Deliverable No. 3.3

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AquaVitae

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New species, processes and products contributing to increased production and improved sustainability in emerging low trophic, and existing low and high trophic aquaculture value chains in the Atlantic

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Deliverable D3.3

Report on second development phase in case studies WP3, with user acceptance testing feedback

31/05/2022

Executive Summary

The objectives of AquaVitae's WP3 is to develop new products from the selected aquaculture Value Chains (VC) and Case Studies (CS). Everything that can be sold, value added or processed qualifies as a product. Different from WP1 and WP2, it relates only to post-harvest – mainly key exploitable results (KER) that are, or can be, produced based on low trophic species (LTS), including new and existing feed formulas and diets for high trophic species. This deliverable (D) reports on the second development phase (M19-M36) for all of these. The report also presents an analysis of the user acceptance testing feedback survey that presented stakeholders from the aquaculture sector with the outputs generated by WP1-3 in order to understand their impact.

This deliverable D3.3 is the follow up of deliverable D3.2 (the report on the first development phase). It mainly uses the same methodology for progress reporting. As for D3.2, the CS Reports were completed by CS leaders and recorded through a coordinated effort of WP1, 2 and 3, using the database and reporting templates that were specifically designed to make all data from the CS easily accessible and useable for the project as a whole. Both the reporting template and the database tool were central elements of the methodology and used to gather and collate the information needed to assess and measure the progress of the Case Studies (CSs). In addition, a stakeholder survey on user acceptance testing feedback of flagship results was developed and implemented by the leaders of WP1, 2 and 3. For that purpose, this deliverable introduces the idea of "flagship Key Exploitable Results" (fKER). An approach to identify the KERs with the highest maturity and potential impact.

In order to avoid duplication across deliverables D1.4 (progress in WP1), deliverable D2.3 (progress in WP2) and this deliverable D3.3 (progress in WP3) **Annex 1 from D1.4 and Annex 1, 2,3 and 4 from D2.3 should be read in conjunction with this deliverable** (they have not been replicated here in the interest of brevity). All detailed planning, scientific, technical and innovation information for each CS which advance the completion of WP3 tasks are presented in Annex 1 of D1.4 (Detailed Case Study Reports (M19-M36)). This annex specifically contains an abstract/summary for each CS. The Case Study Reports (M19-M36) detail the methods used and results obtained. Where applicable the results are discussed. In a final section, the progress, deviations, problems/solutions and work planned for next 12 months (future outlook) are provided. Links to the user acceptance testing feedback surveys are presented in Annex 1 of D2.3, the background of the respondents that took part in the survey for all three WPs can be found in Annex 2 of D2.3 and Annex 3 of D2.3 contains the overall analysis of the survey for WP1, 2 and 3 combined. In addition, Annex 4 of D2.3 also contains an analysis of the surveys per Case Study.

Ten of the 13 CS (CS1, CS3-8 and CS11-13) produced a total of 62 KER that contribute to the main task of WP3. They originate from 20 (out of 59) different Case Study Tasks (CSTs). From these 62 KERs that report to WP3, 15 were marked as flagships outputs or fKERs of WP3.

The percentage of completeness of the 20 tasks that report to WP3 ranged from 0% to 100% complete. Two tasks that were meant to start later in the project, have not yet started due to delays following COVID. Nine tasks are in between 53-75% complete, six in between 80-95% and three are fully completed. This is largely in-line with the progress expected.

The case study work related to WP3 has advanced very well. The 6-month extension that was granted to the project has addressed the delays caused by COVID. This includes two cases studies were the consequences of COVID delayed the start of the work up until now. Two more case studies have advanced but experienced problems (low survival of target species) that led to unsuccessful trials.

In total, 58 stakeholders gave their feedback on the 15 fKERs (Table 2) that resulted from the work within the different CS that report to WP3. Overall, the survey confirmed that the fKERs that report to WP3 are of relevance, acceptable and applicable to a variety of end-users (e.g. industry, research, policy) from the aquaculture value chain. These fKERs have the potential to create new products or processes or improve already existing ones. They have the ability to increase the industry's sustainability (economically, environmentally, socially) and address a number of industry challenges (technical, consumer perception and legislation). Almost half of the respondents have already tested some of the fKERs and the rest are interested in testing or applying them or showed interest in collaborating in their future development. Thus, WP3 is on track to generate its desired impact. This is further supported, since almost half of the respondents considered that these fKERs are likely to be adopted by the aquaculture industry in the next five years.

The survey on user acceptance testing feedback will continue for the duration of the AquaVitae project. An increased effort will be made to involve stakeholders from outside of research, development, and education, and to particularly increase the number of industry, NGO, government and investment respondents. The outcome of the survey will be used by CS and CST leaders in the final stages of their research, and in developing exploitation strategies to ensure that the research and innovation that has been developed in this project will have impact in the aquaculture industry.

The main users of this deliverable will be the leaders of WP1-3, WP5-7 scientists, WP9 participants and the CS leaders. The information summarised here will be used by the project participants to select industry partner(s) (known or networked) for product testing and business-to-business (B2B) feedback collection.

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A reader's guide to accessing the information presented in Deliverables D1.4, D2.3 and D3.3

Work Packages (WP) 1, 2 and 3 developed a coordinated reporting system for all the case study (CS) that contribute to these work package tasks. They also developed a single stakeholder acceptance feedback survey. Due to the close synergy between these work packages, the case study progress and user acceptance feedback are relevant to WP1,2 and 3. To reduce repetition, the details of the progress and the survey are not repeated in deliverables D1.4, D2.3 and D3.3, but reference to these details is made between the deliverables.

This is how each of these deliverables is structured and where the progress details and stakeholder survey information can be found:

	D1.4	D2.3	D3.3
• Progress report method	✓	✓	✓
• M19-M36 progress for each WP	✓	✓	✓
• CS specific progress	Annex 1	-	-
• User acceptance survey method	✓	✓	✓
• Links to the online surveys	-	Annex 1	-
• Survey overview - commentary	-	✓	-
• Survey overview - graphics	-	Annex 2&3	-
• Survey WP specific - commentary	✓	✓	✓
• Survey WP specific - graphics	✓	✓	✓
• Survey CS specific - graphics	-	Annex 4	-
• Survey limited to industry respondents	-	Annex 5	-

1. Introduction

i. Synopsis AquaVitae

AquaVitae is a research and innovation project funded by the EU's Horizon 2020 programme. The project consortium consists of 35 partners, from 16 different countries, spread across four continents. In addition to Europe, partners are situated in countries bordering the Atlantic Ocean, including Brazil, South Africa, Namibia, as well as in North America. Its broad aim is to introduce new low trophic species, products and processes in marine aquaculture value chains across the Atlantic.

ii. Scope and motivation of Deliverable D3.3

The objectives of AquaVitae's WP3 is to develop new products from the aquaculture value chains (VC) under investigation in the project, i.e.:

- VC1 Macroalgae;
- VC2 IMTA;
- VC3 Echinoderm;
- VC4 Shellfish; and
- VC5 Finfish.

This includes products originating from waste material or by-product utilization processes, the use of low trophic species as raw material to produce feed for high trophic species or value-added products for other industries, new technologies, tools or processes, everything that can be sold, value added or processed.

Deliverable D3.3 presents the outcome of the second development phase (M19-M36) of those CS that have or will produce outputs related to the objective of WP3. It summarizes these outputs, presents their requirement specifications and demonstrates the identified exploitation potential to date. All detailed scientific, technical and innovation information for each CS which advance the completion of WP1-3 tasks are presented in Annex 1 of D1.4 (Detailed Case Study Reports (M19-M36)).

This deliverable also presents an analysis of the user acceptance testing feedback survey that shows how stakeholders from the aquaculture sector view the outputs generated by WP3 and allows for the estimation of their impact on the aquaculture industry. For that purpose, this deliverable also introduces the idea of "flagship Key Exploitable Results" (fKER). An overview of the results of the survey for WP1-3 combined is presented in Annex 2 of D2.3 (Respondent background: WP1, 2 and 3 stakeholder feedback) and Annex 3 of D2.3 (Overall analysis of the WP1, 2 and 3 Stakeholder Survey). In addition, Annex 4 (WP1, 2 and 3 Stakeholder Survey per Case Study) also contains an analysis of the survey per Case Study.

2. Methodology

i. Progress Report

Note: The approach and method adopted in WP3 is the same as that presented in deliverable D1.4 and D2.3.

Following the spiral model of innovation methodology (Figure 1 of D1.1) CS leaders have completed their second innovation loop and reached a second in some cases final prototype stage. Here, a prototype translates to any sort of output from a CS, may that be a new or improved product (including new species & technical hardware), process or a report.

To gather the necessary information for this deliverable, three tools were used:

- firstly, the completed Case Study reports that used the "*CS Report Template"* (Appendix 1, D1.2) that was completed by CS leaders at month-24, month-30 and month-36, and will be updated at 6-monthly intervals for the duration of the project;
- secondly, the "*AquaVitae WP 1 - 3 database"* (Appendix 2, D1.2). In order to clearly match the work and outputs of all case studies with the best fitting WP (WP1-3); and
- thirdly, a technical case study report for the work from M19-M36 that was filled in by all CS partners Annex 1 of D1.4 (Detailed Case Study Reports (M19-M36)).

To generate the tables summarising the outputs of the second development phase, a number of filters were set in the database. This allowed extraction of the information specific to WP3. The product specifications were requested by email from all partners and added to the tables.

ii. User acceptance testing feedback

WP1-3 leaders prepared and disseminated a detailed survey questionnaire at the start of the AquaVitae project (Annex 1, D1.1) to understand the industry perspective on and identify the industry and commercial relevance of the planned innovative outputs coming from the 13CSs. Based on the lessons learned from this first questionnaire process and 18M reporting period, the leaders of WP1-3 started an iterative process to create CS specific surveys in order to understand the impact generated by the key outputs of the different CSs and collect user acceptance testing feedback for Deliverable D1.4, D2.3 and D3.3. Due to the high number of identified Key Exploitable results (KERs) – a total of 139 KERs coming from 59 individual Case Study Tasks – a decision was taken to highlight the most relevant as "**flagship Key Exploitable Results**" (**fKER**) and provide stakeholders in the surveys only with the selected flagship results that match their interest.

Selection Process fKERs: The selection process was based on the expert opinion of the CS leaders. From their R&I activities CS leaders selected the most mature and ready for uptake at an appropriate industry level outputs as their flagships. These were then discussed by CS leaders individually with the leaders of WP1-3. In some cases, one or more KERs of one CS task were combined into one fKER. This exercise resulted in a total of 45 fKERs. Table 2 of Deliverable D1.4 summarises these fKERs together with the individual, detailed description that was provided as an explanation to the survey's respondents.

Selection of questions: The questions were formulated by the leaders of WP1-3 with the help of specialist in survey design from WP8. After a feedback loop with the CS leaders, the final questions

were compiled, and link to each survey is available in Annex 1 of Deliverable D2.3. The questions are intended to identify user acceptance testing feedback, i.e.:

- the industry's perspective on the CS outputs in terms of applicability / industry uptake
- the (potential) economic, environmental and social impact of the outputs

In addition, WP5 can use the survey results to identify CS outputs to develop market driven strategies. WP7 can use them select outputs for their business, socio-economic and profitability analysis.

Ethics and data protection: The potential for ethical issues has been considered by the project partners. Prior to its lunch the survey was presented to the coordinator for approval. The survey was and will be conducted with participants' rights to privacy and confidentiality. No identifiable personal information is collected or stored, and participation was/is on a voluntarily basis. Each individual stakeholder must give their consent to participate in the survey. Data will only be presented on an aggregated level to comply with international and national rules for confidentiality including GDPR. Any participant has the right to limit the use of any information they provide and may request.

Target group: People familiar with aquaculture and potential interest in outputs from coming from SME/Industry, Association, Policy, NGO, Research, and other backgrounds. Annex 2 of Deliverable D2.3 "Respondent background: WP1, 2 and 3 stakeholder feedback" shows the broad range and different groups of surveyed participants and their various interests in the aquaculture industry.

Implementation: Different from the original plan set in D1.1/2.1/3.1, the case study events planned for M13, M24 and M36 were cancelled due to COVID restrictions. Therefore, it was not possible to carry out or align the survey as a part of these big scale events. Out of necessity, an online survey using Google forms was implemented. All case study leaders were asked to reach out to relevant stakeholders and provide them with the link to the survey that contained the fKERs of interest to them. A minimum 10+ respondents (per CS) was given as benchmark. The 12th of May 2022 marked the end date for data collection. Using a standard survey (where necessary translated to Portuguese or French) (the links to each survey can be found in Annex 1 of D2.3) participants answered a set of general questions on their position with regard to AquaVitae and the aquaculture value chain and were then introduced to a short-list of 2-6 fKERs only that correspond with their interest in the aquaculture industry. A total of 151 stakeholders (Annex 2 of D2.3) commented on a total of 45 fKERs (Table 2 of D1.4). This resulted in 223 surveys on products and processes that are likely to originate from the AquaVitae project. The number of respondents (151) is not consistent with the number of assessments that were carried out nor the number of answers recorded. Some respondents chose to review only one fKER, very few noted that none of the fKERs were of interest to them, while other respondents chose to review two or more fKERs in their survey. In many cases the respondent had the opportunity of selecting more than one answer to a single question, which increased the number of responses that were recorded for these questions. In some instances, respondents chose not to answer non-mandatory questions, which reduced the number of responses to a question. The combined outcomes of these surveys are presented in in Annex 2 of Deliverable D2.3 and the survey associated with each CS is presented in Annex 3 of the same deliverable.

Out of the 45 fKERs, 15 fKERs report to WP3 (Table 2). Only the results on these fKERs are presented in this deliverable under iii. User acceptance testing feedback.

Exception CS11: Different from all other CSs, the delays caused by COVID in CS11 were so severe that the selected finfish species was changed from Brazilian flounder to Southern Black Drum in M25. For that reason, only preliminary fKERs were agreed upon as they lacked maturity by the time the surveys

were created (they can be found in the complete fKER table (Table 2 of D1.4)). Currently CS11 is using a preliminary survey to evaluate if the selected the outputs can actually be considered as flagships. By the time of the creation of this deliverable, no information was available to the leaders of WP1-3.

3. Report on second development phase in case studies WP3

A report on CS task level detailing all scientific and technical findings during the second development loop can be found in Annex 1 of Deliverable D1.4 (Detailed Case Study Reports (M19-M36)). It specifically contains an abstract/summary for each CS. The Case Study Reports (M19-M36) detail the methods used and results obtained. Where applicable the results are discussed. In a final section the progress, deviations, problems/solutions and planned future outlooks for next reporting period are provided.

The database was used to create the list of outputs. There were 62 potential, exploitable outcomes identified by the CS leaders in AV (Table 1). Each outcome is assigned with a specific identifier, type category, a detailed explanation describing the outcome, its requirement specifications, and the potential for becoming a future sellable product, the level of completeness with regard to what is expected by the end of the project, the current technology readiness level (TRL) and the WP task(s) to which the outcome reports.

The exploitation potential of the AV research and innovation is high. There are 62 exploitable outputs that relate to WP3. They originate from 20 out of 59 different CS tasks spread over CS1, CS3-8 and CS11-13. Out of the 62 outputs, three are categorized as reports, one as a process and 58 as products. The reports (Table 1) will feature the analysis of product quality, sustainability and nutritional value for the newly developed species and a new protocol for sea based native oyster spat production. The process (Table 1, Indent. 6.1.2) is split into (1) a land-based raceway system with an integrated tipper self-cleaning system and (2) a land-based holding system design to enable industry to run sea urchin roe enhancement trials. The products range from low and high trophic species, protein hydrolysates, new feed formulations incorporating LTS, diets for high trophic species, paints, software solutions, foodstuff to new production and harvesting technologies. With the exception of the three reports and the "*holding facilities for sea cucumber IMTA with Abalone*" (Table 1, Indent. 7.3.2), all outputs have a clear potential for becoming future sellable products.

Table 1: All outputs related to WP3 and their requirement specifications at M36 (with: CS = corresponding Case Study Number; Ident. = specific identifier; Pot. Product (Y/N/tbc) = potential for becoming a future sellable product (Yes, No, to be confirmed); Complete = level of completeness with regard to what is expected by the end of the project; current technology readiness level (TRL); WP task = task(s) the output reports to according to description of action).

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
1	1.5.1	Report	Composition of commercially cultivated new species.	EU nutrition labelling for foodstuffs.	N	0%	4	T3.2
3	3.3.2	Product	Anemone production.	Production of anemone (*Anemona sulcata*).	Y	100%	7	T3.2
3	3.5.1	Product	New sea cucumber species optimised for shore based IMTA.	Produce new sea cucumber species in Land based IMTA system integrating abalone/macroalgae and sea cucumbers.	Y	75%	6	T3.2
3	3.8.1	Report	Analysis of the products in terms of quality, sustainability and nutritional value.	Analyse quality and nutritional value of IMTA products to consider their interest as new/improved products for consumption or use.	N	0%	4-5	T3.2

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CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
4	4.2.2	Product	Mussels produced using IMTA in South Africa.	Mussel production with reduced environmental footprint; production method will adhere to all industry and environmental specifications.	Y	90%	7	T3.2
4	4.2.3	Product	Macro-algae produced using IMTA in South Africa.	New product that was not previously produced; improved use of existing infrastructure.	Y	90%	7	T3.2
4	4.6.1	Product	Abalone obtained from IMTA with seaweed.	Process will contribute to reduce environmental footprint of aquaculture production methods and will make production more cost-effective; contribute to developing new industry standards.	Y	90%	7	T3.2
4	4.6.3	Product	Alaria esculente obtained in abalone IMTA co-culture.	Process will contribute to reduce environmental footprint of aquaculture production methods and will make production more cost-effective; contribute to developing new industry standards.	Y	90%	7	T3.2
4	4.6.4	Product	Palmaria palmata obtained in abalone IMTA co-culture.	Process will contribute to reduce environmental footprint of aquaculture production methods and will make production more cost-effective; contribute to developing new industry standards.	Y	90%	7	T3.2
4	4.7.1	Product	Queen scallop obtained from abalone IMTA co-culture.	Queen scallop culture in benthic sea cage is new in Europe and in co-culture it may prove valuable to diversify the production and reduce its impact. It may also improve productivity through the use of phytoplankton in water.	Y	80%	4	T3.2
4	4.7.2	Product	Flat oyster obtained from abalone IMTA co-culture.	Flat oyster culture in benthic sea cage in co-culture may prove valuable to diversify the production and improve productivity through the use of phytoplankton in water.	Y	80%	7	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
5	5.1.2	Product	Shrimp grown by new biofloc system.	High-quality shrimp produced in a sustainable intensive biofloc system without the use of chemicals like antibiotics.	Y	95%	8	T3.2
5	5.2.2	Product	Shrimp grown by new IMTA Biofloc system.	High-quality shrimp produced in an intensive, sustainable IMTA system without the use of chemicals like antibiotics.	Y	85%	7	T3.2
5	5.2.3	Product	Mullet grown by new IMTA Biofloc system.	High-quality fish produced in an intensive sustainable IMTA system without the use of chemicals like antibiotics.	Y	85%	7	T3.2
5	5.2.4	Product	Ulva sp. grown by new IMTA Biofloc system.	High-quality seaweed produced in an intensive IMTA sustainable system without the use of chemicals like antibiotics.	Y	85%	7	T3.2
5	5.3.2	Product	Shrimp grown by new IMTA system.	High-quality shrimp produced in an extensive organic IMTA sustainable system without the use of chemicals like antibiotics.	Y	60%	5	T3.2
5	5.3.3	Product	Oyster grown by new IMTA system.	High-quality fish produced in an extensive organic sustainable IMTA system without the use of chemicals like antibiotics.	Y	60%	5	T3.2
5	5.3.4	Product	Seaweed grown by new IMTA system.	High-quality seaweed produced in an extensive organic sustainable IMTA system without the use of chemicals like antibiotics.	Y	60%	5	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
6	6.1.2	Process	Land based holding system for sea urchin roe enhancement.	The output will be split into two types: (1) Commercial prototype (commercially sensitive) of a land-based raceway system with an integrated tipper self-cleaning system. Testing this system will be part of the project output (Norway) (2) Tech Transfer: Land-based holding system design parameters (e.g. raceway and inlet water designs) to enable industry to run sea urchin roe enhancement trials (Spain).	Y	65%	7	T2.2, T3.2
6	6.2.1	Product	Production of new species *Strongylocentrotus droebachiensis* from a new process (roe enhancement and out of season production).	The roe from wild caught *Strongylocentrotus droebachiensis* is sold extensively in a number of markets around the world including Asia and Europe. The product standards are clearly defined. However, enhanced roe from wild caught sea urchins fed feeds over 2-3-month periods has never been marketed and sold. The aim of this output is to produce high quality sea urchin roe (of at least the same quality, if not higher quality than wild caught roe) in a 2-3-month period from sea urchins collected from that are in poor quality using specifically designed feeds.	Y	65%	7	T3.2
6	6.3.1	Product	Production of new species *Paracentrotus lividus* from a new process (roe enhancement and out of season production).	The roe from wild caught *Paracentrotus lividus* is sold extensively in a number of markets around the world but mainly in Europe. The product standards are clearly defined. However, enhanced roe from wild caught sea urchins fed feeds over 2-3-month periods has never been marketed and sold. The aim of this output is to produce high quality sea urchin roe (of at least the same quality, if not higher quality than wild caught roe) in a 2-3-month period from sea urchins collected from that are in poor quality using specifically designed feeds.	Y	65%	5-6	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
7	7.3.2	Product	Holding facilities for sea cucumber IMTA with Abalone.	The technical requirements of holding facilities for sea cucumber in combination with Abalone are unexamined. It is clear that specific holding systems (possibly cages, structure or nets) will be required in the long term to ensure the integration is successful in terms of animal retention and in terms of controlling interactions between abalone and sea cucumber. These physical technologies will be patentable and will be applied in multiple farms.	tbc	60%	6	T3.2
7	7.3.3	Product	Bêche-de-Mer from Neostichopus grammatus (from IMTA).	Bêche-de-Mer is the dried body wall of sea cucumber and is the main form of export-quality sea cucumber destined to be sold in Hong Kong and/or mainland China. These products are graded and sorted by many different characteristics including; size, shape, spikiness/smoothness, wall thickness and colour. The valuation of the product is extremely nebulous, but will need to be clarified together with providers and with consumers as far as possible to establish the value of the species Neostichopus grammatus (from IMTA) as a sea cucumber export.	Y	60%	6	T3.2
7	7.3.4	Product	Bêche-de-Mer from Holothuria grisea (from IMTA).	Bêche-de-Mer is the dried body wall of sea cucumber and is the main form of export-quality sea cucumber destined to be sold in Hong Kong and/or mainland China. These products are graded and sorted by many different characteristics including; size, shape, spikiness/smoothness, wall thickness and colour. The valuation of the product is extremely nebulous, but will need to be clarified together with providers and with consumers as far as possible to establish the value of the species Holothuria grisea (from IMTA with oyster) as a sea cucumber export.	Y	60%	5	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
8	8.2.1	Report	A new protocol for sea based native oyster spat production including recommendations on new seed collector materials and new protocols adapted to local species.	Seed production using sea-based collectors is a common strategy for extensive seed production. However, existing techniques are adapted to large scale industries and alternatives for small scale industries must be developed. Moreover, in areas where more than one oyster species exists a mixture of seed from different oyster species will be obtained on the collectors. Protocols to optimize capture of target species must therefore be developed.	tbc	70%	5	T1.2, T1.3, T1.5, T3.2
8	8.2.2	Product	A new software for automatic identification of oyster species.	Seed production using sea-based collectors is a common strategy for extensive seed production. In areas where more than one oyster species exists a mixture of seed from different oyster species will be obtained on the collectors. Automated methods to separate oyster seed by species must be developed.	Y	70%	5	T1.2, T1.3, T1.5, T3.2
11	11.2.1	Product	Diet development for juvenile Brazilian flounder.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	100%	4	T3.2
11	11.2.2	Product	Diet development for juvenile Brazilian flounder with protein sparing effect of lipid.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	100%	4	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
12	12.2.2	Product	Ecological paint manufacturing.	Industrial application of CaCO3 from shellfish aquaculture, consisting on substituting mineral by shellfish CaCO3 as a primary extender. This paint application will contribute to shellfish CaCO3 sequestration for decades. Shellfish CaCO3 production and needs of the paint industry are balanced in Galicia.	Y	80%	5	T3.2
12	12.3.1	Product	Production of hydrolysed proteins and oil from fishery by-catch.	By 2019 the Common Fisheries Policy of the EC forces to land in ports the fishing discards. To valorise this substantial amount of waste, we propose to extract hydrolysed proteins and oil to be used as high-quality ingredients on aquaculture diets.	Y	100%	7	T3.2
12	12.3.2	Product	Production of hydrolysed proteins and oil from sardine heads.	Proposes to valorise this waste form the sardine canning industry, extracting hydrolysed proteins and oil to be used as high-quality ingredients on aquaculture diets. Since sardine is relatively low trophic species (about 2), this product will be transferred to CS13.	Y	100%	7	T3.2
12	12.3.3	Product	Production of hydrolysed proteins and oil from boiled mussel meal waste.	Proposes to valorise the undersize individuals from mussel cookers, extracting hydrolysed proteins and oil to be used as high-quality ingredients on aquaculture diets. Since mussels are relatively low trophic species (about 2), this product will be transferred to CS13.	Y	100%	7	T3.2
12	12.3.4	Product	Production of mussel meal from non-commercial boiled specimens.	Proposes to valorise the non-commercial boiled mussels into mussel meal.	Y	100%	7	T3.2
12	12.4.1	Product	Diet for Senegalese sole with inclusion of hydrolysates.	A new diet for Senegalese Sole juveniles based on high quality ingredients from fishery by-catch analysing key performance indicators compared with a control diet.	Y	70%	6	T3.2

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
13	13.2.1	Product	Diet formulation for gilthead seabream with inclusion of mussel meal (IL1).	The formulation that will be based on mussel meal needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for gilthead seabream to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.2	Product	Diet formulation for gilthead seabream with inclusion of mussel meal (IL2).	The formulation that will include mussel meal needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for gilthead seabream to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.3	Product	Diet formulation for Brazilian flounder with inclusion of macroalgae.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for Brazilian flounder juveniles to meet the known requirements for optimal growth.	Y	53%	4	T3.3
13	13.2.4	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL1).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.5	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL2).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.6	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL3).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.7	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL1) as lipid replacement.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.8	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL2) as lipid replacement.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
13	13.2.9	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL3) as lipid replacement.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.10	Product	Diet formulation for whiteleg shrimp with inclusion of microalgae (IL4) as lipid replacement.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for whiteleg shrimp to meet the known requirements for optimal growth.	Y	53%	5	T3.3
13	13.2.11	Product	Diet formulation for pirarucu with inclusion of macroalgae.	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for Brazilian flounder juveniles to meet the known requirements for optimal growth.	Y	53%	4	T3.3
13	13.2.12	Product	Diet formulation for tambaqui with inclusion of macroalgae (IL1).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for Brazilian flounder juveniles to meet the known requirements for optimal growth.	Y	53%	4	T3.3
13	13.2.13	Product	Diet formulation for tambaqui with inclusion of macroalgae (IL2).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for Brazilian flounder juveniles to meet the known requirements for optimal growth.	Y	53%	4	T3.3
13	13.2.14	Product	Diet formulation for tambaqui with inclusion of macroalgae (IL3).	The formulation that will include algae needs to be nutritional balanced (protein, amino acids, lipid, fatty acids, vitamin and minerals) for Brazilian flounder juveniles to meet the known requirements for optimal growth.	Y	53%	4	T3.3
13	13.2.15	Product	Diet for gilthead seabream with inclusion of mussel meal (IL1).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.16	Product	Diet for gilthead seabream with inclusion of mussel meal (IL2).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
13	13.2.17	Product	Diet for Brazilian flounder with inclusion of macroalgae.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	4	T3.3
13	13.2.18	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL1).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.19	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL2).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.20	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL3).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.21	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL1) as lipid replacement.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.22	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL2) as lipid replacement	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.23	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL3) as lipid replacement.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.24	Product	Diet for whiteleg shrimp with inclusion of microalgae (IL4) as lipid replacement.	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	5	T3.3
13	13.2.25	Product	Diet for pirarucu with inclusion of macroalgae	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	4	T3.3

CS	Ident.	Output type	Detail	Requirement Specifications	Pot. Product (Y/N/tbc)	Com-plete	Current TRL	WP task
13	13.2.26	Product	Diet for tambaqui with inclusion of macroalgae (IL1).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	4	T3.3
13	13.2.27	Product	Diet for tambaqui with inclusion of macroalgae (IL2).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	4	T3.3
13	13.2.28	Product	Diet for tambaqui with inclusion of macroalgae (IL3).	The diet will have a pellet quality (e.g. density, durability, hardness, water stability), size, and shape suitable for the species and stage.	Y	53%	4	T3.3

The work carried out in the CS tasks that report to WP3 has progressed as expected, with the exception of two tasks (Table 1, CST1.5 & CST3.8). In both cases, COVID delayed the start (0% complete), since this work was scheduled to start later in the project (M31 & M25 respectively); however, CS leaders report that the 6-month extension of the project will provide sufficient time to complete the research. The completeness of the remaining 18 tasks that report to WP3 and their respective outputs range from 53% to 100%. Nine tasks are between 53% and 75% complete, six between 80 and 95% and three (Table 1) are fully completed. This is largely in-line with the expected progress.

Out of the three completed CST, six products reached their final development stage within the project. While the diets for juvenile Brazilian flounder without and with protein sparing effect of lipid are only at TRL4 (trials were done in lab scale), the production of anemone (*Anemona sulcata*) , and the production of hydrolysed proteins and oil from fishery by-catch from sardine heads and from boiled mussel meal waste are all at TRL7 (Table 1).

With regard to the CSTs that rank from 53%-95% completeness the TRL levels vary but have advanced from the last reporting period across the board with the exception of these outputs (Table 1):

- Queen scallop obtained from abalone IMTA co-culture.
- Diet (formulation) for Brazilian flounder with inclusion of macroalgae
- Diet (formulation) for pirarucu with inclusion of macroalgae
- Diet (formulation) for tambaqui with inclusion of macroalgae
- Shrimp, Oysters and seaweed grown by new IMTA system

All but the shrimp, oyster and seaweed IMTA system work are still at TRL4 (i.e., have been or are in the process of being validated in the lab). For the queen scallop spat the observed survival during trials was disappointingly low (<5%) and after an unreliable hatchery production in 2021, there was no queen scallop spat available for further trials. The diets and diet formulations are still at TRL4 as COVID delayed the production of the needed low trophic species to be include in the diets. For Ident. 5.3.2-.4 the work was not successful. Extreme droughts and a substantial increase of rainfall in the rainy season – both likely related to climate change – altered the culture conditions at the PRIMAR farm site severely. It increased the input of suspended solids (reducing the light in the water column and increasing the rate of sedimentation), and widened the oscillation of temperature and salinity in the ponds. This in turn caused an unsuitable environment for the reared organisms (mainly to algae and oysters). Still, three experiments with macroalgae, three experiments to define the proportion of species in the IMTA and a trial to test the prototype system were carried out at commercial scale ponds but the changed conditions led to the mortality of both oysters and macroalgae and reduced the survival of the shrimps. Although alternatives are still being considered to hopefully address this concern, it is foreseen that this task might not achieve the desired TRL by the end of the project.

The following outputs have advanced (see also Table 1):

- Bêche-de-Mer from *Holothuria grisea* (from IMTA);
- A new protocol for sea based native oyster spat production including recommendations on new seed collector materials and new protocols adapted to local species;
- A new software for automatic identification of oyster species;
- Ecological paint manufacturing;
- Diet (formulations) for gilthead seabream with inclusion of mussel meal;
- Diet (formulations) for whiteleg shrimp with inclusion of microalgae reached TRL 5 as they were validated in relevant environments;
- New sea cucumber species optimised for shore based IMTA;

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- Production of new species *Paracentrotus lividus* from a new process (roe enhancement and out of season production);
- Holding facilities for sea cucumber IMTA with Abalone;
- Bêche-de-Mer from Neostichopus grammatus (from IMTA); and
- Diet for Senegalese sole with inclusion of hydrolysates reached TRL 6 or are in the process of being demonstrated in relevant environment.

The following have past validation and at demonstration stage in an operational environment (TRL7):

- Mussels and macroalgae produced using IMTA in South Africa;
- Abalone, *Alaria esculente* and *Palmaria palmata* obtained from IMTA;
- Flat oyster obtained from IMTA co-culture with abalone;
- Shrimp, Mullet and *Ulva Sp*. grown by new IMTA Biofloc system;
- Land-based holding system for sea urchin roe enhancement; and
- Production of *Strongylocentrotus droebachiensis* from a new process.

Shrimp grown by new biofloc system can even be considered to have reached TRL 8, since the production system has been completed and qualified.

For more and detailed information on the percentage completeness and progress of any specific output please see Annex 1 of Deliverable D1.4 (the first two numbers of the identifier – see Table 1 will lead you to the respective CS task).

In summary, only two case study tasks have experienced problems (low survival) that led to unsuccessful trials. In turn part of their respective outputs, have not progressed in TRL. The great majority of the case study work related to WP3 has advanced very well and is mostly on time given the 6-month extension that was granted to the project. The extension is believed to be sufficient to make up for the problems caused by COVID.

4. User acceptance testing feedback

The 13 case studies in AquaVitae are developing 139 outputs in the form of reports, products and process that can be considered "key exploitable results" (KERs). They will result from case study tasks (CSTs) that report to WP1, 2 and 3. It was not considered feasible to collect stakeholder feedback on all these outputs because some are less likely to have impact, others are supporting-outputs that contribute to key-outputs that will have impact in the aquaculture industry, and some are likely to impact when applied in combination with others; as such, these KER were either not considered in the user acceptance feedback analysis or they were combined to form joint KER's that are more likely to have impact. The case study leaders, together with WP1, 2 and 3 leadership, selected a short-list of outputs (some on their own and some a combination of KERs) that took these concerns into consideration and called them "flagship" key exploitable results (fKERs) (for further info see methodology section). This short-list of 45 fKERs is presented in Table 2 of Deliverable D1.4. The fKERs were used to carry out stakeholder surveys to collect user acceptance feedback. A total of 151 respondents participated in the WP1, 2 and 3 stakeholder survey up until 12th of May 2022. The combined results on the surveys as a whole and per CS can be found in Annex 2 – 4 of Deliverable D2.3.

Out of the 45 fKERs of Table 2 of Deliverable D1.4, 15 fKERs report to or are relate to WP3 (Table 2).

Table 2: All flagship Key Exploitable Results (fKER) related to WP3, including their number, name, short description, the specific identifier number of the output(s) that the fKER is based on (→ see also "Indent." in table 1) and the WP task that

the fKER reports to. (fKERs in blue have not received any answer/interest by stakeholders or in case of CS11 are still preliminary).

flagship KER No.	flagship KER Name	Short description	based on output No. (Indent)	WP task
fKER3.2	Process - Co-culture of abalone & sea cucumber	Sea cucumber remove solid waste from land-based abalone tanks, reduces cleaning, labour costs, and handling. Plus, potential new product in sea cucumber.	3.4.1, 3.5.1	T2.2, T3.2
fKER4.2	Product - Macro-algae produced on mussel rafts using IMTA	New macro-algae for the inclusion in aquafeeds, produced using existing mussel raft infrastructure.	4.2.3	T3.2
fKER4.5	Process - IMTA of abalone and macro-algae (*Saccharina/Alaria/Ulva*)	Novel methods for the co-culture of abalone and macro-algae using the same space at sea.	4.6.1-.3	T2.2, T2.4, T3.2
fKER4.6	Product - flat oyster obtained from abalone/oyster IMTA	New flat oyster product produced using existing abalone and kelp IMTA system.	4.7.2	T3.2
fKER6.2	Production of new species *Strongylocentrotus droebachiensis* from a new process (roe enhancement and out of season production)	Production on a commercial scale of enhanced *Strongylocentrotus droebachiensis* in Norway.	6.2.1	T3.2
fKER6.3	Production of new species *Paracentrotus lividus* from a new process (roe enhancement and out of season production)	Roe enhancement and out of season production of *Paracentrotus lividus* in Spain for the European industry.	6.3.1	T3.2
fKER7.1	Holding facilities for sea cucumber IMTA with Abalone	Systems to integrate sea cucumbers into Abalone tanks to eat abalone faeces. Reduce tank-cleaning need and provide sea cucumber biomass as secondary product.	7.3.2	T3.2
fKER7.2	Bêche-de-Mer from Neostichopus grammatus (from IMTA)	A low-medium grade sea cucumber for export market in Hong Kong / CN. Worth investigation as by-product especially if processing improved.	7.3.3	T3.2
fKER8.3	A new protocol for sea based native oyster spat production	Implementation of wild spat collection protocols for sea-based seed collection and on-growing.	8.2.1	T1.2, T1.3, T1.5, T3.2
fKER11.1	Product - Diet development for juvenile Brazilian flounder.	Determination of protein requirement on diets for juvenile Brazilian flounder	11.2.1	T3.2
fKER12.1	Process - Valorisation of shell CaCO3 into Eco-Paint	Using fine grinded biological (shell) instead of mineral CaCO3 as filler in paints to contribute keeping the carbon footprint of shellfish aquaculture low.	12.2.2	T3.2
fKER12.2	Process – Production of marine protein hydrolysates from fishery and aquaculture side streams	Applying the biorefinery concept to obtain protein hydrolysates from previously discarded fish and mussel aquaculture side streams to be used as feed additives.	12.3.1-.4	T3.2

fKER12.3	Product – Marine protein hydrolysates from fishery and aquaculture side streams	Delivering added-value protein hydrolysates to be used as high nutritional quality feed additives for aquafeed and pet food industry.	12.3.1-.3	T3.2
fKER13.2	Product - Shrimp feed with inclusion of microalgae	Feed that improves resistance to thermal stress and immune defence.	13.2.4-.10 13.2.18-.24	T3.3
fKER13.3	Product - Gilthead seabream feed with inclusion of mussel meal	Fishmeal-free diet. Valorised side streams and less waste in mussel production.	13.2.1-.213.2.16-.17	T3.3

The following analysis draws on the stakeholder reviews/surveys related to the 15 fKERs that report to WP3 (Table 2).

Fifty-eight respondents reviewed the fKERs that relate to WP3. The respondents provided feedback on 12 fKER only, and none of them commented on the following:

- Flat oyster obtained from abalone/oyster IMTA (fKER4.6);
- Diet for juvenile Brazilian flounder (fKER11.1); and
- Shrimp feed with inclusion of microalgae (fKER13.2).

Ninety-five percent of these respondents were drawn from outside of the project (Figure 1). More than half of them (57%) were involved in research and/or education, while 36% were from industry. A small percentage were regulators (3%), NGOs (2%) or others (2%) (Figure 2).

Out of the 58 respondents 44% have actually tested or trialed one or more fKER that they have answered the questions of the survey on. Almost one quarter (24%) is interested in either testing (13%) or applying/adopting (11%) at least one fKER related to WP3, almost another quarter (23%) is interested in collaborating in the further development. A minority (3%), i.e. one respondent is interested in offering, supplying or selling one of the fKERs. This has been the only respondent that selected being a seafood processor as their principle activity. To get a better understanding of how many of the new species coming out of AquaVitae/WP3 are likely to be thought after products on the market, a higher number of such processing and/or sales sector should be asked to fill in the survey.Only 6% of the respondents were not interested in any of the offered answers.

A number of respondents commented on more than one fKER and 61% considered that the implementation of the usable outputs - i.e. fKERs that they commented on - would result in new products or new processes, while 39% assume that the fKERs that they selected would improve existing products and processes (Figure 4).

Over 80% of respondents thought that the fKERs selected by them would improve or greatly improve the economic (88%) and environmental (82%) sustainability of the aquaculture industry (Figure 5 and 6), whereas only 64% thought social sustainability of the aquaculture industry would be improved through the implementation the selected fKERs (Figure 7).

Most respondents (46%) thought that the future implementation of the fKERs of the case studies that report to WP3 would address technical challenges associated with aquaculture. Some are of the opinion that concerns associated with consumer perception (26%) and legislation (16%) are also addressed (Figure 8).

From the stakeholders that reviewed WP3 outputs 48% considered that they are very likely to likely be adopted by the aquaculture industry in the next five years, 40% were undecided and only 12% have the view that the newly developed processes and products are unlikely to be adopted (Figure 9).

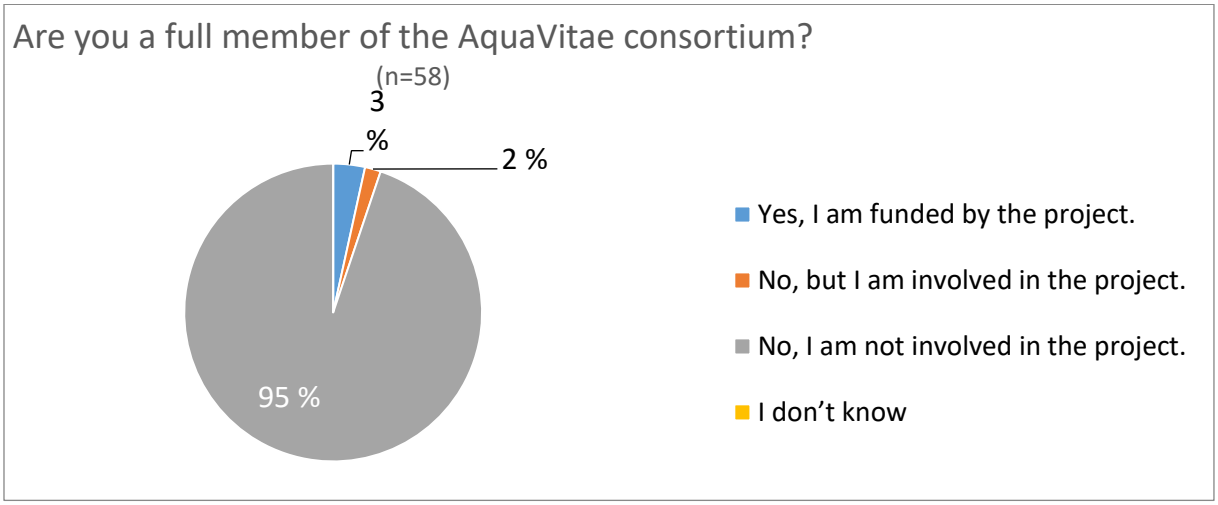

Figure 1: Relation to the AquaVitae Project of respondents that participated in survey on fKERs related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

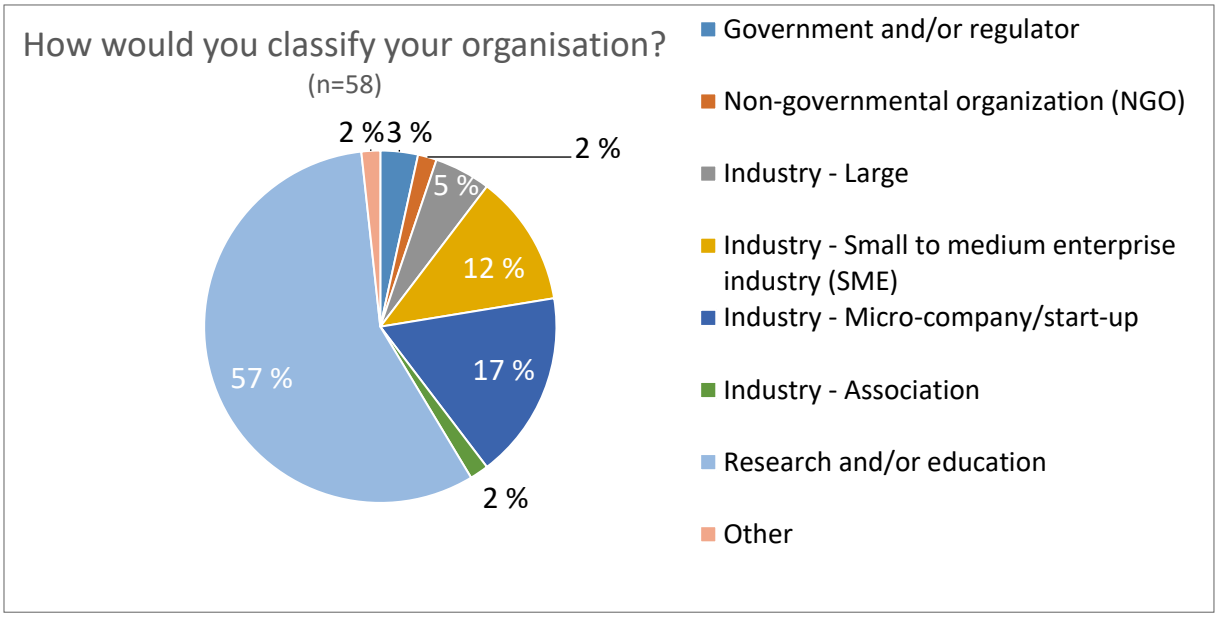

Figure 2: Background of respondents that participated in survey on fKERs related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

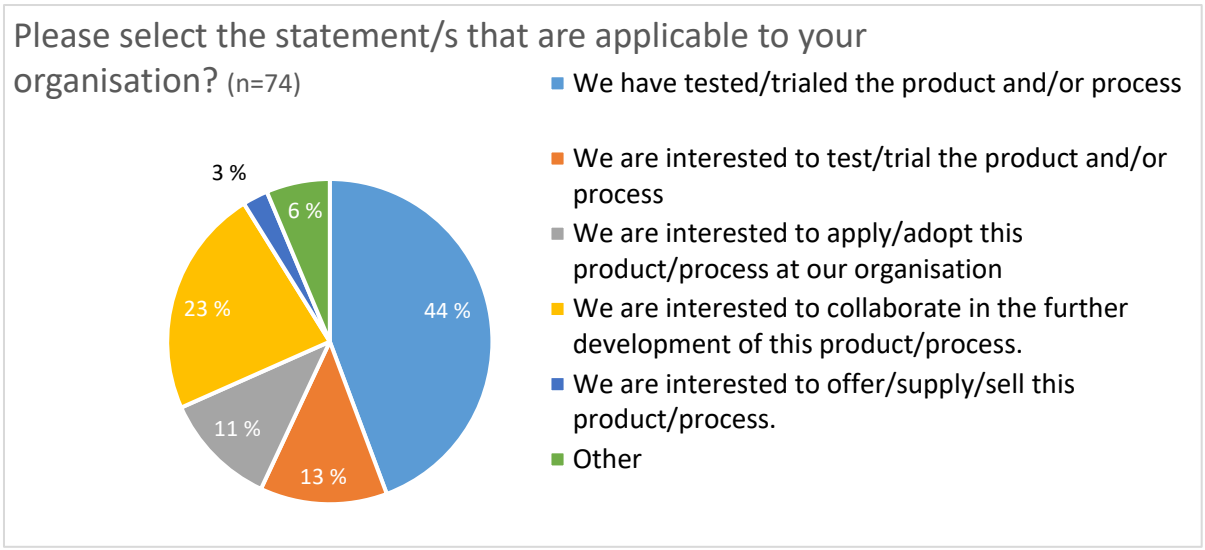

Figure 3: Interest in fKERs related to WP3 of respondents that participated in survey (AquaVitae stakeholder survey, 12 May 2022).

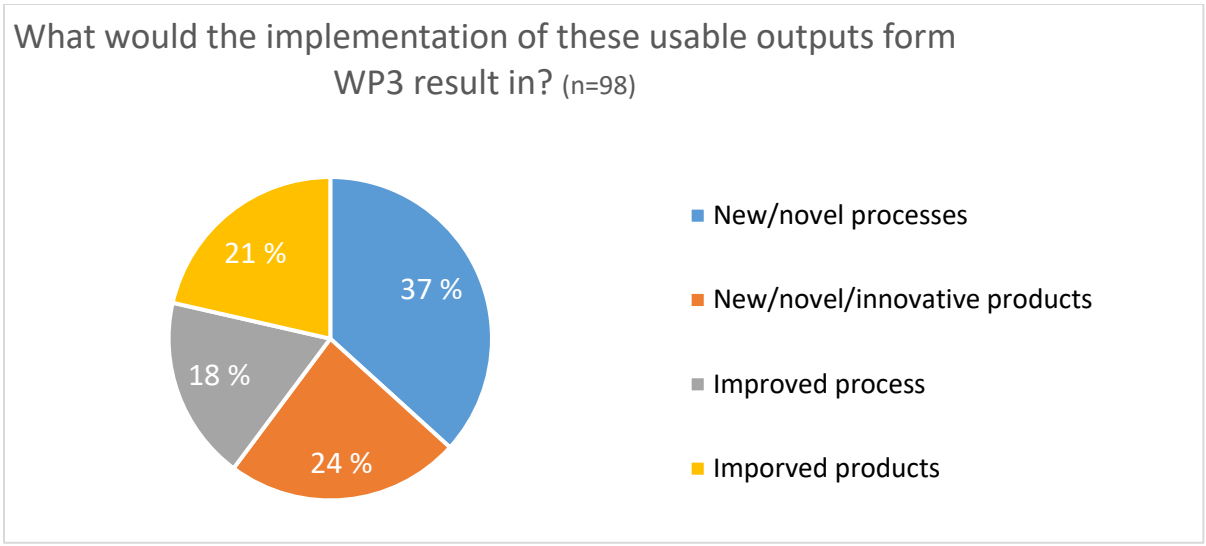

Figure 4: Stakeholder's expected outcome if the fKERs that relate to WP3 were to be implement by the industry (AquaVitae stakeholder survey, 12 May 2022).

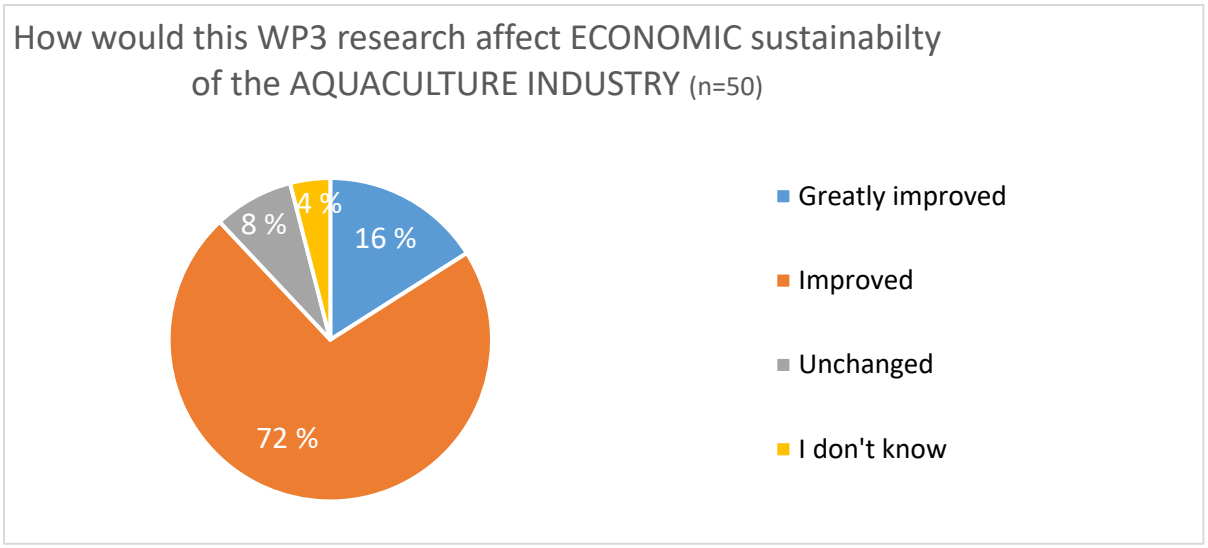

Figure 5: Stakeholder's expectation on the impact on economic sustainability of the aquaculture industry, following the implementation of the selected fKER related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

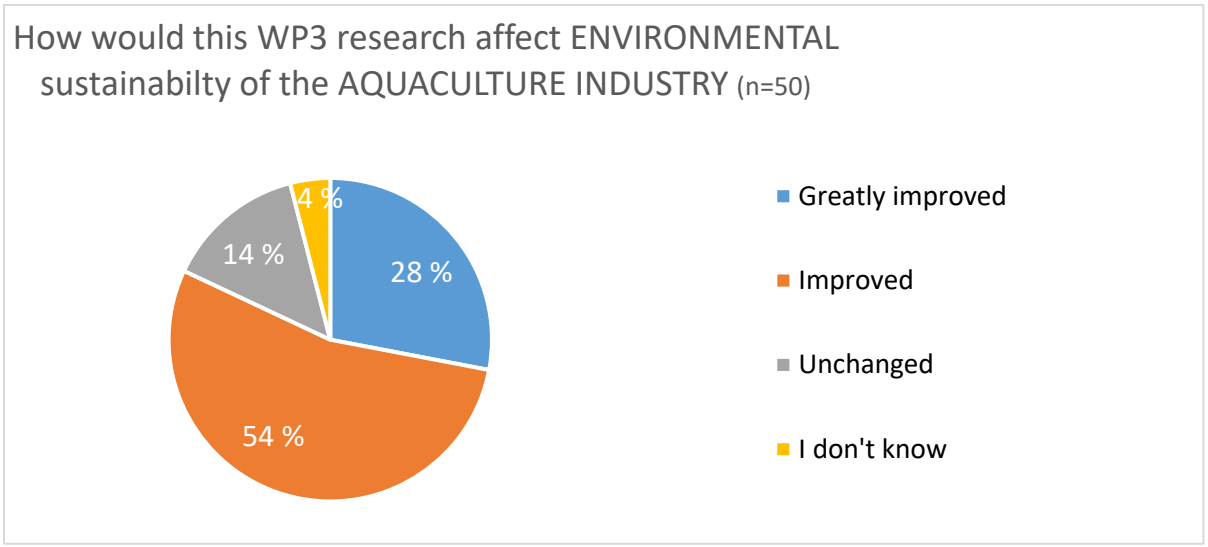

Figure 6: Stakeholder's expectation on the impact on environmental sustainability of the aquaculture industry, following the implementation of the selected fKER related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

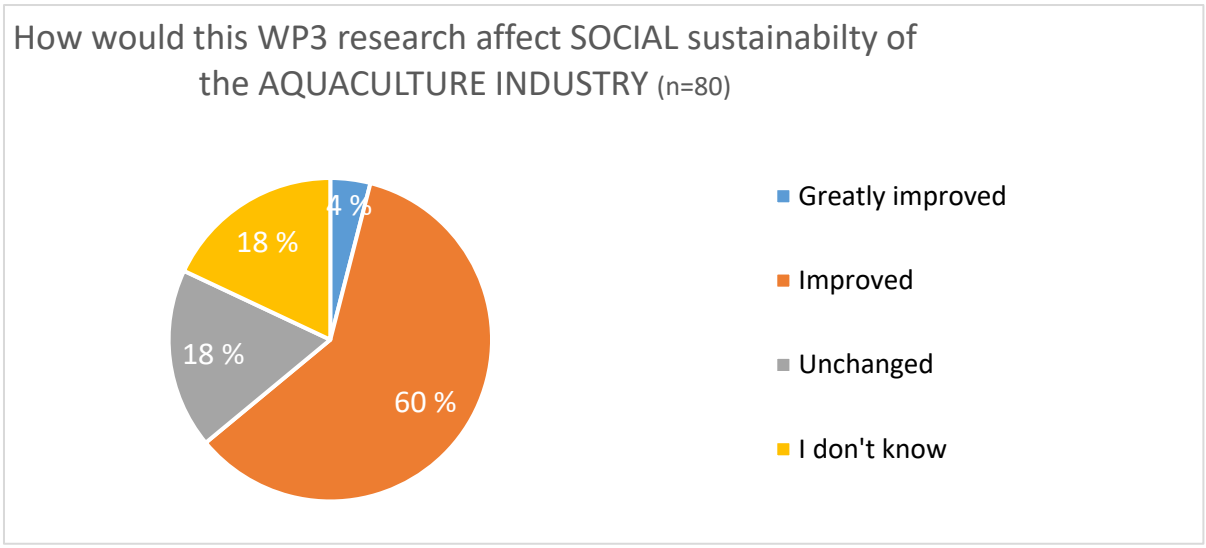

Figure 7: Stakeholder's expectation on the impact on social sustainability of the aquaculture industry, following the implementation of the selected fKER related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

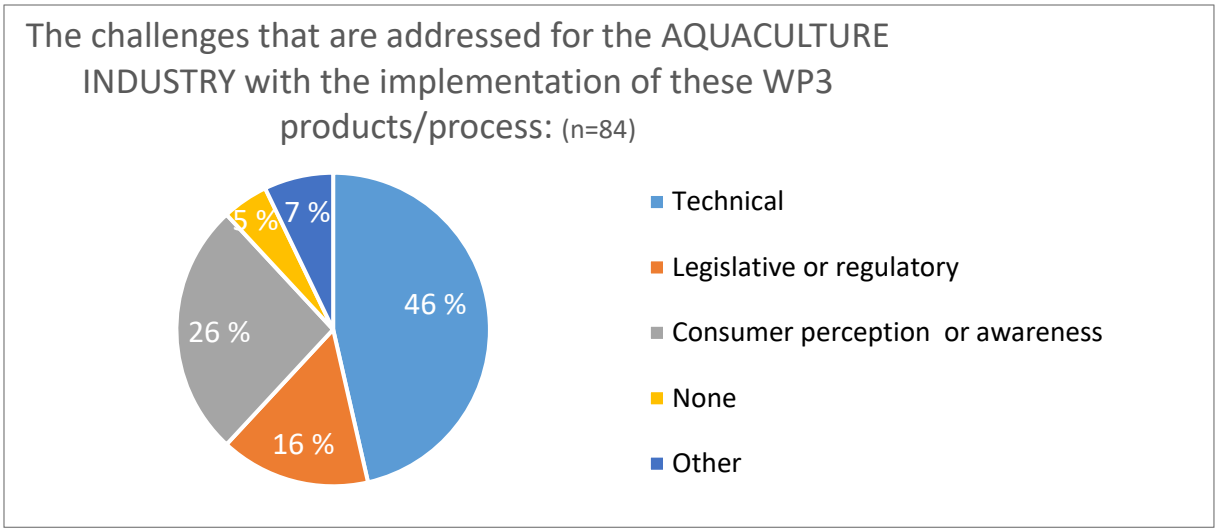

Figure 8: Stakeholder's view on the challenges of the aquaculture industry that will be addressed, following the implementation of the selected fKER related to WP3 (AquaVitae stakeholder survey, 12 May 2022).

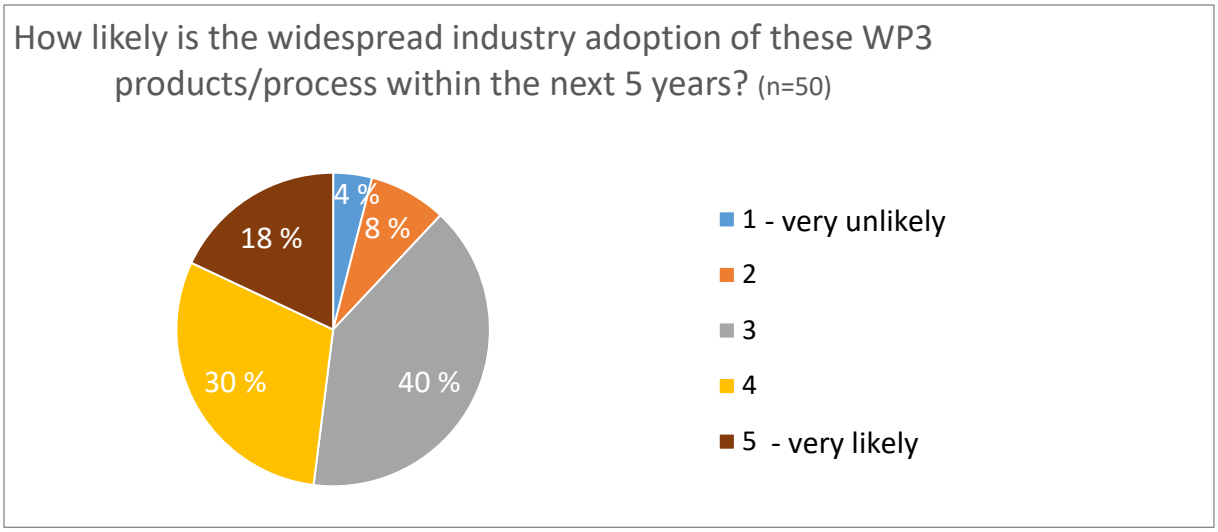

Figure 9: Stakeholder's view on the likelihood of the adoption of the selected fKER related to WP3 by the aquaculture industry within the next five years (AquaVitae stakeholder survey, 12 May 2022).

In summary, the feedback of 58 stakeholders on the fKERs that resulted from the work within the different CS that report to WP3 revealed that 12 fKERs were of relevance to the industry by the time of the cut-off date of the current surveys (22.5.2022). Only three of the fKERs related to WP3 have not yet been commented on, but a higher number of respondents might also prove their industry relevance in the future. The survey demonstrated the acceptance and applicable of 12 fKERs to a variety of end-users (e.g. industry, research, policy). The future perspective of the fKERs can be considered good judging from the fact that the interest for testing, direct application or collaboration in the future developments was very high and that almost half of the respondents considered that the fKERs are likely to be adopted by the aquaculture industry in the next five years. The fKERs related to WP3 offer both, the potential for new products or processes as well as the improvement of already existing ones). The products and processes have the ability to increase the sustainability (economically, environmentally, socially) of the aquaculture industry and address their current challenges. The validity of these results is supported by almost half of the respondents having already tested some of the fKERs.

5. Conclusion

The work of the 13 CS within AquaVitae is made up of 59 CSTs has resulted in 139 KERs. Each is supported by detailed experimental design and by data collected by 35 partners across 16 countries that border the Atlantic Ocean. Despite restrictions and problems caused by COVID, CST leaders still produced innovative research that demonstrated synergistic, collaboration between partners from different geographical areas.

Twenty out of AquaVitae's 59 CSTs report to WP3, and they produced 62 KERs. One of these CSTs and its resulting two KERs are shared with WP1, another CST and its KER is shared with WP2. From these 62 KERs that report to WP3, 15 were marked as flagships outputs or fKERs of WP3.

The common reporting system designed during the first 12 month of the project by the leaders of WP1-3 has made the large volume of research easily available to the project team and a reliable tool to compile the large amount of information provided by each CS.

The case study work related to WP3 has advanced very well. The 6-month extension that was granted to the project has addressed the delays caused by COVID. This includes two cases studies were the

consequences of COVID delayed the start of the work up until now. Two more case studies have advanced but experienced problems (low survival of target species) that led to unsuccessful trials and hindered an increase in TRL level.

A stakeholder survey on user acceptance testing feedback of fKERs was developed and implemented by WP1, 2 and 3. This demonstrates the joint-planning and cooperation among the leadership of these work packages. In total, 58 stakeholders gave their feedback on the 15 fKERs that resulted from the work within the different CS that report to WP3. Overall, the survey confirmed that at least 12 of the fKERs that report to WP3 are of relevance, acceptable and applicable to a variety of end-users (e.g. industry, research, policy) from the aquaculture value chain. These fKERs have the potential to create new products or processes or improve already existing ones. They have the ability to increase the industry's sustainability (economically, environmentally, socially) and address a number of industry challenges (technical, consumer perception and legislation). Almost half of the respondents had already tested some of the 12 fKERs and the rest are interested in testing or applying them or showed interest in collaborating in their future development. Thus, WP3 is on track to generate its desired impact. Furthermore, almost half of the respondents considered that the fKERs that are related to WP3 are likely to be adopted by the aquaculture industry in the next five years.

The stakeholder survey on user acceptance testing feedback will continue for the duration of the AquaVitae project. An increased effort will be made to involve stakeholders from outside of research, development and education, and to particularly increase the number of industry, NGO, investment and government respondents. The outcome of the survey will be used by CS and CST leaders in the final stages of their research, and in developing exploitation strategies to ensure that the research and innovation that has been developed in this project will have impact in the aquaculture industry.