified.

**Fig. 8.** Water-quality dynamics during FISHVISA cultivation. Insert verified time-series graphs for temperature, oxygen, pH and nitrogen compounds. Use confirmed cycle dates and analytical units; do not copy reference-limit lines from earlier presentations without checking their applicability.

## II.7. Complementary crayfish feeding experiments

Complementary feeding experiments were undertaken to distinguish direct sludge consumption from the broader effects of operating a crayfish tank within aquaponics. Early exploratory work included Australian red-claw crayfish offered fish feed, sludge,

algae, trout meat and a fish-feed–carrot combination. The supplied April 2025 presentation documents these treatments, but does not provide a complete quantitative dataset for reporting their comparative growth performance.

More detailed feeding trials used narrow-claw crayfish and compared commercial feed with dried sludge or wet sludge from the aquaponics system. Bachelor students and secondary school pupils participated in this work. The final-conference description specifies three individuals per box, nine individuals per treatment, a duration of approximately one month and a nominal feeding rate of 10% of body weight. The worksheet records mean temperatures of approximately 17.6 and 19.4 °C for the two trials.

The two sludge trials should be interpreted separately because they were not a single simultaneous three-treatment experiment. In addition, a ration expressed as a percentage of body weight does not ensure equal dry matter or energy input when wet sludge, dried sludge and commercial pellets are compared.

**Table 5.** Descriptive results of the narrow-claw crayfish feeding trials from the individual weight records.

| Trial and diet | Initial/final n | Initial mean g ± SD | Final mean g ± SD |
|---|---|---|---|
| Dried-sludge trial commercial feed | 9 / 9 | 23.46 ± 2.66 | 24.69 ± 2.53 |
| Dried-sludge trial dried sludge | 9 / 9 | 22.54 ± 2.90 | 23.49 ± 3.13 |
| Wet-sludge trial commercial feed | 9 / 8 | 24.64 ± 1.36 | 25.20 ± 1.44 |
| Wet-sludge trial wet sludge | 9 / 7 | 24.13 ± 1.77 | 24.99 ± 1.75 |

All nine animals in each treatment of the dried-sludge trial had final weights. Mean individual weight increased by approximately 1.23 g with commercial feed and 0.94 g with dried sludge, corresponding to descriptive increases of about 5.3% and 4.2% over the trial. These observations show that dried aquaponics sludge was consumed and could support a modest weight increase under the tested conditions. They do not establish nutritional equivalence to commercial feed.

In the wet-sludge trial, the final mean weights refer to eight commercial-feed survivors and seven wet-sludge survivors, whereas initial means include all nine animals. Survival was therefore approximately 88.9% and 77.8%. Increases in survivor mean weight must not be presented as an equivalent increase in total treatment biomass. Total recorded biomass declined from 221.8 to 201.6 g in the commercial-feed group and from 217.2 to 174.9 g in the wet-sludge group.

Wet sludge was difficult to portion, handle and quantify. Dried sludge flakes remained stable in water long enough to permit more convenient feeding observations. The improved handling of dried material is operationally useful, but its apparent advantage over wet sludge cannot be separated from differences in moisture content, trial conditions and mortality without a standardised comparison.

Because three animals shared each box, the box is the relevant independent husbandry unit for a treatment comparison. Individual animals within a box cannot automatically be treated as nine independent replicates. No formal treatment-equivalence claim is made from the descriptive results supplied. Several worksheet dates also contain inconsistent years and should be checked before a final experimental chronology is approved.



**Fig. 9.** Narrow-claw crayfish feeding trials with wet and dried aquaponics sludge.

## II.8. Experimental outcomes and practical recommendations

The pilot established a functioning freshwater demonstration system connecting fish, crustaceans, plants, microorganisms and conventional water treatment. Trout and lettuce, followed by sturgeon and basil, were cultivated successfully during the experimental programme. The experiments demonstrated that a practical circular aquaculture concept can be tested and taught using one accessible glasshouse facility.

The central biological finding was that sludge consumption, outlet solids reduction and crustacean biomass production are separate outcomes. Noble crayfish in the trout system were associated with an approximately 40% reduction in collectable sludge according to project summaries, but did not provide consistent biomass gain. Narrow-claw crayfish in the sturgeon system showed limited and variable apparent sludge reduction and net biomass losses. Feeding trials confirmed that sludge can be eaten, and the dried-sludge trial documented modest growth, but this does not resolve the production limitations observed in the integrated system.

Differences in fish feed, faecal consistency, sludge composition, stocking density and hydraulic retention could help explain the different outcomes. The final-conference discussion suggested that trout sludge may offer a different nutritional resource from sturgeon sludge. However, a comparative biochemical or calorimetric dataset was not supplied, so differences in nutritional value remain a hypothesis rather than a measured explanation.

For further operation, the crustacean tank should be managed as a distinct husbandry compartment, with sufficient shelters, controlled stocking density, accessible feeding areas and removal of accumulated sludge. Mixed feeding strategies merit testing when crustacean growth is an objective. Any supplementary feed must be included in the nutrient and feed budget rather than treated as a free improvement in circularity.

Future sludge measurements should use matched collection durations and measured flow, standardised dewatering and dry-matter or volatile-solids analysis. Solids retained in the tank, sludge leaving downstream treatment, uneaten feed and animal biomass should all be included. This would distinguish consumption from sedimentation, fragmentation and mineralisation and support a defensible mass balance.

The next comparative experiments should use independent replicate tanks or systems where possible, document stocking and mortality throughout each cycle, and standardise feed input, temperature and planting density. Nutrient recovery should be calculated from harvested biomass and tissue composition. Economic evaluation should include labour, energy, water, seed stock, supplementary feed and the value of all marketable products.

The warm-water African catfish–basil installation provides a basis for continued development. Giant freshwater prawns and Australian red-claw crayfish are candidates for subsequent integration, but their sludge-removal efficiency, growth, survival and compatibility must be demonstrated before the warm-water concept can be regarded as validated.

## II.9. Summary and outlook

FISHVISA demonstrated the practical integration of freshwater fish, crayfish and plants in a small RAS-based aquaponics installation. Its strongest documented applications were cultivation of fish and plants, experimental evaluation of solids handling, and practical training. The work identified a potentially useful noble-crayfish contribution to sludge management in the trout combination, alongside clear limits to relying on sludge alone for crustacean production.

The available evidence does not establish a fully closed nutrient loop, zero waste, consistent growth of the added crustacean crop or commercial profitability. The pilot instead provides an operational platform and a set of testable improvements: more suitable crustacean husbandry, standardised solids accounting, balanced feeding and species-specific system design. Continued use in teaching and experimental work after the project preserves this practical value.

## II.10. Sources used for pilot results

The implementation and results described in this protocol are based on the six supplied Klaipeda University AquaLoop activity reports, the FISHVISA project presentations, the two experimental spreadsheets and associated results summary, and the FISHVISA-based coursework. The TARAS and NEMATIC protocols provide the common AquaLoop report structure and shared project context; their pilot-specific results are not transferred to FISHVISA.

- Klaipeda University. AquaLoop PR1 ACTIVITIES pap; PR2 ACTIVITIES; PR3 ACTIVITIES; PR4 ACTIVITIES; PR5 ACTIVITIES; PR6 ACTIVITIES. Internal project reporting documents, 2023–2026. Chronology follows the narrative where copied period headings are inconsistent.
- Nika, N., Narvilas, G., Čepulis, M., and Petreikytė-Knašienė, G. 2026. Crustaceans in multitrophic freshwater RAS for sludge mitigation. Results from AquaLoop FISHVISA Pilot testing. AquaLoop International Conference, Bremerhaven, 25 February 2026. File: 7_Session1_KU AquaLoop Final Conference__presentation.pptx.

- Nika, N., and Narvilas, G. 2025. FISHVISA pilot progress presentation, AquaLoop partner meeting, Gdynia, 8–9 April 2025. File: AquaLoop_WP2_Pilot3 progress_GDYNIA 8-9_April.pptx.
- Nika, N., and Dmochowska, B. 2026. AquaLoop cross-border student exchange program. AquaLoop International Conference, Bremerhaven, 25 February 2026. File: 15_Session3_Nika_students_AquaLoop Final Conference.pptx.
- Klaipeda University. Eršketai-bazilikai (3).xlsx; Eršketai-bazilikai (1).docx; vėžių-eksperimentas-su-šlapiu-ir-su-sausu-dumblu (1).xlsx. Working experimental records and summaries supplied for the protocol.
- Jazdauskas, V. 2026. Multitrofinės recirkuliacinės akvakultūros sistemos efektyvumas, panaudojant auginimui žuvis, vėžius ir augalus. Biology and Marine Biotechnology coursework, Klaipeda University. Supervisor: Dr Nerijus Nika. Supplied working version.
- Klaipeda University. TrainingLoop STEAM Activities Programme for School Youth – FISHVISA Aquaponics System. Supplied programme document. Proposed learning activities are distinguished from delivery documented in the period reports.

# III. PILOT DEMONSTRATIONS

The AquaLoop project aimed to prepare school pupils, students and professionals for circular economy approaches, with a focus on aquaculture production and consumption. FISHVISA supported this objective by making the relationships between fish feeding, solids production, microbial processes, plant nutrition and water reuse visible within one practical installation.

The target groups included school teachers and pupils, bachelor's and master's students from Klaipeda University and the partner universities, researchers, public authorities, aquaculture businesses and organisations supporting innovation in the sector. Training was implemented within TrainingLoop – Circular aquaculture training pool, while stakeholder visits and cooperation with industry also contributed to SupportLoop – Circular aquaculture stakeholder support.

The pilot's educational value included discussion of results that did not fully confirm the original hypothesis. Participants could distinguish the promise of reusing side streams from the need to demonstrate animal growth, welfare, nutrient recovery and economic feasibility. Measurement, documentation and critical interpretation were therefore central to the demonstrations.

## III.1. Secondary school youth and teacher involvement in FISHVISA

The school programme used FISHVISA to introduce sustainable food production and the roles of fish, crustaceans, plants and water treatment in a circular system. The supplied STEAM programme translates these themes into activities for grades 9–12 and a simplified programme for primary school pupils. It includes observation, measurement, recording, calculation and discussion, with tasks adapted to age and visit duration.

Teacher seminars took place at the FISHVISA facility on 22 May 2025 for 13 teachers and on 30 May 2025 for 30 teachers. Participants were introduced to circular economy principles and aquaponics, undertook practical measurements of crayfish and plants,

and discussed how aquaponics could be used in schools. These events supported testing and refinement of the TrainingLoop teaching approach.

In 2026, two first-year gymnasium classes visited on 6 April and 30 April, with 25 and 22 pupils respectively. The period report records intensive one-hour sessions involving measurements of fish, plants and water quality, followed by interpretation of the observations and discussion of circular food production. Two further events for fourth-year primary school classes, approximately ten years old, took place on 7 May and 3 June 2026.

The older-pupil programme supports quantitative tasks such as comparing organism size, recording water-quality results and discussing how feed becomes fish biomass, solids and dissolved nutrients. The younger-pupil version focuses on guided observation, identifying the needs of fish and plants, and explaining the recirculating water pathway. These are programme options; delivery dates and participant numbers above follow the activity reports rather than the draft programme's recommended group sizes or durations.

Pupils also participated in complementary crayfish-feeding activities, linking a direct biological question – whether crayfish eat aquaponics sludge – to observation and measurement. Work with live animals and water-quality equipment was carried out as supervised training rather than independent production management.

[INSERT PHOTO / FIGURE HERE]

**Fig. 10.** TrainingLoop teacher seminars and school activities at the FISHVISA facility. Insert photographs from the teacher seminars and the 2026 pupil visits, showing practical plant, animal and water measurements. Identify the event dates and confirm permission for use of photographs.

## III.2. Klaipeda University students involvement in FISHVISA pilot

Klaipeda University students contributed to pilot development, routine operation, experimental measurements and data analysis. During PR3, third-year bachelor's students in Biology and Marine Biotechnology and second-year master's students in Sustainable Management of Aquatic Ecosystems were involved through practical teaching activities. Tasks linked animal and plant performance with water quality and solids management.

From September to December 2025, third-year bachelor's students implemented two semester research projects as part of the Aquaculture course. One group monitored the Siberian sturgeon–narrow-claw crayfish–basil combination, while the other investigated narrow-claw crayfish feeding on aquaponics sludge. Students gained experience in experimental planning, organism measurements, sample collection, data recording and interpretation of inconclusive or variable results.

Vaclovas Jazdauskas subsequently used the FISHVISA experiments for his coursework on the efficiency of a multitrophic recirculating aquaculture system using fish, crayfish and plants. The work was supervised by Dr Nerijus Nika and defended in June 2026

according to PR6. It included sturgeon and crayfish biomass observations, sludge comparisons and analysis of basil root development.

The coursework demonstrates how a pilot facility can generate extended student research rather than a single demonstration visit. Its working version also illustrates the importance of final data quality control: unit consistency, species names, cycle boundaries, stock movements and the link between raw records and summary tables require checking before scientific publication.

The final period report records continued student involvement in African catfish–basil operation from July 2026 and continued use of FISHVISA in Aquaculture practical classes from September 2026. The retained installation therefore supports further TrainingLoop teaching and refinement of the warm-water concept after the project.

[INSERT PHOTO / FIGURE HERE]

**Fig. 11.** Klaipeda University students conducting FISHVISA experiments. Insert photographs of students weighing fish and crayfish, measuring basil roots and shoots, analysing water and collecting sludge; include coursework-related activity where available.

## III.3. AquaLoop cross-border student exchange program

The AquaLoop project established a cross-border student exchange programme between the University of Rostock, the University of Gdańsk and Klaipeda University. Bachelor's and master's students received one week of practical training based on the TARAS, NEMATIC and FISHVISA pilots, complemented by visits to commercial aquaculture facilities. The jointly developed framework included application and selection procedures, learning activities, certificates and participant feedback.

The final-conference presentation reports 19 participants across the programme, implemented between January and June 2025. FISHVISA hosted three bachelor's and master's students from the University of Gdańsk from 23 February to 1 March 2025, followed by four master's students from the University of Rostock from 8 to 14 June 2025.

Visiting students worked at the Marine Research Institute's Fisheries and Aquaculture Laboratory, where they measured fish, crayfish and plants, analysed water quality, observed and maintained the aquaponics system, and conducted short-term crayfish-feeding experiments using fish faeces as a feed resource. These tasks combined routine RAS operation with investigation of the pilot's central circularity hypothesis.

The visits also included an Arctic char farm in the Klaipeda region and the Lithuanian Sea Museum, connecting laboratory-scale work with commercial aquaculture, biodiversity and recirculating technologies. Klaipeda University students took part in reciprocal exchanges at the University of Gdańsk from 26 January to 1 February 2025 and at the University of Rostock from 23 February to 1 March 2025.

Feedback presented at the final conference showed programme evaluation scores of 96–100% across communication, organisation, collaboration and overall satisfaction.

These are programme-wide results and are not presented as a separate FISHVISA-only evaluation. Participant reflections highlighted practical experience, exposure to local research and aquaculture businesses, and opportunities for international collaboration.

[INSERT PHOTO / FIGURE HERE]

**Fig. 12.** AquaLoop cross-border student exchange programme at Klaipeda University. Insert the programme banner or Klaipeda agendas and photographs of the University of Gdańsk and University of Rostock groups working with FISHVISA and visiting the Arctic char farm.

## III.4. Demonstration to professionals

FISHVISA was demonstrated to project partners and stakeholders during the Klaipeda partner meeting on 15–17 April 2024. The programme combined visits to the Marine Research Institute's Fisheries and Aquaculture Laboratory with visits to regional aquaculture businesses, including an Arctic char RAS farm and UAB Kintai. At the laboratory, partners examined the pilot infrastructure and discussed experimental development and further cooperation.

The dedicated TrainingLoop programme for professionals was delivered on 2 July 2026 through the seminar "Circular economy potential in Lithuanian aquaculture" and a study visit at Klaipeda University. Participants were introduced to AquaLoop results, the FISHVISA fish–crayfish–plant concept, sludge-mitigation trials and opportunities for cooperation with the university.

The programme included a tour of the research infrastructure and FISHVISA glasshouse, together with examples of shrimp RAS and multitrophic approaches using polychaetes. The period report identifies participants from the Fisheries Department of the Ministry of Agriculture, Klaipeda Science and Technology Park, aquaculture associations and aquaculture SMEs. A verified attendance total is not provided in the supplied sources.

For professionals, the pilot offered a practical basis for discussing species compatibility, solids management, plant production, monitoring and the limits of sludge-only feeding. Its results are relevant to technology development and training, while investment decisions would require additional performance, cost and market evidence.

[INSERT PHOTO / FIGURE HERE]

**Fig. 13.** FISHVISA demonstration to professionals and the 2 July 2026 TrainingLoop seminar. Insert the verified seminar agenda and photographs of participants visiting

the glasshouse and discussing the pilot results. Add the attendance total only after checking the attendance list.

# IV. PILOT RESULT DELIVERY AND COMMUNICATION

FISHVISA results were communicated through AquaLoop partner meetings, scientific conferences, practical training, stakeholder demonstrations and project communication materials. The pilot contributed both a technical case study on freshwater multi-trophic aquaponics and a training platform for different generations of aquaculture stakeholders.

The strongest directly documented dissemination activities are the Aquaculture Europe 2025 presentation, the AquaLoop International Conference in February 2026, the cross-border student exchange and the July 2026 professional seminar. Shared AquaLoop communication channels and wider project events provided additional context and visibility for the three PilotLoops.

## IV.1. AquaLoop partner and Advisory Board meetings

Throughout implementation, progress was discussed through regular online consultations and physical AquaLoop partner meetings in Rostock, Germany, in November 2023; Klaipeda, Lithuania, in April 2024; the Tollarp/Copenhagen programme in August 2024; Gdynia, Poland, in April 2025; Aalborg, Denmark, in October 2025; and Malmö, Sweden, in June 2026.

These meetings brought together the partner universities, public organisations, industry associations, businesses and other stakeholders. The Advisory Board, established during the Copenhagen meeting, included representation from the Lithuanian Ministry of Agriculture alongside experts from other partner countries. The common project forum connected pilot testing with training design and support for aquaculture stakeholders.

FISHVISA was demonstrated during the Klaipeda meeting, and its experimental progress was presented at later meetings, including the supplied Gdynia presentation of 8–9 April 2025. The exchange of experience supported discussion of the revised species sequence, crayfish feeding, monitoring needs and integration of students into the pilot work.

The partner meetings also connected Lithuanian aquaculture businesses with relevant production examples in other countries. PR2 records participation by a UAB Kintai representative in the Swedish study visit, while PR6 records a Lithuanian RAS company representative joining the Malmö meeting and a visit to Protena Food. These were broader SupportLoop activities complementing the pilot's technical and educational work.

[INSERT PHOTO / FIGURE HERE]

**Fig. 14.** AquaLoop partner meetings and Advisory Board cooperation. Insert photographs from the Klaipeda pilot visit and selected partner meetings; add an Advisory Board photograph with verified names and affiliations where available.

## IV.2. AquaLoop International Conference

FISHVISA results were presented at the AquaLoop International Conference "Strengthening Circular Economy and Valorisation of Side Streams in RAS Aquaculture" in Bremerhaven, Germany, on 25 February 2026. The common pilot protocols describe the conference venue as Klimahaus and report participation by more than 70 researchers, industry representatives, policymakers, public institutions and students, including online participation.

The FISHVISA presentation, "Crustaceans in multitrophic freshwater RAS for sludge mitigation", was delivered by Nerijus Nika and credited Nerijus Nika, Gintautas Narvilas, Matas Čepulis and Gerda Petreikytė-Knašienė. It explained the system configuration, cold-water and cool-water trials, complementary feeding experiments and preliminary conclusions on sludge management and crayfish growth.

The presentation communicated both positive and limiting findings: noble crayfish were associated with reduced collectable trout sludge, while narrow-claw crayfish showed a weaker response in the sturgeon system; neither integrated combination demonstrated consistent crayfish biomass production on sludge alone. Presenting these limitations supported practical discussion of how a circular aquaculture concept should be improved and assessed.

The conference also included the joint presentation "AquaLoop cross-border student exchange program" by Nerijus Nika and Basia Dmochowska, together with student reflections. This connected the pilot's technical work with the project's educational outcomes and presented FISHVISA as one of the three practical exchange platforms.

[INSERT PHOTO / FIGURE HERE]

**Fig. 15.** FISHVISA and TrainingLoop presentations at the AquaLoop International Conference. Insert conference photographs and title slides from the FISHVISA results presentation and the cross-border student exchange presentation, dated 25 February 2026.

## IV.3. International branch conferences

Klaipeda University representatives Nerijus Nika and Gintautas Narvilas attended AQUA 2024 in Copenhagen in August 2024 as part of the project's international aquaculture engagement. At that stage, the project was developing and testing its pilot approaches and building links between the partner institutions and sector stakeholders.

The FISHVISA results were subsequently presented at Aquaculture Europe 2025 in Valencia, Spain, on 22–25 September 2025. Gintautas Narvilas, Gerda Petreikytė-Knašienė and Matas Čepulis participated with the poster "Aquaponics system with crayfish: a more sustainable solution for sludge management". The contribution communicated the tested aquaponics approach and the role of crayfish in solids handling to the wider aquaculture research and professional community.

Together with the other AquaLoop pilot contributions, these activities placed FISHVISA within a broader discussion of nutrient recovery, resource efficiency and aquaculture side-stream use. The available records support participation and presentation; they do not provide a separate numerical audience count or a measured rate of technology uptake resulting from these events.

[INSERT PHOTO / FIGURE HERE]

**Fig. 16.** FISHVISA communication at international aquaculture conferences. Insert the Aquaculture Europe 2025 poster and photographs of the Klaipeda University presenters; add AQUA 2024 participation photographs where available.

## IV.4. International conferences for different stakeholder groups

The common TARAS and NEMATIC protocols describe AquaLoop communication through wider blue economy and bioeconomy platforms, including European Maritime Day in Svendborg in May 2024 and the Danish Bioeconomy Conference in Nykøbing Falster in November 2025. These activities supported project-wide visibility among research, policy, business and innovation communities.

Within FISHVISA, cross-border education and practical training offered an additional route to these stakeholder groups. The supplied final-conference training presentation documented the common exchange programme and the experience gained across the three universities. For this report, wider consortium events are identified as project-level communication rather than treated as separate FISHVISA presentations by Klaipeda University where that is not documented.

## IV.5. Interreg program events

The AquaLoop pilots formed part of the project's communication of circular aquaculture within the Interreg South Baltic cooperation framework. The companion pilot protocols document participation in Interreg events, including the South Baltic Annual Event in Stralsund in September 2024 and the TransformEU event in Rønne, Bornholm, in September 2025.

These shared platforms connected project outputs with other regional initiatives and stakeholders interested in cooperation, sustainability and innovation. FISHVISA contributed to AquaLoop's overall portfolio of physical demonstrations. The supplied Klaipeda activity reports do not identify a separate FISHVISA-specific presentation at each Interreg event, so no additional individual participation or presentation is inferred.

## IV.6. Online dissemination materials and communication channels

The common AquaLoop communication approach used the project website, newsletters, brochures, posters, promotional publications and LinkedIn. These channels provided a shared route for presenting the three pilots, training opportunities and project results to researchers, professionals, policymakers, students and the wider public.

Klaipeda University's period reports also identify an interview and article in the November–December 2025 issue of Eurofish Magazine as an AquaLoop dissemination activity. The reported issue is available at https://eurofish.dk/magazine-issues/em-6-2025/. The supplied sources do not contain a verified readership figure or a full content audit, so no quantitative communication impact is assigned to that publication here.

The FISHVISA conference presentations, student research, STEAM programme and professional training provide reusable material for future teaching and knowledge exchange. Continued operation of the pilot after the project makes it possible to demonstrate the tested concept while updating training materials as the experimental evidence develops. General project information is available at https://aqualoop.edu.pl/.


## ACKNOWLEGMENTS

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We thank Klaipeda University students, including Vaclovas Jazdauskas, and the visiting students from the University of Gdańsk and the University of Rostock for their contributions to experimental work, routine measurements and the cross-border exchange programme.

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