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Final Evaluation of the SMARTAQUA Operation

CIOTEK LIMITED

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Final Evaluation of the SMARTAQUA Operation

Submitted by CIOTEK Limited

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Final report following from an inception and mid-term evaluation undertaken by CIOTEK Limited.

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Glossary of Terms	
CSAR	Centre for Sustainable Aquatic Research
ERDF	European Regional Development Fund
HEI	Higher Education Institutions
ISO	International Organisation for Standardisation
OWI	Operational Welfare Indicators
PM	Project Manager
RAS	Recirculation Aquaculture Systems
RD&I	Research, Development, and Innovation
SO	Specific Objective
WEFO	Welsh European Funding Office
WP	Work Package
WW&V	West Wales and the Valleys

Independent External Evaluation of the SMARTAQUA Operation

Final Evaluation Report

Synopsis

SMARTAQUA is a 59-month operation funded by the European Regional Development Fund (ERDF) under Specific Objective 1.2 (SO 1.2) “to increase the successful translation of research and innovation processes into new and improved commercial products, processes and services, in particular through improved technology transfer from Higher Education Institutions (HEIs)”. SMARTAQUA is aimed at the development of non-food aquaculture in West Wales and the Valleys (WW&V) through the adoption of advanced aquaculture technologies. SMARTAQUA was originally a 42-month operation, extended to 49-months following a reprofile agreed in December 2019. The operation was further extended to a 59-month operation with and end date of September 2022, as agreed with WEFO in December 2021.

The SMARTAQUA operation uses world-class science in sustainable aquaculture, which builds on established infrastructure, goods, and services to enable Welsh companies to respond to current and future opportunities in the non-food aquaculture market. SMARTAQUA is designed to strengthen SMEs capacity for research, development, and innovation (RD&I), and technological development which is essential for the enhancement of the international status and global competitiveness of Welsh non-food aquaculture, as well as the strengthening of the local economy through growth in productivity.

The final evaluation report comprises the findings of an independent assessment of the SMARTAQUA operation, including a review of the progress to date, operational context, conclusion and recommendations for the completed operation and future opportunities.

Further Information

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Executive Summary

This final evaluation report comprises the findings of an independent evaluation of the SMARTAQUA operation. Specifically, this report assesses the progress against targets, evaluates the operational context and structure, reviews outputs, results, data collection methods, CCT activities, evaluates any barriers faced, highlights the feedback collated from collaborative companies and provides recommendations for the operation moving forward.

To achieve the objectives of this evaluation, CIOTEK undertook a comprehensive desk research exercise to understand SMARTAQUA's activities and achievements to date, to review the logic model and monitoring and evaluation plan to assess any changes made throughout the operation. Additionally, field research was undertaken through one-to-one interviews with key SMARTAQUA management and staff, and with collaborative companies.

It was evident that SMARTAQUA remains clearly aligned to Welsh, UK and EU policies and strategies. The SMARTAQUA team has detailed monitoring and evaluation plans in place. These plans remain effective and focused on achieving the objectives of the operation. The operation team were praised for their efficient and thorough collection, storage, monitoring, and management of data. Furthermore, SMARTAQUA has had good levels of communication and effective teamwork. The team has been clear, transparent, and robust with its communication and work.

The SMARTAQUA operation has achieved a wide range of CCT activities throughout the operation. These activities have been particularly successful in areas such as positive action measures (women), female participation in STEM, resource efficiency measures, local supply chain development, and mentoring/advocacy activities. In addition, it has been noted that SMARTAQUA have provided learning opportunities for students.

After a comprehensive review of the SMARTAQUA operation at its final stage, it is concluded that this operation has been both successful and consistent in the delivery of activities. This has been achieved despite the delays caused by COVID-19, and the changing of key staff during the programme delivery, with three Research Officers leaving their role in the operation, necessitating the engagement of new members of staff, and the Deputy Strategy Technology Manager taking a period of maternity leave. Despite the change in management staff, the leadership has remained consistent and effective in providing clarity of direction.

Despite the COVID-19 setbacks and constraints, the SMARTAQUA team has made excellent progress towards the achievement of their indicator targets, with two targets being exceeded and a further three achieving between 85.7% and 87.5%. Of the four targets that fell short of their objective, a collaborative partner

patent (although one was registered by the university), non-financial support, partners cooperating in research projects and new to firm and market products, these were the targets that were most impacted by the pandemic with the uncertainty created affecting investment confidence and reduced R&D expenditure.

Although not specific to SMARTAQUA targets, the following achievements should be noted as they have been attributed to SMARTAQUA as a consequence of the collaboration and support:

Achievement	Number / Value
Increased level of business	£2,150,000 million p.a.
Increased employment	34
Increased Investment	£35k annually
Number of Staff Upskilled	30

The evaluation concluded that SMARTAQUA has been a valuable operation which provided a range of benefits for the industry and collaborative partners including:

- Provision of resources, data and knowledge
- Assistance with development of processes and procedures
- Improvement of welfare standards driving positive change in the industry.
- Promotion of equal opportunities
- Launch of new products or services
- Introduction of new processes or procedures
- Links to other businesses in convergence area

Due to the successful collaborative opportunities provided by SMARTAQUA, it was identified that they would like to work with SMARTAQUA again for a number of reasons:

- Staff expertise
- Very responsive team
- High level of technical ability
- Excellent communication and management
- Excellent execution of initial launch
- SMARTAQUA provided simplicity, effectiveness, and openness
- Staff had broad range of knowledge

Overall, it has been acknowledged that SMARTAQUA is a vital operation that has had significant positive impact on companies within the sector and the sector itself. However, due to the rapidly changing nature of the sector, continuous work needs to be undertaken and the research of the SMARTAQUA team can help to enhance the sector. It has been evidenced that the demand for SMARTAQUA remains strong.

Recommendations

Recommendation 1 – Maintain the Momentum

It has been identified during the final evaluation that the SMARTAQUA operation has provided significant benefits for collaborative companies and had a wide impact on the non-food aquaculture sector including the improvement of welfare standards. It was also acknowledged by the companies that there is still much work to be done within the sector and that the companies would like to work with SMARTAQUA again. As a result, it is recommended that the CSAR operation seeks to engage with these businesses when the SMARTAQUA operation and funding ends. This engagement should seek to establish how the businesses might be supported and to ensure that there is a minimal break in delivery to maintain project momentum and benefit from continued success.

Recommendation 2 – Make Further Applications to Seafood Innovation Fund

It is recommended that SMARTAQUA (or CSAR) should capitalise on the track record and expertise achieved throughout the operation to make further applications under the Seafood Innovation Fund 4th Call (Appendix A). This fund is accepting Expressions of Interest through to 31st October 2022.

Recommendation 3 – Resource planning

It is recommended that for any future collaborations there is a more definitive formulation of mutual goals (industry & academia). Industry sometimes has unrealistic expectations of the levels of support, resource and equipment available to them. It is recommended that, going forward, there is a more definitive statement of resource available, equipment that might be accessed and a consideration that in the absence of funding, there may need to be a financial contribution from the business for the support and equipment they are seeking to access.

Recommendation 4 – Monitor Horizon Europe

It is recommended that both Swansea University and CSAR monitor progress of the Horizon Europe funding programme (See Appendix B). During the ongoing period of negotiation over the Northern Ireland protocol it is recommended that exploratory links are forged with potential European partners, that may become collaborative partnerships in the future. It is further recommended that this focus should initially be on partner countries with whom SMARTAQUA has already forged successful relationships in the Aquaculture sector.

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1. Introduction

This evaluation report outlines the findings of an independent assessment of the SMARTAQUA operation at Swansea University. SMARTAQUA aims to develop non-food aquaculture in West Wales and the Valleys (WW&V) through the adoption of advanced aquaculture technologies. The inception and mid-term evaluations of the operation were undertaken by CIOTEK Ltd and were completed and submitted in March 2020 and December 2020, respectively.

Following the completion of the inception and mid-term evaluations, CIOTEK has undertaken the final evaluation of SMARTAQUA. The final evaluation will summarise the key outcomes from the mid-term evaluation before presenting the findings from a thorough investigation of the SMARTAQUA operation at its final stage including an assessment of its ongoing progress. Furthermore, key recommendations will be outlined that can be used to shape the future direction of the operation beyond its ERDF funding lifecycle.

1.1. Evaluation Aims and Objectives

The final evaluation of the SMARTAQUA operation has the following objectives:

- Assess whether the recommendations from the mid-term evaluation have been implemented
- Review the fitness for purpose of the management structure and monitoring and evaluation processes
- Assess the data collected after the mid-term evaluation
- Evaluate the extent to which SMARTAQUA is delivering against targets
- To assess progress against CCT objectives, case level indicators, and contributions to the Well-being of Future Generations Act
- To assess project impact achieved using data collected with the logic model as a baseline
- To summarise constraints, barriers and problems faced by the SMARTAQUA operation and how the team has responded

- Provide an assessment of the overall impact of the operation and make recommendations beyond the life of the operation.

1.2. Evaluation Methodology

CIOTEK has developed the evaluation methodology for the operation in conjunction with the SMARTAQUA management team. A summary of the methodology that has been used is outlined below:

1.2.1. Desk Research

The desk research conducted entailed and extensive review of secondary research, publications, and operation documentation to effectively:

- Understand the development and progress of the operation through reading key documents such as the Welsh European Funding Office (WEFO) progress reports, CCT indicators and other relevant update documents
- Review Monitoring and Evaluation (M&E) processes to understand whether any changes have been introduced since the inception evaluation
- Review and update the inception logic model.

1.2.2. Fieldwork

CIOTEK Ltd have held meetings with the management team of SMARTAQUA to confirm the status of the operation and to discuss any specific operational or strategic changes that may impact the ongoing or future objectives.

Additionally, in preparation for the final evaluation, CIOTEK consultants prepared questionnaires that were approved by the SMARTAQUA project manager (PM), after consultation with and agreement from WEFO. Following this, CIOTEK consultants undertook qualitative research that comprised of interviews via online platforms as well as quantitative research in the form of a questionnaire. A total of 11 interviews were completed as detailed in Table 1.

The research conducted with the SMARTAQUA team sought to identify:

- The implementation of the mid-term evaluation recommendations
- Delivery of key outputs and indicators
- Mechanisms in place
- Management structure
- Monitoring and evaluation processes
- Progress of work packages
- Barriers faced
- Progress against CCTs

- SWOT analysis
- Impact of SMARTAQUA on participating businesses
- Impact of COVID-19
- Impact of Brexit.

The research conducted with the industry collaboration partners included the following areas of discussion:

- Contact with SMARTAQUA
- Reasons for engaging with SMARTAQUA
- Business needs
- Quality of support provided by SMARTAQUA
- Impact created by SMARTAQUA collaboration
- Benefits accrued
- Expectations

1.2.3. Data Analysis

- **Data Collation and Analysis** – Qualitative and quantitative analysis has been collated anonymously and presented in subsections. The deliverables achieved and their impact and benefits have neem assessed and reported.

1.2.4. Conclusions and Recommendations

- **Conclusions and Outcomes** – Drawn from fieldwork and desk research phases
- **Recommendations** – Which may be used to further the operation beyond its lifecycle

1.2.5. Primary Research Scope

As part of the final evaluation, CIOTEK have collected data from SMARTAQUA team members and collaborative partners, as outlined in table 1.

Role		Organisation
SMARTAQUA Team	Project Manager	Swansea University
	Principal Investigator	Swansea University
	Co-Principal Investigator	Swansea University
	Strategy and Technology Manager	Swansea University
	Deputy Strategy and Technology Manager	Swansea University
	Research Officer	Swansea University
External Collaborations	5 x Industry Collaboration Partners from the marine and aquaculture sector	Confidential

Table 1: Interview List

A list of the 12 SMARTAQUA participant organisations was provided to CIOTEK by SMARTAQUA. From this list CIOTEK selected eight organisations for interview. These organisations were then advised by SMARTAQUA that they had been selected for interview and invited to participate in an anonymous feedback process. A series of emails and telephone calls were made by CIOTEK to each organisation from which five responded, these were subsequently interviewed and the results collated and presented in Section 4 of this report.

1.2.6. Secondary Research

To supplement the primary research, CIOTEK Ltd has also undertaken a review of the following internal and external documents:

1.2.6.1. Internal Documents

- SMARTAQUA business planning documents
- M&E forms and updates
- WEFO quarterly progress reports
- Operational materials
- Delivery indicators

1.2.6.2. **External Documents**

- ERDF: Priority Axis 1: Research and Innovation[1]
- Delivering Science for Wales[2]
- Innovation Wales[3]
- Wales Seafood Strategy[4]
- Brexit and our Seas[5]
- Building our Industry Strategy: Green Paper[6]
- Future of the Sea: Trends in Aquaculture[7]
- Economic Prioritisation Framework[8]
- Open Innovation, Open Science, Open to the World[9]

[1] european-regional-development-fund-research-and-innovation-performance-indicators.pdf (gov.wales)
[2] https://gov.wales/sites/default/files/publications/2019-04/science-strategy-annual-report-2015-to-2016.pdf
[3] https://gov.wales/sites/default/files/publications/2019-04/innovation-wales-strategy.pdf
[4] https://www.seafish.org/about-us/working-locally-in-the-uk/working-with-the-seafood-industry-in-wales/seafish-wales-advisory-committee-swac/
[5] https://gov.wales/sites/default/files/consultations/2019-05/marine-and-fisheries-policies-for-wales-after-brexit-consultation-document.pdf
[6] https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf
[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/635209/Future_of_the_sea_-_trends_in_aquaculture_FINAL_NEW.pdf
[8] https://gov.wales/sites/default/files/publications/2019-09/welsh-european-funds-economic-prioritisation-framework.pdf
[9] http://publications.europa.eu/resource/cellar/3213b335-1cbc-11e6-ba9a-01aa75ed71a1.0001.02/DOC_2

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2. Mid-term Report Outcomes

This section will reiterate the recommendations made in the mid-term evaluation and report on the actions that SMARTAQUA have implemented to address these recommendations.

2.1. Summary

CIOTEK completed the mid-term evaluation report of SMARTAQUA in December 2020. The mid-term evaluation incorporated the following:

- An evaluation of the SMARTAQUA operation along with its context, evaluation aims, objectives and methodology applied
- Review of the SMARTAQUA logic model which outlines the demands, policy drivers, inputs, activities, outputs, outcomes, and impacts
- An assessment of the business plan and delivery plans associated with the operation to ensure that they were delivered as anticipated to produce the intended outcomes and impacts
- A review of the monitoring systems to ensure the efficient and effective delivery of the operation

It was evidenced that the SMARTAQUA operation remained firmly and directly aligned to Welsh Government and UK aims and objectives. SMARTAQUA also achieved demand led collaborative RD&I and knowledge exchange with industry through an adaptive smart specialisation approach to boost Wales to be a world leader in this science-driven niche sector.

The mid-term evaluation identified that the management team has an effective hands-on approach and excellent communication. The management team often provided an open space for team members to discuss ideas and issues and propose solutions and actions.

SMARTAQUA successfully introduced new Standard Operation Procedures as well as published scientific papers resulting in the generation of important knowledge for the industry. SMARTAQUA made good progress towards its indicator targets and were on track to achieve their targets. It was evidenced that

SMARTAQUA had made excellent progress towards the delivery of their CCT indicators. COVID-19 regulations had a negative impact on the progress of the SMARTAQUA work packages as SMARTAQUA staff had restrictions on laboratory use.

2.2. Mid Term Evaluation Recommendations

Mid-term Recommendation (1) – Reprofile

Due to the six-month delay encountered as a result of the COVID-19 pandemic, it was recommended that SMARTAQUA submit a reprofile application which should include reallocation of funds underspent on areas such as travel. This funding could then be used to extend the contracts of staff members who were unable to finish their laboratory work because of the COVID-19 restrictions. It was also suggested that SMARTAQUA indicator targets should be reviewed and amended to take into consideration the impact of COVID-19.

Mid-term Recommendation (1) – Action Taken

At the time of the mid-term evaluation, the SMARTAQUA team confirmed that WEFO had advised that no reprofile was possible in the current circumstances. However, it was advised that there was the potential to apply for additional funding to extend staff contracts and purchase equipment. For this funding, SMARTAQUA submitted an Expression of Interest to the WEFO PDO for consideration, detailing how any further funds would be utilised and how this would meet the objectives set out for the operation. Accordingly, the reallocation of unspent funds was utilised to support staff in the completion of active collaborations. SMARTAQUA was originally a 42-month operation, extended to 49-months following a reprofile agreed in December 2019. In December 2021 WEFO agreed a further 10 month costed extension which also addressed an amendment of SMARTAQUA indicator targets.

Mid-term Recommendation (2) – Bring Industry and Research Together

It was recommended that SMARTAQUA continue to collaborate with industry collaborative partners through symposiums similar to the 1st Symposium on Welfare in Aquaculture that the operation hosted. This will facilitate conversations and discussions regarding the needs and issues faced within industry as well as any relevant research findings.

Mid-term Recommendation (2) – Action Taken

SMARTAQUA have continued to collaborate extensively with industry collaborative partners and explore the mutual benefits that can be achieved through collaboration. Based upon the information gathered at the 1st Aquaculture

Symposium, a research paper[10] was published which aimed to implement welfare standards for farmed lumpfish. The collation of data required for the paper involved several industry partners and extensive collaboration.

Mid-term Recommendation (3) – Final Evaluation Data Collection

The mid-term evaluation recommended that SMARTAQUA should seek to capture both the impacts achieved to date and projected to result from the collaboration that fall outside the SMARTAQUA operation timescales. It was suggested that projected data against each indicator is explored to provide a fuller picture of the true long-term impact of SMARTAQUA.

Mid-term Recommendation (3) – Action Taken

The SMARTAQUA team, in conjunction with the final external evaluation, have incorporated questions to capture any impacts that will be achieved by collaborative partners in the 3 years post post-delivery and post funding period

Mid-term Recommendation (4) – CCT Case Studies

It was recommended in the mid-term report that SMARTAQUA should introduce a simple CCT process to capture CCT activities in the form of case studies to be included on the SMARTAQUA website.

Mid-term Recommendation (4) – Action Taken

The operation have created a CCT activity tracker, with more in-depth CCT case studies prepared.

Mid-term Recommendation (5) – External Funding

It was recommended that SMARTAQUA should explore opportunities for funding support beyond the ERDF funding period of the operation. This could include Innovate UK initiatives, strategic applications or partnerships with industry sector partners.

Mid-term Recommendation (5) – Action Taken

The Seafood Innovation Fund are funding CSAR to undertake the project, TIWL: Tools for improving the welfare of lumpfish. TIWL will provide a validated, easy to score operational welfare index and develop four complementary welfare tools. These tools will help monitor and improve the welfare of lumpfish, reduce stress-related mortalities, and help make the incipient lumpfish farming industry in the UK more sustainable. The welfare standards for lumpfish to be brought to the market by TIWL are possible as a direct result of the Operational Welfare Indicators (OWI)

[10] https://onlinelibrary.wiley.com/doi/10.1111/raq.12589

and SOPs for lumpfish produced by SMARTAQUA. The solutions proposed by TIWL will ensure the legacy of the SMARTAQUA operation through improvements, not only to the welfare of lumpfish, but also the sustainability, social acceptance, and reputation of the salmon farming industry. Following this success, the operation continues to explore further funding opportunities.

Mid-term Recommendation (6) – Processes Achieved

In order to accurately represent the processes and procedures implemented by collaborative partners as a result of collaborations with the SMARTAQUA operation, it was recommended that the operation should revisit each collaboration to discuss any implementations made within companies. This recommendation could bring SMARTAQUA closer to achieving their intended indicator targets.

Mid-term Recommendation (6) – Action Taken

The SMARTAQUA team have undertaken a collaboration review exercise to capture any achieved indicators that have not yet been recorded.

Mid-term Recommendation (7) – Engage with New Partners

It was recommended that SMARTAQUA should appoint an individual to engage with new partners who wish to collaborate in research. By doing this, SMARTAQUA would be working proactively to achieve their targets. It was further suggested that SMARTAQUA select less substantial projects to complete in the final stage of the operation in order to meet their targets.

Mid-term Recommendation (7) – Action Taken

The operation has utilised the skills and contacts of the Strategy and Technology Manager in order to drive collaborative activity due to lack of available funding to appoint an individual to the role of engaging new partners. SMARTAQUA has also undertaken further collaborative activities since the mid-term evaluation.

Mid-term Recommendation (8) – Strategic Review Meeting

It was recommended that SMARTAQUA hold a strategic review meeting to discuss the impact of the operation, any barriers faced, and the opportunities for the operation beyond the funding period.

Mid-term Recommendation (8) – Action Taken

Due to the current economic climate, the opportunity to host a strategic review meeting has not arisen. However, the operation are in contact with all collaborating companies and perform regular horizon-scanning actions to ensure opportunities for impact both during and beyond the project lifecycle are not missed.

Mid-term Recommendation (9) – Opportunity Beyond the Operation Lifecycle

Exploration into opportunities beyond the lifecycle of the operation such as a consultancy operation should be considered. The consultancy operation was suggested to be undertaken in conjunction with an organisation or individual with a track record in the promotion and delivery of consultancy services. Through this, SMARTAQUA could continue to collaborate with non-food aquaculture and aquaculture industry partners to further the sector in Wales and further afield by sharing the knowledge and expertise of the team.

Mid-term Recommendation (9) – Action Taken

The SMARTAQUA team have explored the possibility of the setting up of a consultancy operation following the project extension. It was determined, however, that the team will continue to seek external supports for collaborative R&D which will benefit the whole industry rather than single client organisations.

Mid-term Recommendation (10) – Explore potential future strategic alliances

It was recommended that SMARTAQUA initiate a process to explore the potential of future strategic alliances with external organisations such as SeaFish and Menter a Busnes SeaFood Cluster. It was further suggested that strategic opportunities should be explored within sectors such as pharmaceuticals and cosmetics.

Mid-term Recommendation (10) – Action Taken

Following this recommendation, the SMARTAQUA operation is currently exploring collaboration with organisations in the IT sector that could develop tools, software and hardware for use in the non-food aquaculture industry, thus diversifying the scope of industry sectors with whom the operation connect. Future explorations will be considered into other sectors.

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3. Operational Review

The following section will focus on reviewing the SMARTAQUA operation including assessing the operation in a Welsh, UK and European context, reviewing the M&E plan, CCT activities, output and results indicator targets and highlighting the impact of Brexit and COVID-19.

3.1. SMARTAQUA in a Welsh Context

The final evaluation evidenced that SMARTAQUA remain directly aligned to the priorities and strategies of the Welsh Government. SMARTAQUA aligns to the ERDF Priority 1, Specific Objective 1.2 aim "to increase the successful translation of research and innovation processes into new and improved commercial products, processes and services, in particular through new processes introduced to the industry via collaboration partners and also through improved technology transfer from Higher Education Institutions (HEIs)"[11]

The Welsh Government, through the 'Science for Wales'[12] strategy, aims to build a strong and dynamic science base that supports the economic and national development of Wales. SMARTAQUA contributes to this strategy by enhancing the areas in which Wales has existing strengths, strong economic opportunities, and the potential to combine assets across a range of industrial and research sectors. SMARTAQUA additionally, aligns to the grand challenge areas of life science and health and low carbon energy and environment through WP1, non-food, fish products and WP2, algal-based aquafeeds and nutraceuticals.

The Welsh Government also aims to improve the innovation within Wales as outlined within the 'Innovation Wales'[13] strategy. SMARTAQUA closely aligns to three themes within this strategy:

i) improving collaborations;

[11] https://gov.wales/docs/wefo/publications/1604040-indicators-priority1.pdf
[12]https://gov.wales/sites/default/files/publications/2019-04/science-strategy-annual-report-2015-to-2016.pdf
[13] https://gov.wales/sites/default/files/publications/2019-04/innovation-wales-strategy.pdf

ii) promoting a culture of innovation and
iii) providing flexible support for innovation.

The 'Wales Seafood Strategy'[14] has a target for 30% sustainable growth of the Welsh seafood industry by 2025, whilst maintaining and enhancing a biodiverse natural environment with healthy and functioning ecosystems. The strategy identifies high level objectives to contribute to the achievement of this target:

- Maximise the economic and environmental performance of existing fisheries
- Expand sustainable aquaculture production
- Explore opportunities for new sustainable fisheries
- Add value to fisheries and aquaculture products

SMARTAQUA contributes to this strategy through its evidence-based research and the products, processes and services that are produced as a result of the collaborations undertaken with SMARTAQUA. The operation also uses recirculation aquaculture systems which have the benefit of no waste, minimal water discharge, and the potential to achieve zero nutrient loss.

The 'Brexit and our Seas'[15] document outlines the aims of understanding the growth opportunities in the aquaculture sector by exploring how fishing for non-food products could create commercial value. Within this, entrepreneurs, researchers, academics, and other stakeholders should work in unison to identify innovative ideas in which resources in the marine environment could be sustainably used for commercial purposes. Furthermore, Wales aims to expand the aquaculture sector and become more competitive by producing novel products and processes that increase the value and diversify the sector. SMARTAQUA aligns directly to these aims through the integral collaborations between researchers, academics and industry as well as by increasing the non-aquaculture and aquaculture sectors in Wales. Swansea University's Centre for Sustainable Aquatic Research (CSAR)[16] plays an integral role as Wales only centre of excellence on sustainable aquaculture, and the UK's leading centre on recirculation technology and non-food aquaculture.

Furthermore, CSAR the collaborative operation to SMARTAQUA is vital to the expansion of aquaculture in Wales through research and innovation. The SMARTAQUA operation complements the CSAR operation by targeting the knowledge economy through WP3, knowledge exchange strategy through adaptive smart specialisation. CSAR has focused on industry-driven aquaculture research with the ambition to become the leading research centre for non-food aquaculture in Wales and the UK. The SMARTAQUA operation directly contributes to this through their non-food aquaculture research.

[14]https://www.seafish.org/about-us/working-locally-in-the-uk/working-with-the-seafood-industry-in-wales/seafish-wales-advisory-committee-swac/
[15]https://gov.wales/sites/default/files/consultations/2019-05/marine-and-fisheries-policies-for-wales-after-brexit-consultation-document.pdf
[16] https://www.swansea.ac.uk/bioscience/csar/

3.2. SMARTAQUA in a UK Context

Investment in RD&I has been a priority in the UK due to the recognition of its benefits including faster growth, higher income levels, and the creation of new products, processes, and services. As the RD&I investment in the UK has been heavily subsidised by European Union structural funding, there is continued uncertainty of the levels and sources of future RD&I funding in the UK as a result of Brexit. Brexit has caused many uncertainties and amendments within the aquaculture industry in the UK. Through a new approach outlined within 'Building our Industry Strategy: Green Paper'[17], the UK aims to turn the threats posed by Brexit into opportunities by focusing on the delivery of long-term, sustainable success. This strategy further highlights the importance of continued investment in science, research, and innovation due to the creation of new products and services, more effective processes, and better ways of doing business. SMARTAQUA aligns with these priorities by establishing a platform for industry and academia driven innovation to promote value creation and to strengthen the aquaculture sector.

The Government Office for Science report 'Future of the Sea: Trends in Aquaculture'[18] looks at the potential prospects of aquaculture in the UK. This research is evidenced using government sources for production and economic data as well as peer-reviewed papers for underpinning science background and analysis. The report explores the high parasitic sea lice infection rates that have reduced the salmon production rates in the UK. SMARTAQUA's research into optimising the production of cleaner fish to biologically control sea lice will have an immediate impact by contributing to the reduction of high sea lice infection rates. It will also substantiate and underline the expertise that exists in Wales to effectively address issues such as these.

3.3. SMARTAQUA in an EU Context

Throughout the operation SMARTAQUA have contributed to the delivery of the Economic Prioritisation Framework[19]. The areas in which SMARTAQUA align include:

- Life Sciences and Health – SMARTAQUA optimises the use of laboratory fish for biomedical and translational research, providing fully traceable pedigree lines that can be used by biomedical researchers in Wales

[17] https://beisgovuk.citizenspace.com/strategy/industrial-strategy/supporting_documents/buildingourindustrialstrategygreenpaper.pdf
[18] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/635209/Future_of_the_sea_-_trends_in_aquaculture_FINAL_NEW.pdf
[19] https://gov.wales/sites/default/files/publications/2019-09/welsh-european-funds-economic-prioritisation-framework.pdf

- Energy – SMARTAQUA generate high-value micro-algae products, creating opportunities for low carbon energy efficient architecture
- Food and Farming – SMARTAQUA maximises the production potential of the Welsh cleaner fish industry by facilitating the development of elite lines, thus helping fulfil the Welsh Government's commitment to increase aquaculture production by 2020 and reduce the infection rates of sea lice
- Climate Change and Resource Efficiency – SMARTAQUA develops the production of suitable micro-algae that will have the capacity to absorb carbon dioxide and that can be used in 'Green buildings', thereby helping to reduce the carbon footprint of Wales

The EU provide many funding opportunities within the UK including Horizon 2020 which supports the three strategies of Open Innovation, Open Science and Open to the World[20]. SMARTAQUA continues to align to the strategy of Open Innovation which aims to increase the access to the innovation process for all so that knowledge can circulate freely and be transformed into products and services that create new markets and foster a stronger culture of entrepreneurship.

3.4. The SMARTAQUA Team

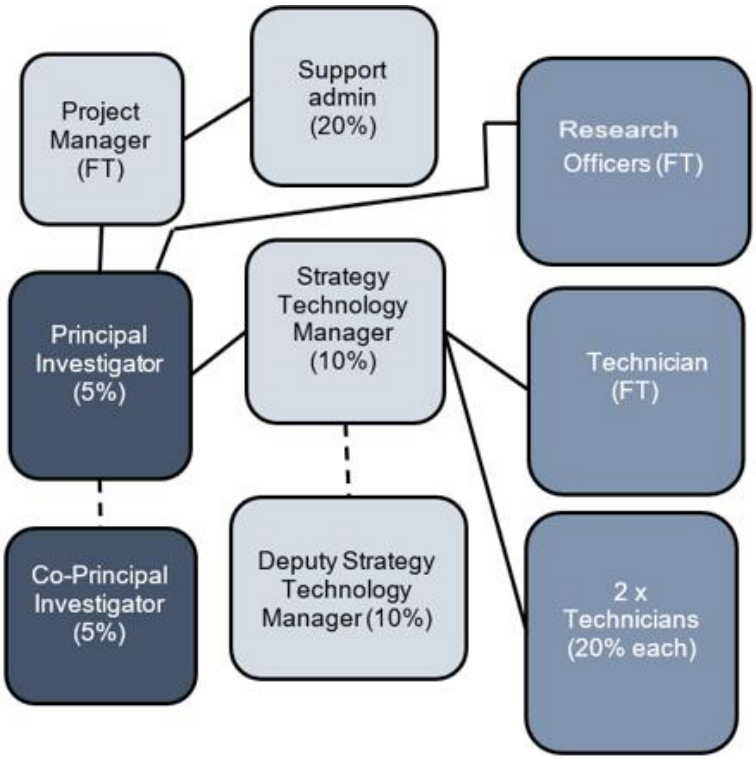

Figure 1: Staff Organogram

Since the mid-term evaluation, changes have been made to the SMARTAQUA team including the replacement of research officers and technicians, as well as support administration staff.

[20] http://publications.europa.eu/resource/cellar/3213b335-1cbc-11e6-ba9a-01aa75ed71a1.0001.02/DOC_2

3.4.1. Communication and Continuous Improvement

As confirmed in the inception and mid-term evaluations, SMARTAQUA continue to be clear, transparent, and robust in their communication processes, encouraging open communication between each of its members. The final evaluation confirmed that all members of the SMARTAQUA team were clear in their role and the communication process between SMARTAQUA team members has been effective. This has remained true with the changes implemented as a result of the COVID-19 pandemic including working from home and online meetings.

3.5. Monitoring and Evaluation

The M&E plan, as outlined in the inception and mid-term evaluation reports, remains effective and focused on achieving its objectives. The plan shows the results and indicators proposed for the operation along with the impact that the operation creates with SMEs and the wider industry in Wales. The SMARTAQUA team have continued to use the M&E plan to ensure the operation demonstrates an effective application of ERDF funds through collection, storage, monitoring and management of data. SMARTAQUA also continue to utilise the databases, email filing and monitoring systems that were created for robust record keeping.

3.5.1. Governance Structure

Swansea University, as the lead beneficiary, have a robust system for the oversight of major projects. This structure has been used for the SMARTAQUA operation.

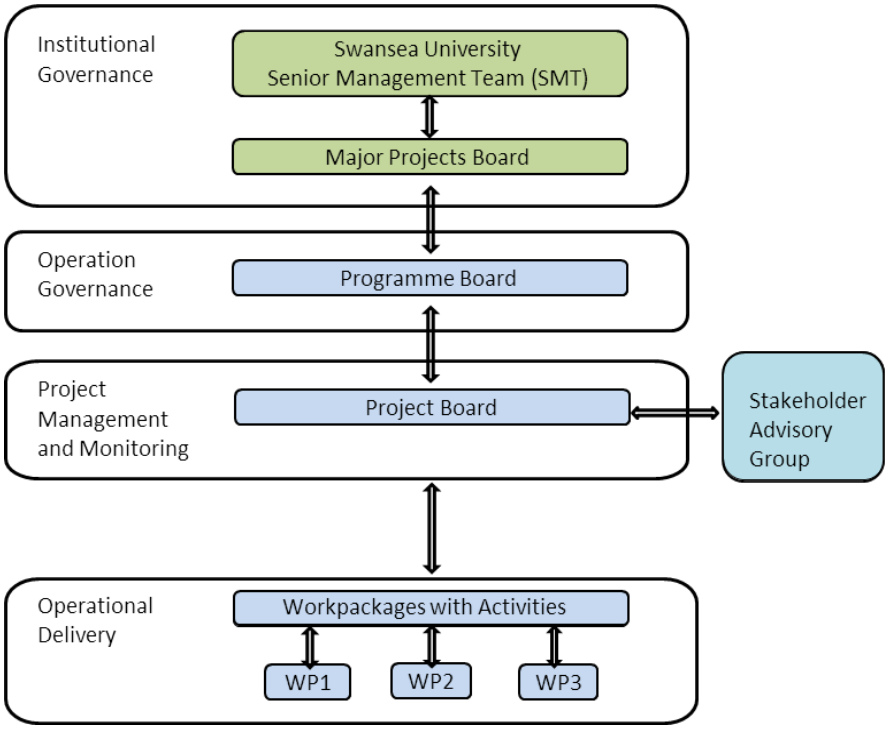

Figure 2: Governance Structure of SMARTAQUA

3.5.2. Data Capture

SMARTAQUA continue to implement a range of data capture documents that are completed with collaborative projects. These documents include the following:

- Scoping Research Plan - This document outlines the background, aims, activities and duration of the project. Furthermore, it documents the SMARTAQUA contribution, company in-kind contribution as well as the estimated contribution to SMARTAQUA targets of the project.
- Minutes - The minutes template is used to capture the minutes of any meeting held with SMARTAQUA. This document specifically includes date, time and location of the meeting, background context as well as a table of actions to be undertaken.
- Outputs Summary - This document is used to outline the contributions that can be made to the key indicator targets of SMARTAQUA by a project. It further includes a description of how the project will contribute to the targets.
- Project Proposal - This document is similar to that of the Scoping Research Plan. The Project Proposal form outlines the background, aims, general activities and duration of the collaborative project. The document also seeks to identify the company in-kind contribution, individual responsible for the progression of the project and the estimated contributions to the targets of SMARTAQUA.
- Time Sheet - This document is used to record the time spent by SMARTAQUA staff supporting a project. This form is to be completed by a SMARTAQUA team member and agreed by the organisation. It specifically includes the date, number of hours spent in collaboration, individuals involved and details of the activities conducted.

3.5.3. Private Sector Displacement

As SMARTAQUA operate within a niche market, it is unlikely that private sector displacement will occur, however SMARTAQUA have implemented a process and have frequent team meetings to ensure no private sector displacement of provisions or activities occur. Building on the extensive network established by CSAR, the SMARTAQUA operation collaborates with the private sector in applied research and development, resulting in the encouragement of communication between industry and academia. Due to this, SMARTAQUA continues to be a catalyst to the Welsh non-food aquaculture sector. Furthermore, SMARTAQUA's research is published in the public domain and can therefore be accessed by any interested parties.

3.5.4. Stakeholder Advisory Group

The Stakeholder Advisory Group comprised the Principal Investigator, the Project Manager, the Strategic Technology Manager and 8 industrial stakeholders in the non-food aquaculture sector. Stakeholders represented each of the operation's three work packages and performed the following functions:

- Received reports on the progress of the operation
- Provided advice on priorities
- Identified opportunities for increasing the economic impact of the operation
- Advised on linkages with other activities taking place in the region with possibility for collaboration
- Contributed to the marketing strategy for the operation •
- Advised on project sustainability possibilities

It was envisioned that the Stakeholder Advisory Group would meet biannually throughout the project lifecycle, however, due to the reduced focus on R, D&I caused by Brexit and Covid 19, this was not possible. To ensure that the Stakeholder Advisory Group still facilitated knowledge exchange in order to stimulate growth in the sector, the operation maintained frequent contact with key representatives from each work package, who in turn had a major impact on project development and progress.

3.5.5. State Aid

SMARTAQUA has continued to maintain a monitoring database which is submitted to WEFO on an annual basis. All activity conducted by the operation is monitored, and case studies are produced to evidence the status of State Aid. Throughout the operation, there have been no State Aid issues.

3.6. Collaboration Engagement and Event Participation

Due to the COVID-19 pandemic, the opportunities for collaborative engagement decreased. Despite this, the SMARTAQUA operation has engaged with a number of companies to discuss potential collaborative projects that could be developed. The potential collaborative projects could include research focused on areas such as the development of the UK-sourced lumpfish industry[21], exploration of ways to expand the research on non-food aquaculture species developed in Wales, and opportunities for inward investment to Wales. The SMARTAQUA operation participated in Swansea Science Festival 2020[22] in which the team showcased their research on lumpfish welfare and fish health and using microalgae oil as an

[21] https://www.swansea.ac.uk/bioscience/research-and-impact/lumpfish-for-sea-lice-control/
[22] http://smartaqua.org.uk/news/smartaqua-at-swansea-science-festival-2020/

alternative to fish oil in fish meal. SMARTAQUA also participated in the online delivery of the 2nd Symposium on Welfare in Aquaculture with more than 500 people registered for this symposium from across the world. The symposium focused on Operational Welfare Indicators (OWI) for salmon, lumpfish, tilapia, sea bream, and sea bass, and build upon the activities of the 1st Symposium in Welfare on Aquaculture[23]. The operation has also participated in events such as European Maritime Day[24] and the Application of Sensors in Precision Aquaculture webinar[25].

3.7. Achievements Against Targets

The final evaluation of SMARTAQUA has reviewed the operations performance against the reprofiled targets. Table 2 shows SMARTAQUA's indicator target achievements.

Indicator	Reprofile Target	Achievement to September 2022	% of Target Achieved
Number of enterprises receiving non-financial support	14	12	85.7%
Number of partners cooperating in a research project	30	26	86.6%
Private investment matching public support in innovation or R&D projects	£7m	£11.9	157%
Employment increase in supported enterprises	16	40	250%
Number of enterprises supported to introduce new to the firm products/processes	10	7	70%
Number of enterprises supported to introduce new to the market products/processes	8	7	87.5%
Number of patents registered for products	1	0	0%

Table 2: SMARTAQUA Targets

The table above shows that SMARTAQUA has exceeded the targets of: "Private investment matching public support in innovation or R&D projects" with

[23] http://smartaqua.org.uk/category/symposium-on-welfare-in-aquaculture/
[24] https://european-maritime-day-2021.b2match.io/
[25] http://access2sea.eu/event/application-of-sensors-in-precision-aquaculture/

SMARTAQUA achieving a figure of 157% of the target. Additionally, there was a notable achievement of 250% of target in the indicator of “Employment increase in supported enterprises”. These two significant achievements demonstrate the impact of the operation on the non-food aquaculture sector.

In addition, three other indicators were in the region of 85.7% to 87.5% achievement as illustrated in table 2. The main reason cited for the modest shortfall in these three indicators was the lowered investment confidence by businesses as a result of Brexit and COVID-19 which together conspired to generate an unsure future and a caution by businesses to invest in anything outside non-core activities.

The only target that fell notably short of the mark was “Number of patents registered for products”. It should be noted that as a consequence of SMARTAQUA, a patent was registered however as this was registered by the university and not by a collaborative partner it has not been counted against this target.

3.8 Additional Guidance Offered

One of the supports available to organisations embarking on or following an innovation journey in Wales is provided by the Welsh Government SMART Innovation Gateway . SMART Innovation is a unique programme lead by the Welsh Government and funded by EU money with the single aim of helping Welsh businesses do better by being more innovative.[26].

During the initial 121 meetings that SMARTAQUA held with all prospective collaborative partners, a reference to and an explanation of the Welsh Government SMART Innovation was provided, outlining the supports that are available to organisations in Wales. An electronic link to SMART Innovation was provided to each organisation on a slide during the initial presentation. Organisations were also made aware that SMART Innovation can help with cross cutting themes.

3.9 Cross Cutting Themes

The final evaluation has shown that throughout the operation delivery, SMARTAQUA has made excellent progress towards its CCT objectives. Outlined below are highlights of the SMARTAQUA CCT achievements taken from the CCT activity tracker that is maintained by the operation

Equal Opportunities and Gender Mainstreaming

SMARTAQUA have undertaken many activities towards this CCT indicator throughout the lifecycle of the operation. SMARTAQUA contributed to this CCT by

[26] https://businesswales.gov.wales/innovation/smart-innovation/what-smart-innovation

providing a supportive environment for all staff through strict compliance with the regulations of non-discrimination, equality and diversity and integration of gender perspective.

Additionally, SMARTAQUA has evidenced the following activities of equal opportunities and gender mainstreaming:

Positive action measures (Women):

- The 2nd Symposium on Welfare in Aquaculture consisted of six speakers including three females and three males. This exposed the attendees to an equal gender balance of experts within their field.
- SMARTAQUA researchers have supported a female student who is analysing data for a collaborative project. The SMARTAQUA team have mentored the student in key techniques which the student will be able to use in future employment.
- A female member of the SMARTAQUA team attended a Welfare in Aquaculture workshop hosted by the RSPCA.
- CSAR hosted two female Year in Industry students who gained valuable insight into the running and development of the centre. This also contributed to the upskilling of females in STEM subjects
- SMARTAQUA staff supported facility tours for students attending college to encourage female students to enter STEM subject areas.

Positive action measures (Disabled People):

- A member of the SMARTAQUA team engaged in a first aid course where risks associated with slips and trips as well as access were discussed. The team member used the information gained to inspect all areas of CSAR associated with SMARTAQUA to ensure appropriate access measures were in place.
- The 2nd Symposium on Welfare in Aquaculture included videos which had subtitles to allow better access for those with hearing impairments.

Female participation in STEM:

- SMARTAQUA team members met with the Chairperson for the UK Aquaculture Common Issues Group to discusses the SMARTAQUA project along with its aims and objectives. The chairperson was encouraged by the industry engagement and the balanced gender representation of the SMARTAQUA team. As a successful aquaculture businesswoman, the chairperson was interested in the development of gender equality in the aquaculture sector including within STEM activities.

- A key SMARTAQUA researcher has become a lecturer within the Bioscience department at Swansea University. Due to this, the many skills the researcher has developed throughout the SMARTAQUA operation will be passed onto the students.

Activity supporting speakers of the Welsh language:

- The SMARTAQUA team continue to make updates to the website in both Welsh and English.

Sustainable Development

SMARTAQUA has supported environmental sustainability by adhering to the International Organisation for Standardisation (ISO) standards. Through the Recirculation Aquaculture Systems (RAS), waste is reduced and water usage is kept to a minimum. Swansea University is involved in innovative research activities with profound implications for the understanding and stewardship of the local, national, and global environment. SMARTAQUA has filly adhered to the wider sustainability policy of Swansea University evidenced in the following activities:

Resource efficiency measures:

- Through the online delivery of the 2nd Symposium on Welfare in Aquaculture, there was a notable reduction in carbon footprint due to zero air and land miles being used.
- OWIs were also discussed during the symposium. OWIs, based on SMARTAQUA research, aim to improve the sustainability of aquaculture by improving welfare standards in the sector and reducing the number of medical treatments being delivered or the number of mortalities at a fish farm.
- SMARTAQUA met with a company to discuss the integration of non-food aquaculture into an urban landscape. This included the use of algae in architecture and how waste from fish can be used to feed microalgae to produce products in cities without the need for long transportation journeys.
- SMARTAQUA met with another company to develop a camera system with AI intelligence that will allow fish production to be de-risked, improving the likelihood of an aquaculture company being approved for insurance. These measures will improve the resource efficiency of lumpfish production in Wales.

Local supply chain development:

- SMARTAQUA collaborated with leaders in the aquaculture industry including one of the largest UK wrasse suppliers and lumpfish broodstock suppliers, the largest lumpfish producer in the UK, and a producer of

Scottish-source lumpfish in the UK to develop a mature lumpfish sector in Wales. Through the direct intervention and support from SMARTAQUA, the sector now supplies over 4 million cleaner fish to Scotland per year. These cleaner fish improve the welfare of tens of millions of salmon by removing sea-lice from them. This collaboration has established Wales as an industry leader in this form of non-food aquaculture.

- The SMARTAQUA team met with a company to discuss the help that SMARTAQUA can provide to enhance opportunities for inward investment to Wales and hence develop local supply chains.
- One of the SMARTAQUA technicians attended a zebrafish conference with international speakers from across Europe[27]. The conference presented an opportunity to learn best practice which has been implemented in CSAR and assist in establishing the CRISPR facility that has been funded through SMARTAQUA. As Wales does not currently have a supply chain for zebrafish, this will inform the foundations establishing one.

Tackling Poverty and Social Exclusion

SMARTAQUA has also made contributions to the CCT of Tackling Poverty and Social Exclusion both directly within the operation and indirectly through collaborative partnerships. Since the mid-term evaluation, SMARTAQUA have completed a number of activities.

Community skill building activity:

- SMARTAQUA have been in discussions with the developers of the Picton Yard biophilic build scheme and have contributed to a document being developed that highlights the gaps in expertise in the biophilic building sector. The building sector needs to work with experts such as the SMARTAQUA team to advance the technological readiness of biophilic build schemes aimed at urban regeneration.

Mentoring/ advocacy activity:

- SMARTAQUA team members have engaged with companies to discuss the range of activities the operation is engaged with as well as the track record of CSAR and its mentoring capabilities. This has resulted in the company aiming to expand the number of companies SMARTAQUA engages with.
- SMARTAQUA are supporting a project to find alternative uses for digestate waste generated in rural areas. The research is aimed at creating additional revenue streams for disadvantaged rural communities where economic opportunities are lower than in urban areas.

[27] http://www.aquaneering.com/zebrafishworkshop2021.php

- SMARTAQUA have undertaken discussions to host a female student as part of the ‘Go Wales’ project The GO Wales: Achieve through Work Experience programme, which is part-financed by the European Social Fund (ESF) through the Welsh Government, and operates pan-Wales, is designed to support the employability of students on higher education courses in Wales and is aimed at students who have faced barriers in accessing higher education or work experience and are therefore most at risk of not securing employment, education, or training when leaving higher education courses.

The SMARTAQUA team has also identified a number of areas that worked notably well and a number of areas that did not work so well in relation to CCT activities and objectives.

It was identified that a particular strength of the SMARTAQUA operation was the incorporation of all CCTs into the project, with multiple categories of CCT targets achieved. This led to the additional target of “Mentoring/Advocacy Activity” being added due to the success of the indicators achieved. Specifically relating to CCT activities, SMARTAQUA was particularly successful in reducing barriers to education and full-time employment by offering a range of placement opportunities. Furthermore, SMARTAQUA have increased the robustness of the cleaner fish supply chain in Wales through network building between suppliers, hatcheries, and salmon companies.

Despite the success of CCT achievements, it was suggested that there was some confusion initially in regard to monitoring and recording CCT activity. Although SMARTAQUA achieved the CCT targets, it was seen to be challenging to understand where each CCT activity would fit within the context of the operation. Relating to this, SMARTAQUA has removed one indicator relating to actively promoting the Welsh language in agreement with WEFO, as this proved to be unrelated to the project delivery.

3.9.1 Well-Being of Future Generations Act

SMARTAQUA is well aligned to the principles of the Well-being of Future Generations (Wales) Act 2015, as shown below:

A Prosperous Wales

As part of their collaborative partnership, SMARTAQUA are seeking to develop expertise in Wales that will contribute to the economy and prosperity of Wales. This includes improving the sustainability of cleaner fish production by developing UK sourced fish and domesticated brood stock which supports both the environment and the Welsh economy.

SMARTAQUA have also collaborated with projects that have resulted in the upskilling of staff and increased employment opportunities. The SMARTAQUA team align to the goal of enabling a low carbon society through active travel such as cycling to work or by using public transport. Many of their promotional materials are also made using recycled materials.

A Resilient Wales

Members of the SMARTAQUA team are collaborating with the Picton Yard Project which is developing a sustainable building design based on micro-algae. This ERDF funding paid for a recirculating aquaculture system that formed part of the SMARTAQUA support to Picton Yard. See Appendix C.

A More Equal Wales

SMARTAQUA aligns to this goal in several ways. The operation team members are diverse in nationality, gender and expertise, creating equal opportunities. The operation has also provided educational opportunities, enabling students from disadvantaged backgrounds to undertake a work placement. The access to aquaculture employment through SMEs has also increased.

A Healthier Wales

As part of WP2, the SMARTAQUA operation is developing novel feeds which can improve human nutritional standards in Wales and further afield.

A Wales of Cohesive Communities

The adaptive smart specialisation approach adopted by SMARTAQUA in WP3 supports businesses, scientists and entrepreneurs, contributing to this goal.

A Globally Responsible Wales

SMARTAQUA continuously promote sustainable aquaculture via events they attend. The research they have conducted has also contributed to the improvement of sustainable cleaner fish production by developing domesticated brood stock and locally sourced fish, which adds value to the local economy and can reduce carbon emissions.

3.10 Impact of COVID-19 and Brexit

Both COVID-19 and Brexit caused significant delays and challenges during the SMARTAQUA operation as outlined:

COVID-19

The impact of lockdown restrictions caused significant impacts including over 6 months of delays. These restrictions meant that no researchers were able to run trials, however, this did allow for the team to complete data analysis and write papers, with 12 peer-reviewed research papers published by SMARTAQUA in total during the period of EU funding . Following the lifting of restrictions, there was a slow start back to operations including limitation on the number of staff allowed in the laboratories and reduced size of experiments. Along with this, companies redirected their resources to cope with the after-effects of the pandemic which further reduced the R&D activities conducted.

Brexit

Brexit also had a significant impact on the SMARTAQUA operation. The withdrawal of the UK from the European Union meant that the operation faced logistical challenges and increased timescales of products being ordered to the UK. The uncertainty surrounding Brexit also reduced the confidence of businesses, leading to less investment into higher risk but higher reward ventures such as non-food aquaculture. Brexit also had an impact on the students' completing placements with SMARTAQUA as PhD opportunities were limited to UK students and EU students no longer studying in the UK due to higher fees and difficulty with visa applications.

4

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4. Evaluation Findings

4.1. SMARTAQUA Team Members

4.1.1. Mechanisms Used

SMARTAQUA has utilised a number of mechanisms throughout the operation to ensure the successful delivery of its key outputs. These mechanisms include a detailed M&E plan which ensured the operation met its aims and objectives as well as outlined how SMARTAQUA should collect, store, monitor, use, and manage data whilst demonstrating impact. The operation also developed a detailed database monitored by the project manager. This database was used to refine the operation and remain on track to achieving the goals of the operation.

The SMARTAQUA team maintained various forms of communication and provided regular updates on the work completed via individual and group emails, outlook calendar invitations, PowerPoint presentations, and by storing data on a one drive system which could also be accessed by the Programme Board.

During the COVID-19 lockdown periods, key species were maintained in CSAR at Swansea University in order to have sufficient fish numbers to start any trials or experiments possible upon easing of lockdown restrictions. This allowed SMARTAQUA staff to continue with all animal husbandry.

Overall, the utilisation of these mechanisms throughout the operation has meant that the SMARTAQUA operation was delivered efficiently and effectively.

4.1.2. Monitoring and Reporting Processes

The monitoring and reporting systems were very effective throughout the SMARTAQUA operation. A strong team relationship was maintained throughout the operation, with good communication between the management and delivery teams. SMARTAQUA held careful discussions and collated input from several team members when completing reporting procedures.

4.1.3. Management Structure

The SMARTAQUA management team have been very effective throughout the operation. The management team provided high levels of communication and support to all team members. It was also suggested that the management team were flexible and available to support staff when needed. During staff changes within SMARTAQUA, the management team provided a high level of training and support to new staff.

Swansea University management structure was supportive of SMARTAQUA by promoting the operation in meetings and signing off on research collaborations.

4.1.4. Challenges Faced

SMARTAQUA faced a number of challenges throughout the operation beyond the impacts of COVID-19 and Brexit. One challenge identified was the changing of home office approval procedures. This was due to a new officer being appointed to the home office who had different priorities and questions. Another challenge faced by the SMARTAQUA team was the redesign of experiments to comply with local ethics. A further challenge was the limitation on the number of staff able to access the laboratories which led to the necessity to euthanise a number of fish. This was an unfortunate but unavoidable consequence of this limitation. Fortunately, as reported to WEFO in Sept 2020, the brood stock was able to be maintained by SMARTAQUA. Additionally, challenges resulted as a result of the changing of key staff during the programme delivery, with three Research Officers leaving their role in the operation, necessitating the engagement of new members of staff, and the Deputy Strategy Technology Manager taking a period of maternity leave. Despite the change in management staff, the leadership has remained consistent and effective in providing clarity of direction.

4.1.5. Lessons Learned

It has been recognised that Wales are now the largest UK producer of cleaner fish as well as having significant potential to lead in non-food aquaculture. There is also a need for, and an opportunity to develop, the expertise in precision aquaculture such as automation, sensors, and video technologies. These can expand the impact non-food aquaculture can have on the economy and de-risk ventures. It was identified that extensive planning as well as the formulation of mutual goals is essential for the success of a collaboration. Operations should also be flexible to accommodate for any unforeseeable events.

4.1.6. Impact of SMARTAQUA

The SMARTAQUA operation has provided successful collaboration and support to many companies resulting in a range of impacts to the companies. It is noted these impacts include:

- Increased knowledge on welfare of fish
- Improved processes, procedures, and tools that can be used to improve businesses
- Increased number of jobs created within companies
- Embedded expertise which acts as a foundation to develop the sector
- Diversification into new product lines
- Stimulation of growth and networking across sectors
- Reduction in the use of chemicals within aquaculture
- Ethical methods of breeding tropical fish developed which can contribute to the multibillion-pound industry[28]

As a result of SMARTAQUA, a project has been put forward which is funded by the Scottish Government with Sterling University and a consortium of three commercial partners. This project will bring direct benefit to Swansea University from this project as well as indirect benefits in terms of the knowledge and expertise gained throughout the project residing in Wales.

One of the SMARTAQUA projects[29] was selected by Swansea University for the Research Excellence Framework submission which highlights the importance and success of the work SMARTAQUA has completed. Furthermore, this emphasises the need for continued support of SMARTAQUA so the operation can continue to address the substantial needs and issues within the sector.

4.1.7. SMARTAQUA Interaction with Funded Projects

SMARTAQUA collaborated with a number of projects throughout the operation as outlined below:

- Wales Ace (European Maritime Fisheries Fund)[30]
- Access to Sea[31] (Interreg Atlantic)
- Picton Yard [32] (multiple funding sources)
- STREAM[33] – Interreg (Ireland and Wales)
- BlueFish[34] (Interreg) shared methods
- CLEANGAIN (Sustainable Aquaculture Innovation Centre)[35]

[28] https://www.grandviewresearch.com/industry-analysis/ornamental-fish-market
[29] https://www.swansea.ac.uk/research/ref-2021/earth-systems-and-environmental-studies/
[30] https://gov.wales/written-statement-european-maritime-fisheries-fund-emff-2014-2020-opening-application-window
[31]http://ceeicadiz.com/access2sea-un-nuevo-proyecto-liderado-por-ceei-bahia-de-cadiz-recibe-el-apoyo-del-programa-interreg-espacio-atlantico/
[32]https://www.swansea.ac.uk/press-office/news-events/news/2022/08/university-expertise-to-help-new-living-building-residents-in-swansea-to-grow-their-own-food-on-roof.php
[33]https://irelandwales.eu/projects/stream-sensor-technologies-remote-environmental-aquatic-monitoring
[34] http://bluefishproject.com/
[35] https://www.sustainableaquaculture.com/

The collaborations undertaken with each of these projects has been noted to be successful.

SMARTAQUA have also submitted an application to BBSRC with the University of the West of Scotland to look at ornamental fish. Submitted in late September, the project *Operational Welfare Indicators for the ornamental fish trade* will further advance the OWIs for lumpfish that were developed based upon SMARTAQUA research to assess welfare in ornamental fish. The project will be centrally funded by the UK Government and a research councils UK grant if successful. SMARTAQUA has also contributed to the creation of a BMI calculator and an online training course for fish farmers under the Seafood Innovation Fund, as well as contributing welfare indicator information to the online learning academy for one of the UK's largest cleaner fish producers.

4.2. Collaborative Partners

CIOTEK Limited interviewed and collated data from 5 collaborative companies. The responses received can be found below:

4.2.1. Initial Interaction

Each of the 5 companies contacted work within the marine or freshwater aquaculture sector. 2 of these companies made contact with SMARTAQUA through CSAR, while 3 were contacted directly by SMARTAQUA. At this final stage, each of the projects have developed long-term relationships with the SMARTAQUA team with all of the companies working with SMARTAQUA for more than 2 years.

Each of the 5 projects indicated SMARTAQUA provided excellent communication throughout the projects, with frequency of communication varying for each project between 2-3 times per year to weekly.

4.2.2. Development Needs

Each of the companies confirmed their business development needs as indicated in Figure 3.

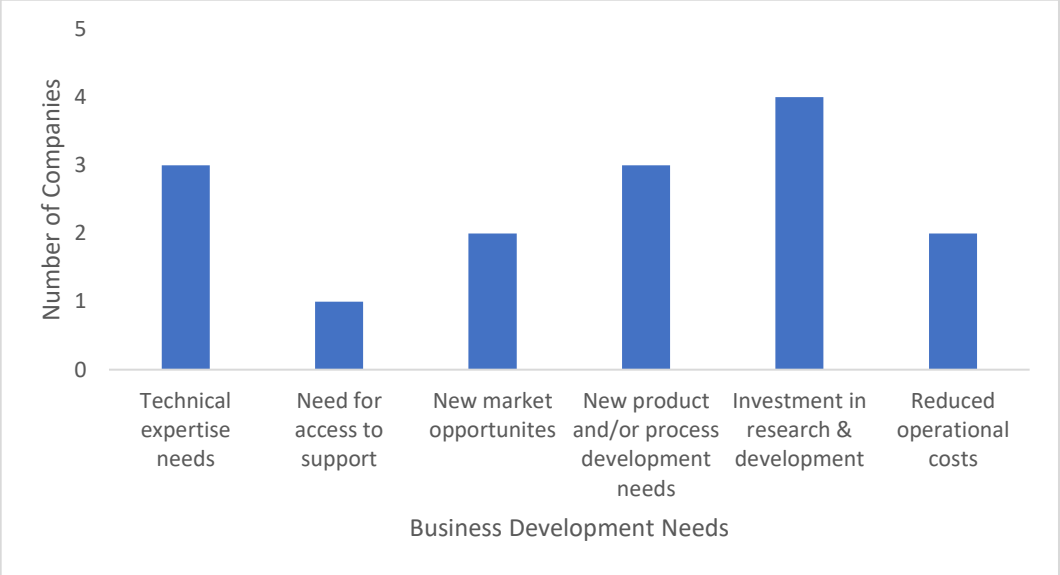

Figure 3: Business Development Needs

The companies highlighted a range of business development needs. The most pressing being the need for investment in R&D, followed by technical expertise needs, and new product or process development needs. The operation were able to meet this particular need through knowledge exchange and through providing access to cutting edge laboratory facilities provided by the project. It was also acknowledged that each of these needs was supported through their collaboration with SMARTAQUA.

The companies also outlined a number of reasons for engaging with SMARTAQUA as shown in Figure 4.

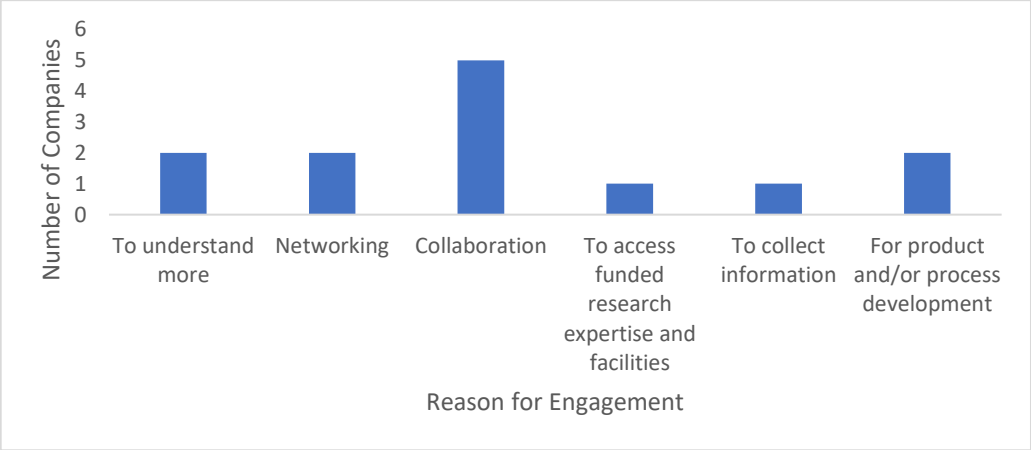

Figure 4: Reasons for Engaging with SMARTAQUA

All of the companies interviewed during the evaluation process identified collaboration as a leading reason for engagement. Additionally, networking opportunities, knowledge and expertise of SMARTAQUA staff, and product and process development were identified as reasons for engagement.

4.2.3. Quality of Support

This section of the evaluation noted that all the businesses interviewed confirmed that the SMARTAQUA operation has provided good or excellent support. Table 3 shows details of the average score given to each of the criteria. Specifically, the SMARTAQUA team provided excellent support, knowledge, and expertise to each of the companies allowing for the completion of successful collaborative projects.

On a scale of 1 to 4, where 1 = poor, 2 = acceptable, 3 = good and 4 = excellent, please rate the following aspects of SMARTAQUA	Averaged score
Ease of making initial contact	4.0
Speed of initial response	4.0
Quality of ongoing support or communication	3.8
Overall experience with SMARTAQUA	3.8
How well the SMARTAQUA programme and support available was explained to you	4
Setting a realistic expectation at the outset of what could be achieved	3.2
SMARTAQUA understanding of your requirements	3.2
Ease of dealing with the paperwork	3.0
Quality of the support you have received to date	3.6
Amount of support you have received	3.2
Knowledge and expertise of SMARTAQUA project staff	4.0
Overall value of the project to the business	3.2

Table 3: Quality of Support Provided

4.2.4. Future Collaborations

Highlighting the success of the SMARTAQUA operation, each of the 5 collaborative companies suggested they would like to explore future collaborations with SMARTAQUA. There are a continued range of needs that need to be met within the aquaculture industry and many gaps in knowledge, expertise, and networking can and have been met by the SMARTAQUA operation. As a result, companies would like to maintain contact with SMARTAQUA for the following reasons:

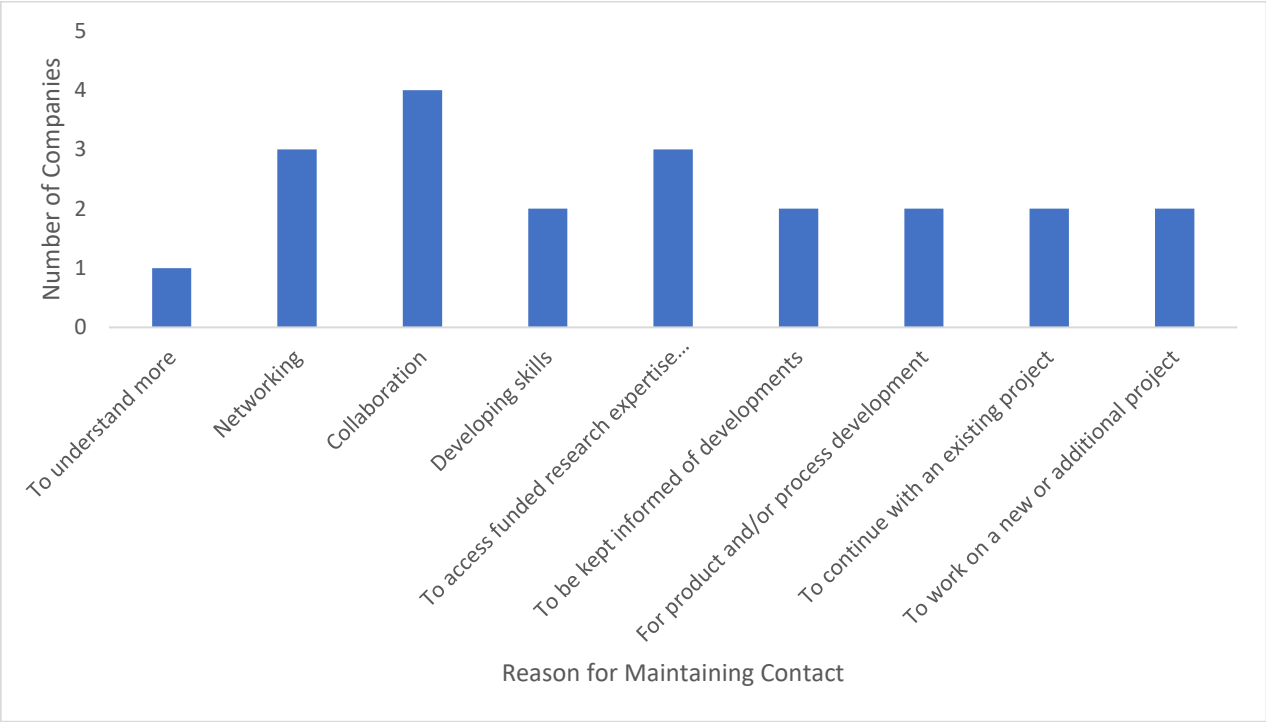

Figure 5: Reasons for Maintaining Contact

As outlined, there are a range of different reasons companies would like to maintain contact with SMARTAQUA, particularly for collaboration, networking and access to expertise. Additionally, some projects would like to maintain contact with SMARTAQUA to continue existing collaborations. This highlights the success and continued need for SMARTAQUA support.

Further to this, the collaborative companies identified areas in which they would be encouraged to make further use of the infrastructure or resources of SMARTAQUA. These included:

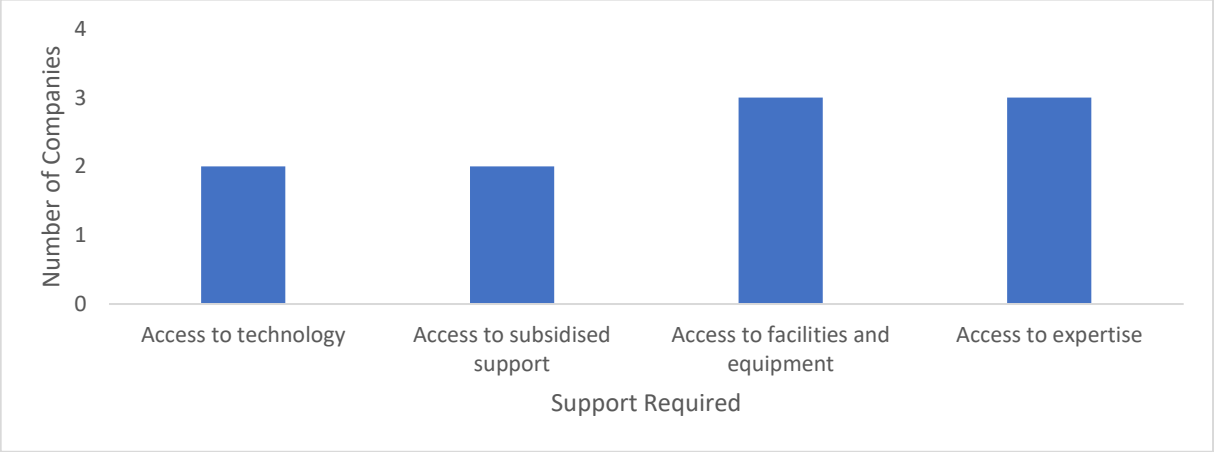

Figure 6: Support Required

4.2.5. Impact of SMARTAQUA

SMARTAQUA has impact on many of the companies in a number of areas as shown in Figure 7.

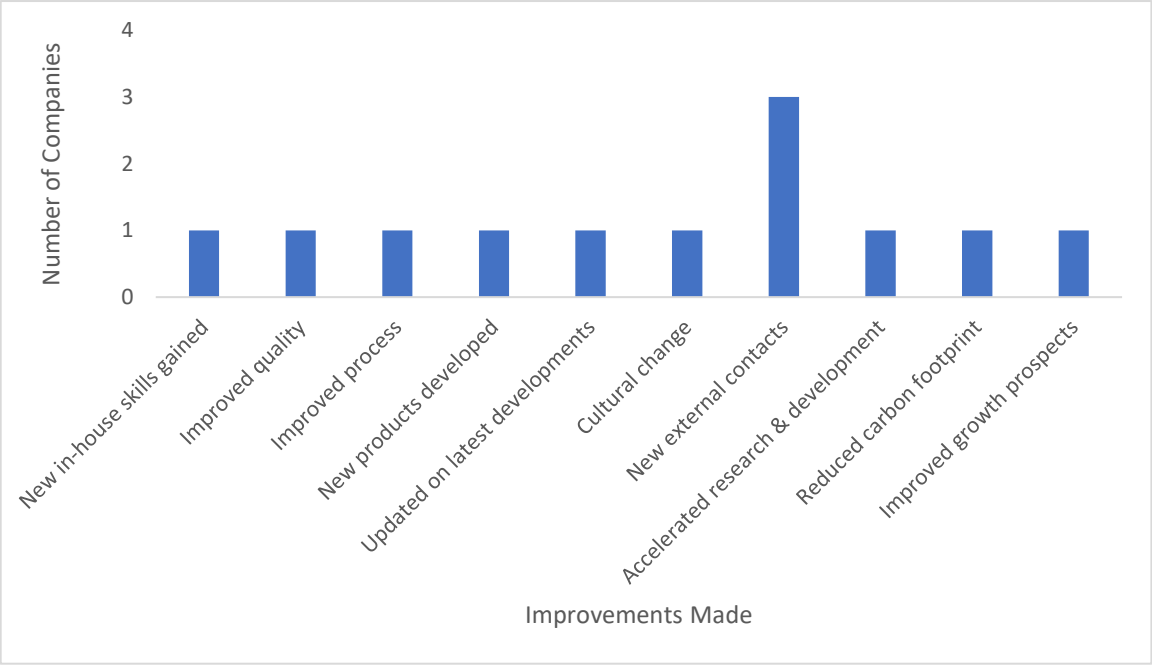

Figure 7: Improvements Made

Along with the improvements made to businesses as a result of collaborations with SMARTAQUA, the five companies interviewed during the evaluation have provided estimated figures on the impact of these collaborations.

	Number / Value
Increased level of business	£2,150,000 million p.a.
Increased employment	34
Increased Investment	£35k annually
Number of Staff Upskilled	30
Promotion of Equal Opportunities	2
Launch of new products or services	1
Introduction of new processes or procedures	2
Links to other business in convergence area	4

Table 4: Contribution of SMARTAQUA

The collated results show that SMARTAQUA has had a significant impact on the level of business for two of the companies, with one increasing by £150,000 per annum and the other by £2 million per annum. A significant number of jobs have also been created with the expansion of one company which was possible because of the research undertaken by SMARTAQUA. The SMARTAQUA team also played a key role in upskilling staff and providing networking opportunities between companies.

Additionally, one of the companies collaborating with SMARTAQUA has been able to grow the cleaner fish sector in Wales from a concept to the current UK leader. This brought about investments of £10 million which included the purchase, construction, and development of new facilities in Wales. As a result of this investment, 32 jobs were created including farm managers, assistant managers, and hatchery technicians with salaries ranging from £25k to £35k+.

4.2.6. Benefits of SMARTAQUA

Collaborating with SMARTAQUA has brought about other benefits to the companies ranging from short to long-term. For example, SMARTAQUA were able to provide companies with equipment, data, and knowledge that the companies would not have otherwise had access to. Furthermore, SMARTAQUA was able to positively impact the processes and procedure companies had in place. It has also been acknowledged that there has been a large shift in the wider industry of cleaner fish farming to improve welfare standards which has driven positive change in the industry. A large part of this success has been due to the SMARTAQUA operation. This is and will continue to have a positive impact on businesses in the industry.

4.2.7. Challenges Faced

The companies interviewed face a range of barriers to business and were asked to rate each barrier on a scale of 1 (low) to 4 (high). The collated responses are:

Financial constraints	3.6	Speed of technical change	3.2
Finding skilled people	2.8	Retaining skilled people	2.0
Time Pressures	3.2	Technical challenges	4.0
Cultural pressures	2.0	Winning new business	2.0
Onerous legislation	1.2	Import of overseas products	2.4
Competition	2.0	Continuous R & D investment	3.6
Retaining existing customers	2.0	Knowing where to go to get assistance	2.4

Table 5: Barriers to Business

It was also acknowledged that COVID-19 and Brexit posed as barriers for some of the companies. Along with this, one company, following the invasion of Ukraine, followed their values and made the decision to suspend all trade operations with Russia. This had a notable impact on business sales, especially within Nordic operations.

Despite the many barriers to business faced by the collaborative companies, it was identified that there were no barriers present to collaborating with SMARTAQUA.

4.2.8. Expectations

Each of the companies suggested they would be likely to work with SMARTAQUA again as there were a number of positive aspects to the collaboration. These included:

- Staff
- Very responsive team
- High level of technical ability
- Excellent communication and management
- Excellent execution of initial launch
- SMARTAQUA provided simplicity, effectiveness, and openness
- Staff had broad range of knowledge

Although the SMARTAQUA operation has received high praise from each of the collaborative companies, it was suggested that on occasions, that the feedback and communication from the SMARTAQUA team slowed down notably during the COVID-19 pandemic.

As a result of the excellent work undertaken by the SMARTAQUA team, as well as the negative impacts caused by COVID-19, the collaborative projects provided mixed responses to the operation meeting their expectations as outlined:

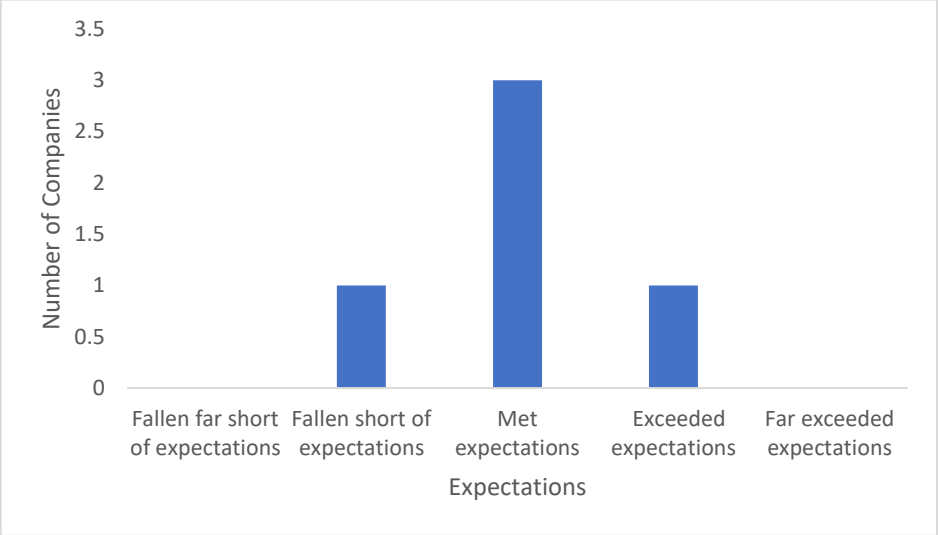

Figure 8: Expectations

The companies each provided further comment as to their expectations as outlined:

Exceeded Expectations:

- Great project management and execution
- Good team leading the research
- The communication and structure approach which ensured all parties were managed appropriately resulted in this collaboration being one of the better academic and industry collaborations experienced by the company

Met Expectations:

- Collaboration achieved all that was expected
- R&D is an ongoing process and there is still more to do
- The knowledge and contacts gained through this collaboration have been valuable to the business
- Undertook an exploratory project which is breaking new ground and researching new applications

Fallen Short of Expectations:

- Due to COVID-19 facilities were closed and research could not be undertaken.

Overall, SMARTAQUA has been a successful operation that has contributed to manyimpacts within the non-food aquaculture sector and to the companies with which the operation collaborated.

4.3. SWOT Analysis

The SWOT analysis illustrated in Table 6 was completed during the final evaluation based on interviews and discussions with SMARTAQUA team members and collaborative partners.

Strengths	Weaknesses
➢ Network growth in Wales including with companies outside of the sector ➢ Down-stream companies in West Wales and the Valleys have benefited from non-food aquaculture sector ➢ Increased networking capabilities ➢ Novelty and focus on non-food aquaculture which has opportunity for commercial exploitation ➢ Collaboration and cooperation within SMARTAQUA team ➢ Strong relationship synergy with collaborative partners ➢ Effective management team and strong leadership ➢ Relationship with CSAR ➢ Science driven and evidence based linking directly to the needs of society and businesses ➢ Research into the field of non-proprietary algal-based aquafeeds and nutraceuticals is very important and holds great potential for improvement of fish farming in terms of welfare, sustainability, disease mitigation and nutritional value. ➢ Research into non-food fish, fish products hold the potential to advance sustainability and general science and might spark ideas for small businesses.	➢ Lack of transitional funding in Welsh Government from EU funding to UK funding ➢ Constraints of ERDF processes and procedures ➢ Geographical project remit ➢ Limited runtime of the operation reduces the longitudinal research, molecular and data analysis that can be completed ➢ Need for stronger formulation of mutual goals (industry & academia) which should take into account available equipment, established methodologies, resource and experience

Opportunities	Threats
➢ Further development of the CRISPR technology and to engage with life sciences ➢ Tech transfer of lessons learned in SMARTAQUA to precision aquaculture. This will create a legacy and connect projects currently being delivered in CSAR ➢ Building on existing relationships ➢ Wider geographical scope ➢ Expertise rolled out into 3 new projects which will allow expertise generated in SMARTAQUA to be taken forward with CSAR ➢ Expansion of networks outside of Wales ➢ Extend the outcomes and results of established projects	➢ Lack of replacement funding for ERDF R&D projects ➢ Brexit implications on overseas trade ➢ Timescale of operation restricts the amount of collaboration and research activities that can be completed ➢ Inadequate UK Science Policy [36] ➢ Termination of research projects due to no further funding

Table 6: SWOT Analysis

4.4. Impact Analysis

SMARTAQUA team members were consulted on their views of the short (completion of operation), medium (3 years) and long-term (3+ years) impacts the operation is likely to have. These responses have been collated and outlined below (Table 7).

It can be seen that a number of these align directly with the impacts projected in the logic model (Section 5 - Figure 9).

The logic model impact of “Improvement in production efficiency of cleaner fish” has been met in the longer-term impact of collaboration leading to one company becoming largest supplier of lumpfish in the UK making Wales the UK centre for cleaner fish production.

The logic model impact of “Increased business growth and employment within the non-food aquaculture sector” has been met in the short-term by the impact

[36] https://www.gov.uk/government/news/government-chief-scientific-advisers-visits-to-cefas-and-fera

recorded of one company upscaling their production with a revenue stream from the excess product supply into the aquarium trade"

The logic model impact of "Additional inward investment for aquaculture within Wales" has been med by the short-term impact of the creation of a commercial hatchery

As referenced earlier in this report the logic model impact of "additional funding opportunities" has been met through a separate project through Access to Sea[37] (Interreg Atlantic)

The logic model impact of "Development of long-term relationships with industry and between academic institutions" has been met in the short term with one company introducing a species of fish they had not previously thought of working with and engaging with SMARTAQUA to gain knowledge on the sector and advise on how their company could work with the salmon industry. In addition this logic model impact was met in the longer term with one company now being the main contact in the UK for supplying UK sourced cleaner fish. This company aims to continue the development of their business model with large scale brood stock collections. The support SMARTAQUA provided in researching lumpfish at CSAR and highlighting the flaws in importing Norwegian eggs created a buzz within the salmon industry for UK sourced fish.

The logic model of embedding CCT's has been discussed extensively in Section 3 of this report

Impacts	
Short-term	➢ New source of lumpfish introduced ➢ There is an opportunity for one company to upscale their production and will have a revenue stream from the excess product supply into the aquarium trade ➢ One company was introduced to a species of fish they had not previously thought of working with and have been able to engage with SMARTAQUA to gain knowledge on the sector and advise on how their company could work with the salmon industry. ➢ Creation of a commercial hatchery ➢ Evidence that there is a market for product use
Medium-term	➢ Extended project work with CSAR following SMARTAQUA collaboration. One company in contact with salmon industry and have visited cages to explore collaborations in deployment at sea.

[37] http://ceeicadiz.com/access2sea-un-nuevo-proyecto-liderado-por-ceei-bahia-de-cadiz-recibe-el-apoyo-del-programa-interreg-espacio-atlantico/

	➢ Justification into the extending of research. Publishable science that will likely improve the public perception of research and scientific studies.
Long-term	➢ Extensive collaborations leading to one company becoming largest supplier of lumpfish in the UK making Wales the UK centre for cleaner fish production ➢ One company is now the main contact in the UK for supplying UK sourced cleaner fish. This company aims to continue the development of their business model with large scale brood stock collections. The support SMARTAQUA provided in researching lumpfish at CSAR and highlighting the flaws in importing Norwegian eggs created a buzz within the salmon industry for UK sourced fish. ➢ Development of commercial diets for fish to boost their nutritional value using marine microalgae oil as a supplement. This will provide nutrition at a low cost to low-income countries. ➢ Expanded business model to a new species. The support provided by SMARTAQUA has also meant the company has well trained staff with experience in species husbandry. ➢ Co-authored a white paper linking each of the companies to the lumpfish industry. This has demonstrated a vested interest in ensuring the welfare standards of fish being raised and deployed are maintained. The paper allows for the sector to clearly identify the main challenges and priorities in addressing lumpfish welfare needs.

Table 7: Impacts of SMARTAQUA

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5. SMARTAQUA Logic Model

In alignment with the evaluation objectives, the logic model has been reviewed in terms of the context, demand, inputs, activities, outputs, and impacts. It was evidenced that the SMARTAQUA operation has been successful in its delivery of outputs and impacts outlined within the logic model. It is suggested therefore that this logic model can be used as an evaluation mechanism beyond the life of the operation.

The information used within this logic model was developed using both existing operation documentation and primary research findings identified (Figure 9).

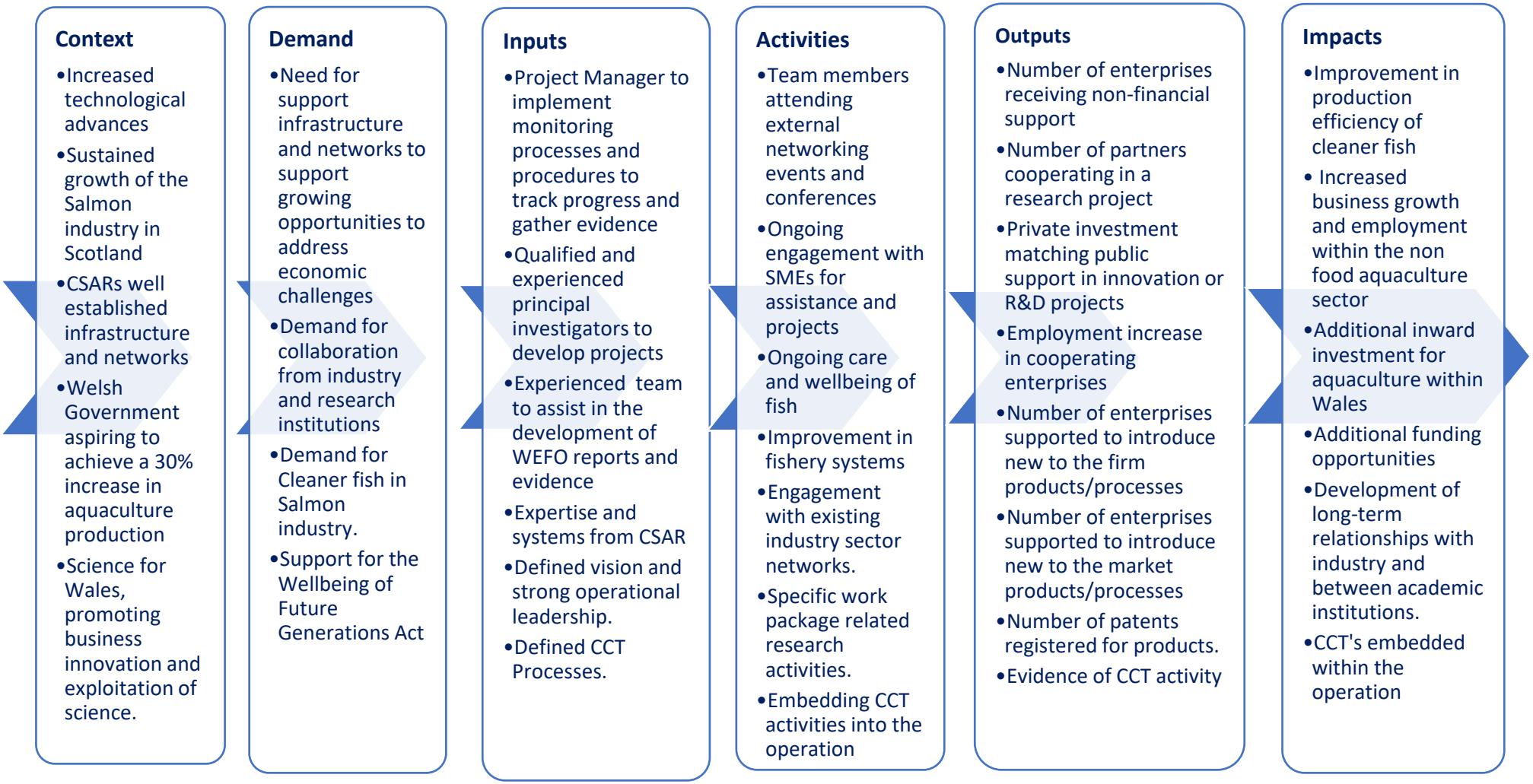

Figure 9: Logic Model

6

6. Conclusions and Recommendations

6.1. Conclusion

The overall conclusion of the evaluation process is the success of the SMARTAQUA programme in a number of areas. Feedback from collaborative partners (Section 4) confirmed that overall, the SMARTAQUA operation has provided good or excellent support. Specifically, it was reported by collaborative partners that the SMARTAQUA team provided excellent support, knowledge, and expertise to each of the companies, supporting the completion of successful collaborative projects.

After a comprehensive review of the SMARTAQUA operation at its final stage, it is concluded that this operation has been both successful and consistent in the delivery of activities. This has been achieved despite the delays caused by COVID-19, and the changing of key staff during the programme delivery. Despite the change in management staff, the leadership has remained effective and has provided clarity of direction.

Despite the COVID-19 setbacks and constraints, the SMARTAQUA team has made excellent progress towards the achievement of their indicator targets, with two targets being exceeded and a further three achieving between 85.7% and 87.5%. While the operation fell slightly short of meeting the targets for a collaborative partner patent (although one was registered by the university), non-financial support, number of partners cooperating in research projects and new to firm and market products, these were the targets that were most impacted by the pandemic with the uncertainty created affecting investment confidence and reduced R&D expenditure.

As a consequence of COVID-19, the SMARTAQUA team also faced a number of scientific challenges such as the closing of the laboratories and the restrictions on number of people able to work at any one time. Due to the nature of some of these

research projects as an ongoing R&D investigation, it proved difficult to fit completion into the short sharp project constraints imposed by EU funded projects.

The SMARTAQUA team latterly (Sept 2022) held a face-to-face networking event which was well attended, including by the Fisheries and Aquaculture Policy Manager from the Welsh Government. The feedback evidenced that the event was received positively by attendees with active networking and discussions on collaborations in the future cited as direct benefits.

Through discussions with collaborative projects, it is evident that SMARTAQUA has played a vital role in developing new processes and achieving industry sector advancements (in particular in the cleaner fish sector). It is concluded that the SMARTAQUA collaborative research and development projects have advanced knowledge, expertise, technology, and processes in the industry that would not have occurred without SMARTAQUA acting a catalyst to support collaborative R&D.

It is noted that additionally, effective cross cutting themes were evidenced throughout the programme as detailed in section 3.8 of this report.

6.2. Recommendations

Recommendation 1 – Maintain the Momentum

It has been identified during the final evaluation that the SMARTAQUA operation has provided significant benefits for collaborative companies and had a wide impact on the non-food aquaculture sector including the improvement of welfare standards. It was also acknowledged by the companies that there is still much work to be done within the sector and that the companies would like to work with SMARTAQUA again. As a result, it is recommended that the CSAR operation seeks to engage with these businesses when the SMARTAQUA operation and funding ends. This engagement should seek to establish how the businesses might be supported and to ensure that there is a minimal break in delivery to maintain project momentum and benefit from continued success.

Recommendation 2 – Make Further Applications to Seafood Innovation Fund

It is recommended that SMARTAQUA (or CSAR) should capitalise on the track record and expertise achieved throughout the operation to make further applications under the Seafood Innovation Fund 4th Call (Appendix A). This fund is accepting Expressions of Interest through to 31st October 2022.

Recommendation 3 – Resource planning

It is recommended that for any future collaborations there is a more definitive formulation of mutual goals (industry & academia). Industry sometimes has

unrealistic expectations of the levels of support, resource and equipment available to them. It is recommended that, going forward, there is a more definitive statement of resource available, equipment that might be accessed and a consideration that in the absence of funding, there may need to be a financial contribution from the business for the support and equipment they are seeking to access.

Recommendation 4 – Monitor Horizon Europe

It is recommended that both Swansea University and CSAR monitor progress of the Horizon Europe funding programme (See Appendix B). During the ongoing period of negotiation over the Northern Ireland protocol it is recommended that exploratory links are forged with potential European partners, that may become collaborative partnerships in the future. It is further recommended that this focus should initially be on partner countries with whom SMARTAQUA has already forged successful relationships in the Aquaculture sector.

Appendix A – Relevant Articles and Information

This Appendix contains links to relevant articles and information relating to the work undertaken by the SMARTAQUA operation.

UK Seafood Innovation Fund

https://www.seafoodinnovation.fund/

UK and European scientists urge EU to allow UK access to £80bn fund

https://www.theguardian.com/politics/2022/feb/08/uk-and-european-scientists-urge-eu-to-allow-uk-access-to-10bn-fund-brexit

UK scientists attack 'reckless' Tory cuts to international research

https://www.theguardian.com/science/2021/mar/14/uk-scientists-attack-reckless-tory-cuts-to-international-research

UK may soon abandon £80bn Horizon Europe network, universities warn

https://www.theguardian.com/education/2022/jun/01/uk-may-soon-abandon-80bn-horizon-europe-network-universities-warn

Addressing the welfare needs of farmed lumpfish: Knowledge gaps, challenges and solutions. Aquaculture Vol 14 Issue 1. Jan 2022

https://onlinelibrary.wiley.com/doi/full/10.1111/raq.12589

Biophilic Project in Swansea

University expertise to help new "living building" residents in Swansea to grow their own food on roof.

https://www.swansea.ac.uk/press-office/news-events/news/2022/08/university-expertise-to-help-new-living-building-residents-in-swansea-to-grow-their-own-food-on-roof.php

Access2Sea Project

https://access2sea.eu/