Towards a Research & Innovation Initiative in Sustainable Aquaculture

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1. EXECUTIVE SUMMARY

1.1 Two of the UK's leading public funding agencies for the environmental and biological sciences, NERC and BBSRC are developing a pre-competitive funding initiative to provide new solutions for sustainable aquaculture. The aim of the initiative is to support innovative research and research translation, to increase aquaculture capacity in the BBSRC and NERC research communities and to ensure the UK aquaculture sector receives benefit from innovation arising from the research base. By funding projects that incorporate both the environmental and biological sciences, this cross-Research Council initiative will bring together different expertise, knowledge and facilities to deliver innovative approaches to solving industry problems. In doing so, it will strengthen the research community to underpin the long-term needs of industry through interdisciplinary research, the provision of training, and research translation.

1.2 Aquaculture is increasingly important to global food security: by 2030, 62% of fish eaten by humans is expected to be produced from aquaculture. In the UK, aquaculture is a key strategic food production sector, as production from UK aquaculture is the largest in the European Union. Sustainable expansion of the UK industry requires improved understanding of the basic biology, health and environmental interactions of farmed fish and shellfish[1]. In recognition of this importance BBSRC and NERC are acting to turn around the declining investment made by Research Councils in recent years.

1.3 This new initiative will build on the 2014 BBSRC and NERC capacity-building aquaculture research call, known as 'phase 1', which aimed to deliver bioscience and environmental science research projects in seven priorities for aquaculture research; draw in researchers new to the aquaculture sector to work in collaboration with aquaculture researchers; expand the uptake and development of novel tools, methods, and technologies; and encourage multidisciplinary, systems science and cross-council approaches.

1.4 Consultation with industry has demonstrated that research and innovation challenges for aquaculture companies align with research priorities for the aquaculture sector set by national and international bodies. These include issues of welfare; health and disease, including sealice; sustainable feed; legislation and regulation; environmental effects; spatial planning; consumer expectations; breeding and genetics; water quality; product quality; new facilities and technologies; and knowledge and technology transfer.

1.5 At a BBSRC/NERC Sustainable Aquaculture industry workshop held in March 2015, companies indicated an interest in collaborating with academia, citing benefits to collaboration including access to skills, equipment and cutting-edge research. However there are some barriers to industry-academic collaboration, including a lack of familiarity with the academic community and challenges in finding match-funding. These barriers can be addressed through the new

[1] James, M.A. (2009) UK Aquaculture R&D Database – Strategic Summary 1999 – 2009, Defra Report

initiative with the correct delivery mechanism, for example, by investment in a network and ensuring that in-kind contribution to projects is acknowledged.

1.6 NERC and BBSRC will continue to work with stakeholders to ensure Phase 2 of the Sustainable Aquaculture Initiative will bring the greatest possible benefit to the aquaculture sector. Based on the findings of this report BBSRC and NERC will convene a Working Group consisting of a small number of key industry and academics, as well as interested co-funders. We will propose options of thematic areas and funding mechanisms most suitable to the sector and the Working Group will help develop the shape and scope of the BBSRC/ NERC Sustainable Aquaculture Initiative.

2. INTRODUCTION

2.1. Aquaculture is one of the UK's key strategic food production sectors and helps to underpin sustainable economic growth, both in rural and coastal communities, and in the wider economy[2]. In terms of value, the UK is the largest EU producer with 20% of the total EU aquaculture[3]. Aquaculture accounts for over half of the world's fish supply for human consumption. This is expected to rise to 62% by 2030 as catches from wild capture fisheries level off[4].

2.2. Continued sustainable expansion of the industry requires improved understanding of the basic biology, health and environmental interactions of farmed fish and shellfish, but Research Council investments in aquaculture have declined considerably in recent years[5]. NERC's research investments have been modest since the end of the Defra-NERC funded LINK aquaculture research programme in 2002/03. The BBSRC Animal Disease Working Group identified that BBSRC were funding very little in aquaculture and analysis of the portfolio showed that in 2012-13, BBSRC invested less than £1M in aquaculture compared to £40M in animal health, against farm gate values of £643M and £2Bn respectively.

2.3. In recognition of this importance of the sector, BBSRC and NERC are acting to turn around the declining investment made by Research Councils in recent years by developing a pre-competitive funding initiative to provide new solutions for sustainable aquaculture. Industry has played a key role in determining both the scope and strategic direction of this collaborative initiative.

2.4. The aim of the initiative is to support innovative research and research translation, to increase aquaculture capacity in the BBSRC/NERC research communities and to ensure the UK aquaculture sector receives benefit from innovation arising from the research base. By funding projects that incorporate both the environmental and biological sciences, this cross-Research Council initiative will bring together different expertise, knowledge and facilities to deliver innovative approaches to solving industry problems. In doing so, it will strengthen the research community to underpin the long-term needs of industry through interdisciplinary research, the provision of training, and research translation.

2.5. For the purposes of this document, 'aquaculture' is defined as the farming of aquatic animals and plants. It excludes capture fisheries (catching wild fish from seas or fresh water), although some aquaculture may depend at least in part on feed derived from wild-caught fish. Aquaculture includes the culture of algae or other plants for food or fish-feed, but here excludes algal culture for bioenergy or non-food industrial products. However, some research,

[2]Defra - United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. April 2014

[3] Marine Scotland – Aquaculture Science and Research Strategy. May 2014

[4] The World Bank – Fish to 2030, Prospects for Fisheries and Aquaculture. December 2013.

[5] James, M.A. (2009) UK Aquaculture R&D Database – Strategic Summary 1999 – 2009, Defra Report

such as work to increase the productivity of algal culture, would be relevant for both food and non-food uses. In general, in this document 'fish' should be taken to include shellfish.

3. EXTERNAL CONTEXT TO A SUSTAINABLE AQUACULTURE INITIATIVE

3.1. Over the past few years a number of notable and highly influential reports have been published by the UN, the European Commission and UK government departments, giving an insight into the growing importance of UK and global aquaculture. These reports have helped BBSRC and NERC to understand the potential of the aquaculture industry, as well as the prevailing challenges it faces. The prioritisation exercises and approaches of various bodies have enhanced our knowledge of the funding landscape and informed our thinking of where Research Council funding could have the biggest impact. The following section highlights the key finding of these reports which are also summarised in Table 1.

3.2. The State of World Fisheries and Aquaculture (SOFIA) is the flagship publication of the FAO Fisheries and Aquaculture Department. In the 2014 edition[6], it stated that "*aquaculture remains one of the fastest-growing food producing sectors. In 2012, aquaculture set another all-time production high and now provides almost half of all fish for human food. This share is projected to rise to 62% by 2030 as catches from wild capture fisheries level off and demand from an emerging global middle class substantially increases. If responsibly developed and practised, aquaculture can generate lasting benefits for global food security and economic growth.*" The report highlighted the role of aquaculture in improving nutrition. With regard to the increasing concern about fishery products containing harmful substances, the report stated that sustainably produced aquaculture products are not major sources of contaminants. Control mechanisms generally work very effectively, ensuring that only safe products reach the consumers.

3.3. In June 2014, an FAO High Level Panel of Experts on Food Security and Nutrition (HLPE) produced a report[7] which seeks to address what should be done to maintain and enhance the importance of fish for food security and nutrition now and in the long term, given the challenges that both the fisheries and aquaculture sectors are facing in terms of sustainability and governance.

3.4. The European Commission has clearly articulated objectives for growth in sustainable aquaculture, as a component of Blue Growth, thereby enhancing long term seafood security[8]. The Commission intends to boost aquaculture through the Common Fisheries Policy reform, and has published Strategic Guidelines presenting common priorities and general objectives at EU level.

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[6] FAO – The State of World Fisheries and Aquaculture. 2014

[7] High Level Panel of Experts on Food Security and Nutrition - Sustainable fisheries and aquaculture for food security and nutrition. May 2014.

[8] European Commission - Strategic Guidelines for the sustainable development of EU aquaculture. April 2013

3.5. Aquaculture policy in the UK is a devolved matter, with the separate administrations of Wales, England, Northern Ireland and Scotland responsible for its collective oversight. The Multiannual National Plan[9] developed by Defra in April 2014 states that: "*Aquaculture is one of the UK's key strategic food production sectors and helps to underpin sustainable economic growth, both in rural and coastal communities and in the wider economy. The industry provides community benefits in high quality, secure jobs and related social infrastructure. The UK is committed to continue supporting industry-led sustainable growth of aquaculture."* Their planned activities aim to support innovation and links between research and development and the industry, and focus around the challenges shown in Table 1.

3.6. Scotland supports an industry plan to increase finfish production sustainably from 164,380 tonnes (in 2012) to 210,000 tonnes by 2020 and shellfish production from 6,525 tonnes (in 2012) to 13,000 tonnes in 2020. The Welsh 'Marine and Fisheries Strategic Plan[10]' sets sustainable growth targets for the industry to increase sustainable production of finfish from 761 tonnes (in 2012) to 2,000 tonnes by 2020 and shellfish from 8,376 tonnes (in 2012) to 18,000 tonnes in 2020. At a UK level these figures imply growth projections of approximately 27% in finfish production by 2020 and 66% increase in shellfish production by 2020[11].

3.7. In order to facilitate the ambition of achieving Scotland's 2020 sustainable production, the Ministerial Group for Sustainable Aquaculture's Science (MGSA) produced a comprehensive science and research strategy[12].

3.8. The Scottish Aquaculture Innovation Centre (SAIC)[13] is a virtual hub drawing together the collective expertise and resources found across its 13 research partners and its extensive aquaculture supply chain. SAIC is primarily focused on industry-led competitive R&D biosciences projects (i.e. close to market) that will draw on the fundamental and pre-industrial research arising from this NERC-BBSRC initiative. SAIC supports innovative projects and research that tackles urgent industry issues as shown in Table 1, promotes sustainability, and mitigates risks for producers[14].

3.9. Scottish Aquaculture Research Forum (SARF) is an independent charity tasked with prioritising, commissioning and managing applied aquaculture research, based upon the needs of industry and its key regulators and stakeholders[15]. As shown in Table 1, SARF has a focus on small-scale, short-term, strategic topics, including science and best practice underpinning regulation, fish health, product safety and sustainability.

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[9] Defra - United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. April 2014

[10] Welsh Government – Wales Marine and Fisheries Strategic Action Plan. November 2013.

[11] Defra - United Kingdom Multiannual National Plan for the Development of Sustainable Aquaculture. April 2014

[12] Marine Scotland – Aquaculture Science and Research Strategy. May 2014

[13] Scottish Aquaculture Innovation Centre

[14] Scottish Aquaculture Innovation Centre – What is Innovation?

[15] Scottish Aquaculture Research Forum

3.10. The Global Food Security (GFS) Insight report between on 'The UK Aquaculture Industry[16]' was produced following a meeting between GFS's Champion, Professor Tim Benton and the Director General in the EU. The report covers the current state of knowledge, why the industry has recently expanded and the role that research will increasingly play to advance the sector.

3.11. Table 1 shows research priorities as identified by national and international bodies. Common themes are:

- Welfare, health and disease in fish, including pathogens, pests and in particular sea lice;
- Understanding how the industry interacts with the environment, in terms of climate change and impacts on wild ecosystems;
- Improving sustainability in the industry, particularly regarding alternative sources of feed;
- New technologies, facilities and approaches to enhance capacity;
- Genetics and breeding for stock improvement;
- Shellfish farm challenges including food safety, the development of multispecies hatcheries, sustainable sources of seed, and water quality;
- Legislative frameworks that promote enterprise and boost growth.

3.12. The Research Councils are well-placed to invest in the key research priorities highlighted in section 5.2. As shown in Figure 1, the Research Councils and Scottish Government invest in basic science underpinning aquaculture innovation and support it through to pre-competitive research and development. Research Council investment through Responsive Mode has been limited, but strategic investment through a Research and Innovation Initiative would support more research and research translation outputs in aquaculture, which could be picked up by the levy bodies, SARF, SAIC and Innovate UK, which all invest in near-market, industry-led research and development. It is important that a new Research Council funded initiative can co-ordinate activities with these other organisations in the funding landscape to ensure investments have the maximum breadth and scale of impact possible.

[16] Global Food Security – Insight: The UK Aquaculture Industry. July 2014

Table 1: Summary of aquaculture research priorities identified by global and national groups

Themes	Global (HLPE, SOFIA 2014)	EU Strategic Guidelines	UK (Defra)	Scotland (MGSA)	SARF	SAIC
Welfare, health and disease (including sea lice)	Fish diseases Overuse of antibiotics, drugs and chemicals			Health and welfare	Fish health Sealice	Improved sea lice control in Scottish aquaculture Rapid detection methods for viral pathogens and diseases
Managing environmental impacts that affect and are caused by aquaculture	Risk of aquaculture stock release to wild populations and ecosystems		Reducing potential impacts on wild species and ecosystems	Wild-farmed interactions		
Alternative sustainable feeds	The overuse of fish in fishmeal and fish oil		Constant innovation in development of sustainable feedstocks		Sustainable feedstocks	Alternative sustainable feeds for finfish
New technologies to enhance the capacity of UK aquaculture			Moves to further exposed sites through adherence to equipment technical standards	Technology and engineering Blue biotechnology		
Spatial planning	Spatial planning	Improving access to space and water				
Breeding, genetics for quality	Domestication and genetic improvement of key traits			Stock improvement		
Shellfish: Hatcheries and food safety	Health control and food safety		Reduce shellfish sector reliance on variable wild seed supplies	Food safety and hygiene	Product safety eg norovirus	Development of secure health-certified Scottish mollusc spat production systems
Capacity			Partnering in developments in non-food aquaculture	Capacity (acknowledging limits and expansion potential)		
Policy and social challenges		Increasing competitiveness Exploiting competitive advantages: high quality, health and environmental standards		Markets, economics and social science	Efficiency of regulatory regime	
Other		Reducing administrative burdens		Nutrition		
Water quality			Water quality improvements, especially shellfish			

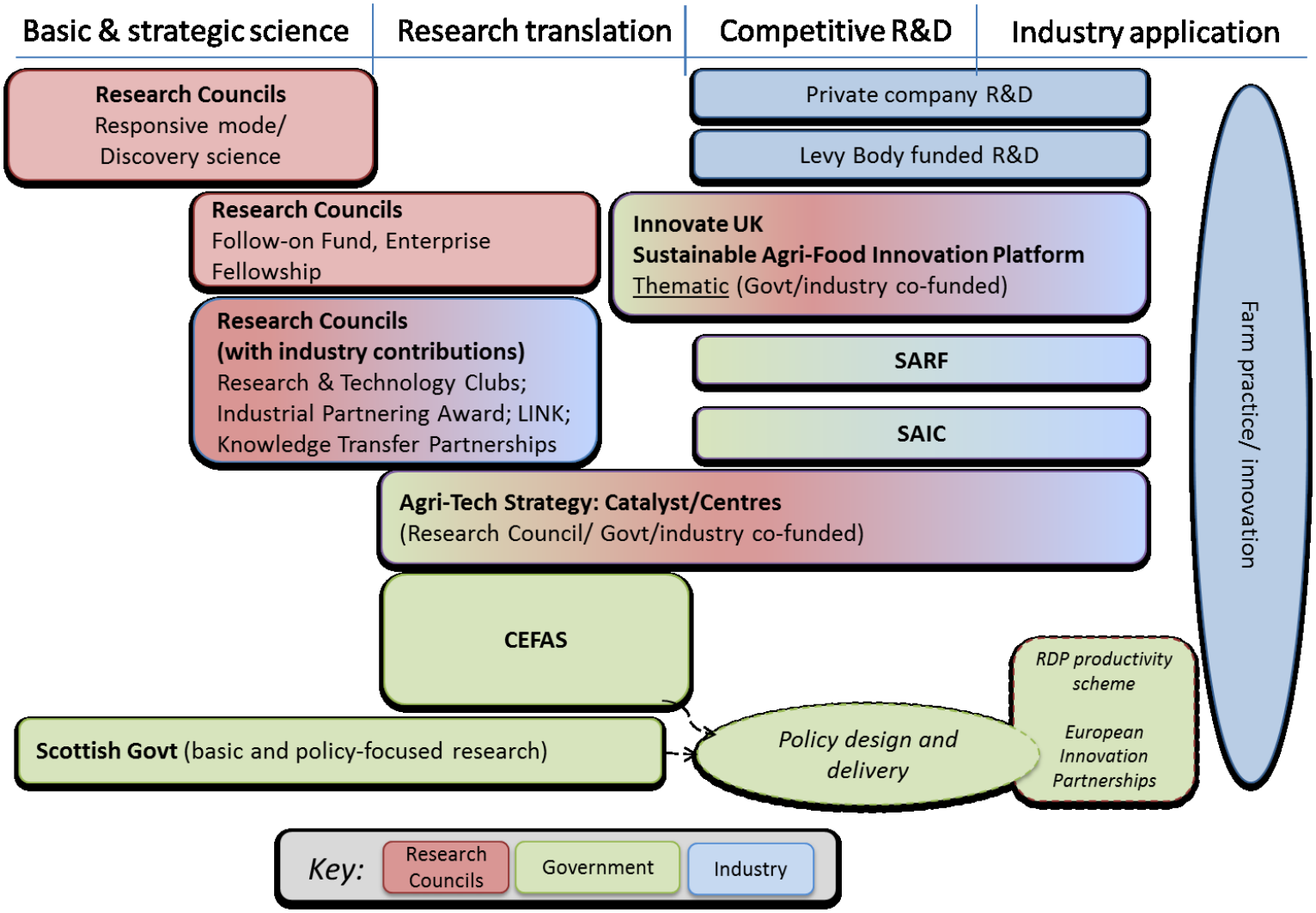


Figure 1: UK Aquaculture funding landscape

4. A SUSTAINABLE AQUACULTURE INITIATIVE: CAPACITY BUILDING

4.1. Research expertise relevant to aquaculture is based in higher education institutions (HEIs) and research centres spread throughout the UK; although some of the larger research centres are based in Scotland, for example the University of Aberdeen, Scottish Association for Marine Science and the University of Stirling. Expertise covers a wide range of NERC and BBSRC relevant topics including breeding, disease, environmental impact, fouling, genetics and genomics, harmful algal blooms, non-natives and invasive species, nutrition and feeds, parasites, modelling, technology, health and welfare and wild-fish interactions. Research expertise also includes ESRC relevant areas such as social-economics and policy and spatial planning.

4.2. The summary of the knowledge and skills in the UK aquaculture research community shown in Table 2 resulted from the development of a database of aquaculture researchers in the UK done by a NERC Knowledge Exchange Fellow (see Annex 1). A combination of methods were used: a literature search to identify who in the UK had published aquaculture-relevant research during the last ten years; searches in Gateway to Research (http://gtr.rcuk.ac.uk/); searches in University websites and referrals from researchers. When the database was as up-to-date as possible (this is a live document), HEIs and research centres were contacted regarding the expertise and facilities they offer. In some cases, it was not possible to obtain information and in these cases details were gathered from their university or departmental websites.

Table 2: Summary of UK aquaculture research capability

Overarching research area	Specific expertise
Genetics, genomics and associated technologies for breeding	Hatchery technology for fish and shellfish (including novel species such as nephrops) Research and development of algae culture and other invertebrates Selective breeding for disease resistance and to target traits such as omega-3 levels and general survivability
Disease and parasites	Bacteriology and virology (identification and classification) Disease resistance and immunology Infections and behaviour Parasites as vectors of disease Parasite population dynamics Control and host-parasite-environment interactions
Fish welfare	Impacts of contaminants Meat quality Stunning and slaughter
Environmental impact	Benthic impacts Interactions with predators (e.g. seals) Impacts of invasive species on aquaculture. Harmful algal blooms Fouling Wild-fish interactions (including genetic introgression)
Nutrition and feed	Quantifying nutritional requirements Determining species-specific nutrition for trout, salmon, tilapia, catfish, sea bream, sea bass and turbot Impacts of diet on health and growth

	Alternative and more sustainable feed ingredients
Social-economics and policy	Impacts of policy and regulation on the aquaculture industry Stakeholder and consumer perceptions of aquaculture Economics of production from aquaculture Marine and coastal ecosystem services, goods and benefits Marine planning, spatial analysis and GIS.

4.3. Aquaculture research in the UK is largely supported by Defra, Scottish Government and European investment, with some recent investment from the Agri-tech Catalyst. As shown in Figure 1, these are all investors with a focus on industry or policy application. During 2013, BBSRC and NERC noted that their investment in aquaculture appeared to be limited, and held a number of informal consultations and surveys to determine whether there was a real gap in research, in which Research Council support could be useful, and whether there was the capacity in the community to respond. The outcomes of the informal consultations can be found on the BBSRC website[17]. A survey of 70 academics and 20 industry or policy representatives showed research gaps in immunology, nutrition and health, shellfish research, resistance, vaccines and host-pathogen interactions. As described in Section 4.2, expertise in some of these areas exists in the UK but the consultation demonstrated a need to develop the biological and environmental science research communities working on aquaculture in order to underpin innovation in the growing aquaculture industry. It was determined that a two-phase approach was necessary.

4.4. In March 2014, BBSRC and NERC held a workshop to develop the first phase of the Sustainable Aquaculture Initiative. The aims of the workshop were to identify and prioritise research gaps in aquaculture, promote collaboration, discuss novel technologies and facilitate research partnerships. The group identified 30 research and expertise gaps and agreed that the topics had considerable overlap, so holistic and multidisciplinary approaches were required. Shellfish in particular were considered under-researched, but the priority areas derived from the list are relevant to both shellfish and finfish. A full workshop report was produced[18].

4.5. The outputs of the workshop were used to help develop a capacity-building research call: The joint BBSRC & NERC call for multidisciplinary proposals in *Sustainable Aquaculture: Health, disease and the environment* (phase one of the Sustainable Aquaculture Initiative). The call was launched in September 2014 with £6M available. BBSRC and NERC each committed £2.5M and additional co-funding from the Agri-Food & Biosciences Institute (AFBI), Marine Scotland and CEFAS was available to cover the costs of their researchers on proposals. In addition, the Food Standard Agency (FSA) and FSA in Scotland considered co-funding contributions on a case by case basis for projects that align with their policy objectives relating to food safety.

4.6. This call had seven priority areas, informed by the workshop described in Section 4.4:

[17] BBSRC Aquaculture Consultation. December 2013

[18] BBSRC & NERC - Report from the Aquaculture Workshop: Multidisciplinary approaches to fish health and disease research. March 2014.

1. Mechanisms of disease (including parasite) infection and spread, including host-pathogen and environmental interactions.
2. Biology of health and disease resistance (including gut health and genetic resistance, effects of intensification).
3. Immunology of infection and protection, including vaccinology.
4. Tools, methods and technologies for diagnostics, experimental resources, and environmental systems.
5. New technologies for monitoring and predicting weather and climate-related hazards and risks to the expanding aquaculture sector as it moves into environments more exposed to wind and waves.
6. Determining interactions between wild and farmed fish.
7. Assessing the long-term environmental capacity for increased aquaculture production.

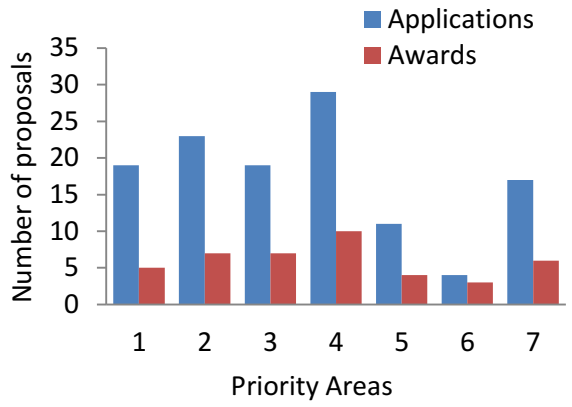
4.7. The call received 63 applications representing 192 named researchers. The call was successful in attracting 41 researchers who were new to the aquaculture sector (21.4% of applicants; Table 3). Of these researchers with no aquaculture background, 17 worked on disease resistance or disease-causing agents in different systems, five were genomics experts, four provided technical expertise in metabolomics, proteomics and microscopy, and three were engineers researching sensor systems.

Table 3: Backgrounds of named investigators on Sustainable Aquaculture Capacity-building Call applications

	Number of named investigators on:	
	Applications	Awarded grants
Background in Aquaculture	151 (78.6%)	72 (82.8%)
New to Aquaculture	41 (21.4%)	15 (17.2%)

4.8. The 21 projects funded through the Sustainable Aquaculture call are listed in Annex 2. These 21 projects represent 87 named investigators, of which 15 are new to aquaculture (Table 3).

4.9. As shown in Figure 2, the call received applications in all seven priority areas. As an underpinning theme with application to other priority areas, the Tools, Methods and Technologies topic (Priority Area 4) was the most common, covered by 29 applications. Priority Areas 1, 2 and 3 (Mechanisms of Disease, Biology of Health and Disease Resistance, and Immunology) were well covered in applications. Topics 5 and 7, relating to monitoring and predicting the incidence and effects of weather and climate related hazards to aquaculture, were covered by 11 and 17 applications respectively. Only four applications were linked to Topic 6, on the interactions between wild and farmed fish.



Sustainable Aquaculture priority areas

1 Mechanisms of disease
2 Biology of health and disease resistance
3 Immunology of infection and protection
4 Tools, methods and technologies
5 New technologies for modelling weather and climate-related hazards
6 Determining interactions between wild and farmed fish.
7 Assessing the long-term environmental capacity for increased aquaculture production.

Figure 2: Topics covered by Sustainable Aquaculture Call applications and awarded grants. In total, there were 63 applications and 21 awards. Applications covering more than one topic are represented more than once in the data.

4.10. This breakdown of priority areas reflects the ratio between BBSRC- and NERC- led applications: nearly twice as many applications were BBSRC-led as NERC-led (Table 4).

Table 4: Summary of applications to the joint BBSRC/NERC Sustainable Aquaculture Capacity-building Call

	Number of applications	Number of projects awarded	Total value of projects awarded
BBSRC-led projects	40	11	£2,534,491
NERC-led projects	23	10	£2,179,219
All projects	**63**	**21**	**£4,713,709**

5. A SUSTAINABLE AQUACULTURE INITIATIVE: CONSULTATION WITH INDUSTRY

5.1. On Thursday 26th March 2015, BBSRC held a Sustainable Aquaculture Industry workshop in Edinburgh. The workshop was split into two parts. The morning session focussed on identifying research and research translation priorities for industry, while the purpose of the afternoon session was to explore the benefits and barriers to collaboration between industry and academia, and suitable delivery mechanisms for research council funding.

5.2. The consultations raised the following challenges in finfish and shellfish farming for consideration (more detail can be found in the full workshop report in Annex 3):

1. Fish and shellfish welfare
2. Health and disease, including sea lice
3. Sustainable feedstocks
4. Understanding the effects of aquaculture on the environment and vice versa, specifically regarding water quality
5. Breeding and genetics approaches for stock improvement

6. Product quality, including food safety
7. New facilities and technologies for monitoring and predicting risks, and to enhance the capacity of aquaculture

5.3. As described in Section 4.1, and supported by the diversity of applications to the 2014 BBSRC/NERC Sustainable Aquaculture capacity building call, the UK research community is capable of meeting the majority of these challenges. The research community underpinning fish health, disease and vaccines was particularly engaged with the 2014 call.

5.4. As shown in Table 1, industry representatives also raised concerns relating to legislation, regulation, consumer expectations and spatial planning issues. The Economic and Social Research Council[19] (ESRC) invest in research underpinning these areas, which are not within remit for BBSRC or NERC. The Research Councils will work together to link up researchers and industry who want to address these challenges collaboratively.

5.5. Delegates at the Sustainable Aquaculture Industry workshop were asked to consider what the benefits and barriers of business collaborating with academia are. Details of the responses can be found in Annex 3.

5.5.1. **Benefits:** There was recognition that public-private investment in research and innovation will bring wide-ranging benefits to the aquaculture industry, including an exchange of skills and facilities; a two-way exchange of knowledge and expertise from commercial and academic perspectives; the ability to build long term relationships for continued collaboration for future projects; and the cost-effective provision of in-kind funding.

5.5.2. **Barriers:** Delegates acknowledged there are barriers to industry-academic interaction on research that underpins aquaculture. These barriers include difficulty in identifying collaborators; small R&D budgets in industry; the burden of finding match-funding for company partners; intellectual property management, a particular concern for small businesses; and timing and administrative issues with funding calls. As described in Section 4, an appropriate delivery mechanism will be able to overcome these barriers.

6. POTENTIAL MECHANISMS FOR DELIVERING A SUSTAINABLE AQUACULTURE INITIATIVE

6.1. The Sustainable Aquaculture Initiative needs to truly engage practitioners and decision-makers. To appeal to companies in the aquaculture sector, it must directly deal with the barriers to collaboration mentioned in Section 5.5. BBSRC and NERC will continue to work with the community in developing a funding mechanism suitable for the UK aquaculture sector.

6.2. Phase 2 of the Sustainable Aquaculture Initiative will be one of the Research Council's strategic investments in industrially-relevant, pre-competitive research focussed on a

[19] Economic and Social Research Council

particular sector.[20] Such investments are the result of extensive community consultation to ensure the funding mechanisms are tailored to the community whose research challenges they seek to address. A number of examples of mechanisms used in the past are described below. These examples will be used to inform discussion with aquaculture stakeholders as the Sustainable Aquaculture Initiative is developed. The different types of funding mechanisms are flexible and can be shaped according to the aquaculture's needs; equally, the Research Councils are open to proposals for a new mechanism altogether.

6.3. **The BBSRC/NERC Sustainable Agriculture Research and Innovation Club (SARIC):** The research and innovation club model bridges the disconnect between research outputs and industry needs by inviting companies to co-develop and co-invest in a funding programme. It dilutes the risk of investing in research to solve broad, cross-sector challenges and provides them with networking opportunities and early access to research outputs. In order to become an industry member of the club, companies must pay an annual subscription fee. Funded projects may collaborate with non-members, however any resulting intellectual property will be offered first to industry members.

6.3.1. Company members pay an annual membership fee over a 5 year period and the Research Councils match the combined industry funds at a ratio of at least 9:1. Industry members can contribute one-third of their membership fee in-kind. Other funding bodies may also contribute to the total available funds.

6.3.2. SARIC is overseen by a Steering Group of company representatives and academic researchers; other stakeholders may hold observer status. BBSRC and NERC provide secretarial support, administer the peer-review process and provide overall strategic guidance.

6.3.3. Investments made through SARIC include research projects and research translation (see Box 1).

6.3.4. Special conditions are attached to grants to ensure industry members receive priority access to project outputs, enabling industry members to progress outputs further independently should they be so inclined.

6.3.5. Club dissemination events funded by BBSRC and NERC are held every nine months. The purpose of these events is for grant holders to give progress updates on their projects and discuss funding with industry members; they also provide an excellent opportunity for networking and community-building. Dissemination events restrict attendance to industry members and grant holders.

[20] http://www.bbsrc.ac.uk/innovation/sharing-challenges/;
http://www.bbsrc.ac.uk/innovation/collaboration/collaborative-programmes/

Research translation is the integration or adaptation of existing research outputs (e.g. datasets), to enable the development of technologies and solutions for the benefit of practitioners and decision-makers. This includes merging or adapting research outputs to either significantly reduce the technical uncertainty of a particular solution or technology, or the bringing together of dispersed knowledge in an appropriate form, to overcome barriers to future business investment. Furthermore, research translation is predicated on access to expertise and the exchange of knowledge. Therefore, effective knowledge exchange is the cornerstone of research translation which itself leads to new products, services, tools, technologies, demonstrator projects, evidence-based systematic reviews, and other outcomes that create tangible economic or societal benefits.

Box 1: Definition of Research Translation

6.4. **The BBSRC/NERC Horticulture and Potato Initiative (HAPI)**: The horticulture and potato sector encompasses many plant species and farming methods and involves a variety of companies from a few multinationals to large national companies to many small and micro enterprises. Engaging this community needed a mechanism which recognised the variety of research challenges faced by the sector and allowed all key players, from food processors to growers, to be involved. HAPI therefore invested in individual projects to which industry contributed in-kind or cash, supporting direct collaborations between academia and industry.

6.4.1. HAPI is managed in a similar way to research and innovation clubs, with a Steering Group of industry and academic representatives working with the Research Councils to define the scope of the call and make awards ensuring industrial relevance. However in this model companies do not pay an annual subscription fee to a common funding pot, but are directly involved in projects. Projects are developed by academic research groups with company partners, who are required to meet 10% of the costs of individual projects, either individually or as consortia. In kind contributions are recognised as part of the 10% of costs, though a certain proportion of cash contribution, for example 5%, may be required.

6.4.2. Dissemination events are open to all interested companies and research groups, not just those who are directly involved in the funded projects.

6.4.3. Although all project partners must publish project outputs in accordance with RCUK open access policy, individual collaborations make their own arrangements with regards to intellectual property ownership. There is no initiative-level agreement to share research outputs.

6.5. **BBSRC Networks in Industrial Biotechnology (BBSRC NIBBs)**: Sector-specific networks which are free to join for academics and industry build connections and encourage collaboration. They do not invest in large research projects, but fund small proof-of-concept collaborative projects.

6.5.1. Thirteen BBSRC NIBBs were set up in 2013 with £17M from BBSRC and £1M from EPSRC. They are academic-led, self-organised communities involving both industry and academics. They are intended to encourage interaction between the academic

research base and business/industry to promote the translation of research and to facilitate the development of internationally competitive cross-disciplinary communities capable of undertaking innovative research and attracting further investment from UK and international sources.

6.5.2. Each BBSRC NIBB consists of two academic directors and a Network Manager, who control a core grant consisting of salary and meeting costs, awarded at 100% FEC as non-research activities (estates and indirects were also excluded). The Directors and Manager are supported by a Management Board, commonly split 50:50 between academics and industry representatives. The core grant is used to organise community meetings, sandpit events, and commission relevant reports.

6.5.3. All BBSRC NIBBs also have up to £1.2M in funds to distribute towards short Proof of Concept (PoC) proposals and £200K to award as collaborative £5K Business Interaction Vouchers (BIV) via a light touch review process. BBSRC retains the final approval of all projects in a light touch remit check.

6.6. **The Hub model**: A novel intervention is under development to support the exploitation and advancement of biofilm science and technology. The Hub model is designed to meet the needs of the highly multi-disciplinarily and multi-sectoral biofilm translation chain. This is an emerging sector that would benefit from a community-building exercise and investment in fundamental research. However relevant research is being drawn in different disciplines which may be of interest to industry, so the intervention must also enable translation and collaborative research.

6.6.1. Work on refining the model is still underway, but the overarching aim is to create academic-led research and innovation hubs which are:

- Significantly guided and assessed by industry; and which have significant autonomy.
- Focused on different but critically linked industrial challenges, and all feed in to and enable a series of UK grand challenges for the area.
- Able to provide a balanced and constantly refreshed pipeline of projects: 60% fundamental and 40% feasibility (with early, mid and late stage feasibility pipeline for ease of industry uptake).
- Linked to a highly cross-sector industry network which has easy and free access to all hubs. This would be a managed network with its own ‘linked’ seed funding to enable opportunistic, high-risk pilots between industrialists and different hubs which can they feed into larger hub projects.
- Have membership opportunity for key industry partners interested in the hub topic. These principal partners will make a cash or in-kind contribution to the hub.

7. NEXT STEPS

7.1. NERC and BBSRC will continue to work with stakeholders to ensure Phase 2 of the Sustainable Aquaculture Initiative will bring the greatest possible benefit to the aquaculture sector. Based on the findings of this report BBSRC and NERC will convene a Working Group consisting of a small number of key industry and academics, as well as interested co-funders. We will propose options of thematic areas and funding mechanisms most suitable to the sector and the Working Group will help develop the shape and scope of the BBSRC/ NERC Sustainable Aquaculture Initiative.

8. FUNDERS AND ASSOCIATED PARTNERSHIP PROGRAMMES

8.1. The **Natural Environment Research Council** (NERC) is the UK's leading public funder of environmental science. We invest around £330m each year in cutting-edge research, postgraduate training and innovation, in universities and research centres. NERC scientists study the planet from pole to pole, from the deep Earth and oceans, to the atmosphere and space, to monitor how the environment works and changes on a global scale.

8.2. The **Biotechnology and Biological Sciences Research Council** (BBSRC) invests in world-class bioscience research and training on behalf of the UK public. Our aim is to further scientific knowledge, to promote economic growth, wealth and job creation and to improve quality of life in the UK and beyond. Funded by Government, BBSRC invested over $484M in world-class bioscience in 2013-14. We support research and training in universities and strategically funded institutes. BBSRC research and the people we fund are helping society to meet major challenges, including food security, green energy and healthier, longer lives. Our investments underpin important UK economic sectors, such as farming, food, industrial biotechnology and pharmaceuticals.

8.3. The UK's main public funders of food-related research and training are working together through **Global Food Security** to meet the challenge of providing the world's growing population with a sustainable, secure supply of good quality food from less land and with lower inputs. BBSRC and NERC are partners in Global Food Security and this new funding initiative is aligned with the aims of this broader programme.

The programme delivers coordinated, multidisciplinary research through 4 themes:

1. Economic resilience
2. Resource efficiency
3. Sustainable production
4. Sustainable, healthy, safe diets.

9. PROGRAMME TEAM CONTACT DETAILS

To discuss this report, the industry-academic collaborative initiative and how you might participate, or to seek any other information related to this initiative, please contact the programme development team:

Biotechnology and Biological Sciences Research Council
Charis Cook – Innovation Manager

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Natural Environment Research Council
Jodie Mitchell – Knowledge & Innovation Manager
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Natural Environment Research Council
Judith Youziel – Innovation Programme Officer
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ANNEX 1: RELATED AQUACULTURE ACTIVITIES

Global Research Partnership Aquaculture Call

In 2014, BBSRC and partner funding agencies ESRC, Department for International Development (DfID) and Department of Biotechnology (DBT) India launched a call for proposals to support trilateral research into aquaculture between the UK, India and developing countries. The programme was intended to fund research aimed at developing aquaculture for food security, development and poverty reduction in developing countries. This call formed part of BBSRC's international Newton Fund activities. Proposals for the call were developed at a Sandpit in Kerala, India on 23-26 February 2015. A competitive process was used to identify sandpit attendees from the UK, India and low-income countries, and a total of over 40 academics attended.

During the sandpit, participants worked collaboratively to identify and define the scope of aquaculture challenges in developing countries and think about how they might be addressed. A number of outline proposals submitted at the Sandpit were invited back to submit full stage applications. This call closed on 31 March 2015.

BBSRC & NERC Knowledge Exchange Fellowship

In 2014, BBSRC, NERC and Sainsbury's funded a Sustainable Aquatic Food Supply Knowledge Exchange Fellowship to work in the aquatic food business sector. This fellowship was awarded to Dr Karen Alexander, Scottish Association for Marine Science (SAMS). The fellow is expected to work with BBSRC and NERC to ensure effective knowledge exchange with both research and related user communities in policy-making, society and business.

The three-year, 50% FTE, fellow will work towards a number of key deliverables including: mapping UK academic expertise; outlining current research activity focussing on Sainsbury's priority areas; investigating industry research challenges in the aquatic food supply chain and assisting BBSRC and NERC in the development of a Sustainable Aquaculture Industry initiative, and; develop 'Passports to Research' in a number of key priority areas that will provide industry and other organisations with an overview detailing what research has been done, what the gaps and opportunities are, and what needs to happen to deliver in a commercial context.

ANNEX 2: PROJECTS FUNDED BY STAGE 1 OF THE BBSRC/NERC SUSTAINABLE AQUACULTURE INITIATIVE

Reference	PI	Institution	Project
BB/M025837/1	Mowlem, Matthew Charles	National Oceanography Centre	Quantification and Viability of "Indicator" E. coli by Lab on a Chip Isothermal Nucleic Acid Amplification for Biosecurity in Sustainable Aquaculture
BB/M025861/1	Black, Kenneth D.	Scottish Association For Marine Science	Predicting benthic chemistry around marine fish farms
BB/M025934/1	Davidson, Keith	Scottish Association For Marine Science	Minimising the risk of harm to aquaculture and human health from advective harmful algal blooms through early warning
BB/M026019/1	Cramb, Gordon	University of St Andrews	Hypoxanthine metabolism in salmon: roles in osmoregulation and the innate immune response.
BB/M026132/1	Smith, Valerie Jane	University of St Andrews	The role of chromatin extracellular traps in host defence of fish against pathogens.
BB/M026140/1	Houston, Ross	University of Edinburgh	Investigation of Host Genetic Resistance to Oyster Herpes Virus using a High Density SNP Array
BB/M026183/1	Weidmann, Manfred	University of Stirling	The diagnostic window for detection of viruses infecting salmon in erythrocytes.
BB/M026221/1	Allen, Julian Icarus	Plymouth Marine Laboratory	Risks and Opportunities for Sustainable Aquaculture (ROSA)
BB/M026302/1	Secombes, Chris	University of Aberdeen	Development of a mucosal adjuvant for fish vaccination
BB/M026345/1	Dooley, Helen	University of Aberdeen	Development of a proteomic platform to facilitate the generation of new and improved vaccines for use in aquaculture.
BB/M026388/1	Feil, Edward James	University of Bath	WGS-aqua: Capacity building for the widespread adoption of whole genome sequencing (WGS) for the molecular epidemiology of aquaculture pathogens.
BB/M026426/1	Gage, Matthew James	University of East Anglia	Verifying the reproductive potential of triploid farm Atlantic salmon
BB/M026434/1	Sharkey, Kieran James	University of Liverpool	Use of contact structures for the control of infectious diseases in the British aquaculture industry
BB/M026469/1	Garcia de Leaniz, Carlos	Swansea University	Epigenetic management of stress and disease resistance in Atlantic salmon
BB/M026531/1	Shirazi-Beechey, Soraya	University of Liverpool	Assessments of fish gut microbiota during development, and in response to environmental and dietary change

Reference	PI	Institution	Project
BB/M026566/1	van West, Pieter	University of Aberdeen	The impact of climate change on infection of salmonid fish with Saprolegnia
BB/M026604/1	Martin, Samuel Allen	University of Aberdeen	Gut health and immune function: the emerging role of gut microbiota in sustainable aquaculture
BB/M026620/1	Austin, William Edward Newns	University of St Andrews	Toxic algae and sea-loch sediments: A novel investigation to understand the influence of climate change on harmful algal blooms and aquaculture
BB/M026671/1	Verspoor, Eric	University of the Highlands and Islands	Development of optimal molecular markers of domestication in Atlantic salmon for assessing introgression in wild populations
BB/M026698/1	Miller, Peter Ian	Plymouth Marine Laboratory	ShellEye: Satellite-based water quality bulletins for shellfish farms to support management decisions
BB/M026736/1	Turner, George Francis	Bangor University	Genomic approaches to identification and preservation of wild tilapia genetic resources for aquaculture

ANNEX 3: INDUSTRY WORKSHOP REPORT

Thursday 26th March 2015

Carlton Hotel, Edinburgh

Background and aims

BBSRC and NERC, two of the UK's leading public funding agencies for the biological and environmental sciences, are working in partnership to investigate the need for a new pre-competitive research and innovation initiative in sustainable aquaculture. At this industry-focussed workshop we explored how BBSRC and NERC might contribute to delivering new research and innovative approaches to solving industry's challenges.

Aims of the Workshop

- Develop plans for a multi-million pound investment in research and research translation for sustainable aquaculture.
- Engage industry in determining the scope of an industrially relevant pre-competitive funding programme and its strategic direction.
- Introduce options for the proposed programme delivery model and industry contribution.

Structure

The workshop agenda can be found in **Appendix 1.** The workshop was split into two parts; the morning session focussed on identifying research and research translation priorities for industry, while the purpose of the afternoon session was to explore the benefits and barriers to collaboration between industry and academia, and suitable delivery mechanisms for research council funding. The breakout sessions are described below. All presentations given can be downloaded here.

Breakout Session 1: Scoping industry challenges for a collaborative research and research translation programme

The aim of this session was for workshop delegates to identify and discuss the key research and research translation needs of the range of businesses operating in the aquaculture sector. In groups, delegates were given the opportunity to reflect on the short, medium and long term challenges facing the industry and consider how research council funding might address these. Delegates were asked to prioritise key challenges and provide a clear justification as to why they need to be tackled. This information will be used by BBSRC and NERC to scope an industry-academic collaborative programme in sustainable aquaculture.

Summary of session:

i. Introductions - 5 mins

   Each delegate to briefly introduce themselves.

ii. **Post-its** - 15 mins

Delegates put onto post-its the research and translation needs of their business. These should be sorted into short, medium and long term challenges on flipcharts.

iii. Discussion and Prioritisation - 20 mins

Groups to reduce the challenges to the top 5 group priorities.

iv. Justification of prioritised challenges - 25 mins

Delegates draft a justification for each of the prioritised challenges.

v. Plenary discussion - 30 mins

The Chair will open up a plenary session, giving groups the opportunity to present their priorities and discuss their justifications.

Breakout Session 2: Understanding barriers to collaboration and brainstorming possible funding mechanisms

The aim of this session was for workshop delegates to consider the preceding presentations and identify effective means in which industry and academia can work together to tackle pre-competitive research and research translation challenges in aquaculture. In the same groups as in breakout session 1, delegates were asked to consider the following three questions:

- What are the barriers to your business collaborating with academia?
- What are the benefits of your business collaborating with academia?
- Which funding mechanisms could enable your business to work with academia?

Summary of session:

i. Barriers and benefits - 20 mins

Groups brainstorm barriers to and benefits of industry-academic collaboration in the aquaculture sector.

ii. Funding Mechanisms - 20 mins

Groups to discuss the advantages and disadvantages of the funding mechanisms presented and come up with suggestions of funding mechanisms that could work for the aquaculture industry.

iii. Feedback - 20 mins

The Chair will open up the session and give all groups the opportunity to discuss barriers and benefits, and present their suggestions of effective funding mechanisms.

Attendees

The workshop was attended by sixty-four delegates from a range of businesses including breeders, producers, processors, diagnostics and vaccine developers and retailers across the finfish and shellfish sectors. The workshop was advertised to the industrial community by BBSRC and NERC via a community mailing list, by the Knowledge Transfer Network (KTN), Seafish and the Scottish Aquaculture Innovation Centre (SAIC). A small number of hand-picked academics were invited by BBSRC and NERC to represent the scientific research community. Co-funders of the sustainable aquaculture capacity-building research call[21] were also invited, including the Centre for Environment, Fisheries and Aquaculture Science (Cefas), Marine Scotland, Food Standards Agency and the Agri-food and Biosciences Institute (AFBI). The full list of delegates can be found in **Appendix 2**.

Key messages

BBSRC and NERC would like to thank delegates for their valuable contributions and active participation in the Sustainable Aquaculture Industry workshop.

The main research and research translation challenges for UK aquaculture can be grouped into these broad categories: health and disease, sea lice, fish welfare, breeding including genetics research, product quality, sustainable feedstocks, effects of a changing natural environment, spatial planning and water quality.

UK Aquaculture is a diverse sector with varying scales of production and types of issues. BBSRC and NERC should ensure that the scope of a future initiative is broad enough to encompass challenges across the sector and not restrict interested companies.

There is a strong need for a multidisciplinary approach in addressing sustainable aquaculture issues. The incorporation of social and economic sciences and technology transfer from other sectors was considered to be important in finding innovative solutions to the industry's challenges.

Industry and academia will both benefit from collaboration in the aquaculture sector. A collaborative programme will encourage the exchange of knowledge and facilities, and formation of a network will add value to both academic and industry investment.

UK Aquaculture is largely dominated by SMEs. Small and medium-sized companies are likely to have limited funds available to invest in collaborative research, highlighting the importance of recognising in-kind contributions. Further, many SMEs rely on income generated from intellectual property, and may be reluctant to invest in research where others will be able to exploit the outcomes.

A structure that enables individual collaborations between industry and academia, similar to BBSRC/NERC Horticulture and Potato Initiative (HAPI), would be most appropriate for a BBSRC/NERC aquaculture innovation funding mechanism.

[21] [Reference/webpage no longer available – Feb 2016]
http://www.bbsrc.ac.uk/funding/opportunities/2014/joint-nerc-fish-health-disease/

Outcomes

Industry challenges

On registering for the workshop, attendees were asked: 'In your opinion, what are three of the biggest challenges facing industry in relation to sustainable aquaculture?' There were 179 responses falling into 14 broad categories (**Chart 1**). The categories are listed in order of the number of times the challenge was mentioned on registration:

1. Health & disease
2. Sustainable feed
3. Sea lice
4. Policy
5. Environmental effects
6. Spatial planning
7. Other
8. Social
9. Breeding/ Genetics
10. Water quality
11. Product quality
12. Welfare
13. New facilities & technologies
14. Knowledge & technology transfer

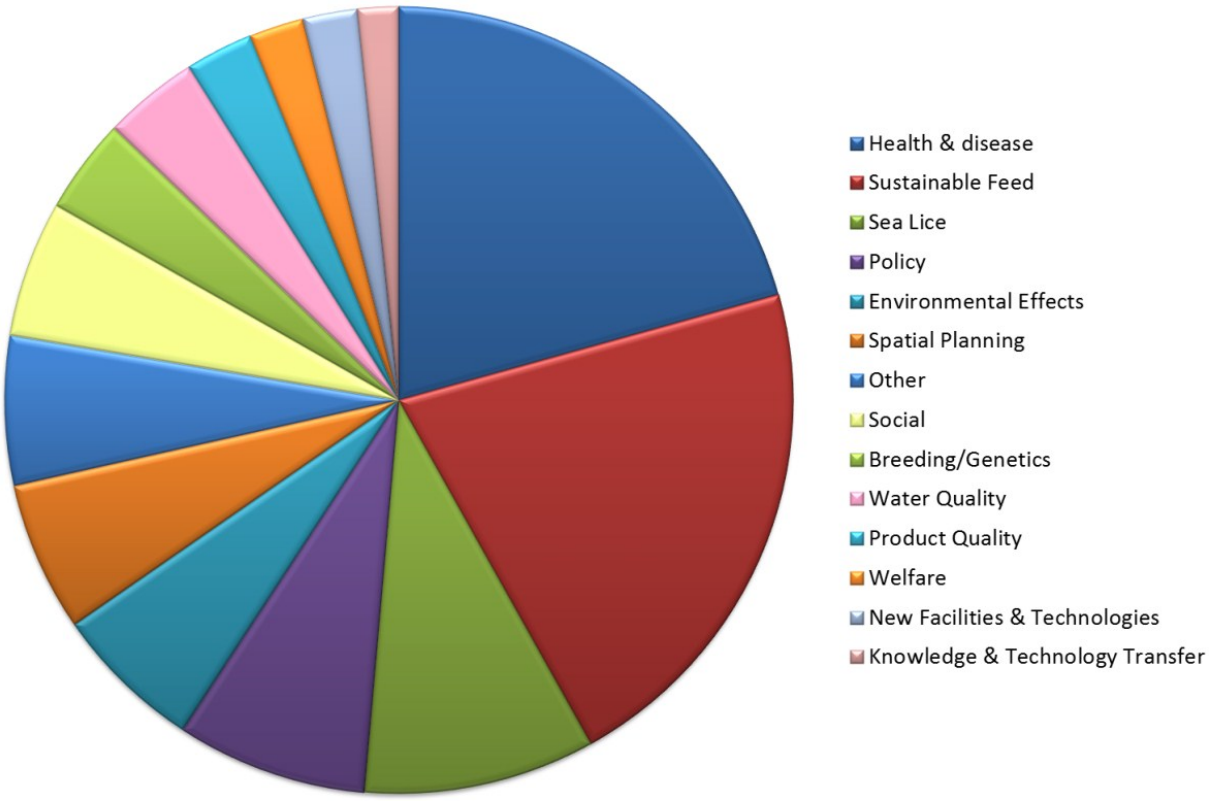

Chart 1: The biggest challenges faced by the aquaculture industry, determined by attendees of the workshop.

The registration survey responses were collated with the points raised during discussions in the first breakout session and plenary discussion. All challenges identified under the headings above can be found in **Appendix 3**. Below are some examples of specific issues that were highlighted as challenges in the short, medium and long term.

Short term	**Medium term**	**Long term**
Control and treatment of sea lice	Shellfish toxin monitoring	Health and welfare in exposed environments
Risk assessment for emerging diseases	Impact of feedstock on fish health	Multi-factor control of disease, especially where diseases continue to evolve
Development of multispecies shellfish hatcheries	Development of sterile lines for mainstream production of salmon (beyond triploidy)	Enhancing flesh quality
Sustainable feed development with focus on maintaining omega-3 content	Biocontainment/escapes/exotic species	GM feed ingredients
Predictive models for harmful algal blooms (HABs) and jellyfish swarms	Effects of climate change on disease, feed production and planktonic events	Tools to promote and give evidence to social licences for aquaculture
Establishing current carrying capacity of existing sites	Identification of new sites: co-location, off-shore production, ITMA, full-integrated systems	Improving public perception of aquaculture
Appropriate infrastructure and equipment for exposed locations	Technology transfer from terrestrial animals to aquatic species	
Need for cross-disciplinary research		

Funding mechanisms

Delegates gave a broad range of benefits and barriers of businesses collaborating with academia. The full results of the second breakout session and plenary discussion can be found in **Appendix 4**.

Some of the key **benefits** were the different skills and facilities academia can provide, in addition to the wider knowledge and expertise that businesses are exposed to when working with academics. Industry representatives put value on the fact that long term relationships can be built as a result of collaboration, leading to further projects and more informal interaction in the future.

The most common **barriers** to industry-academic collaboration were:

- Identifying the right people or departments to talk to within academia.
- Academia and business often have different ways of working; including use of language, timescales and measures of success.
- The grant application process is lengthy, difficult and burdensome for businesses.

- University technology transfer offices can be restrictive around IP and contract terms and conditions.

- Competition between companies restricts the amount of intellectual property businesses are prepared to offer, and project outputs that can be published.

- Many funding calls don't support pilot studies or distinguish between shellfish and finfish sectors.

- Many funding calls require industry to provide high levels of co-funding and don't necessarily take into account the value of in-kind support.

With regard to funding mechanisms that will enable businesses and academics to work together to tackle pre-competitive research and research translation challenges, delegates noted that:

- There are many SMEs in the aquaculture sector, as well as a few large businesses. SMEs are likely to have limited funds available to invest in external research, therefore recognition of in-kind contributions in a research and research translation initiative will be important.

- It is also a diverse sector with varying scales of production and types of issues. BBSRC and NERC should ensure that the scope of the initiative is broad enough to encompass challenges across the sector and not restrict interested companies.

- Knowledge exchange between other academic communities and industry sectors, including engineering, economic and social science in the UK and abroad is important. NERC and BBSRC should explore the possibility of incorporating these sciences and an international element into a future initiative.

- The initiative should engage early career researchers.

- The initiative should be informed by prioritisation exercises previously undertaken by organisations such as Marine Scotland and the Scottish Aquaculture Innovation Centre so as not to duplicate work.

Next steps

Over the coming months BBSRC and NERC will:

- Consider how the industry challenges identified can be best addressed by a pre-competitive research and innovation initiative in sustainable aquaculture.

- Consider research funded under the sustainable aquaculture capacity-building research call and broader UK academic capabilities.

- Consider delivery model options based on information provided by industry at this workshop.

- Undertake further consultations with industry, academia, policymakers and other funding agencies (such as Economic and Social Research Council and Innovate UK) as to how this initiative may fit with their strategic priorities.

- Seek interest from co-funders of the sustainable aquaculture capacity-building research call: Cefas, Marine Scotland, Food Standards Agency and AFBI in co-funding this initiative.

APPENDIX 1 Agenda

BBSRC and NERC Sustainable Aquaculture Industry Workshop 26 March 2015 - Carlton Hotel, 19 North Bridge, Edinburgh EH1 1SD	
09.30	Registration, tea and coffee
10.00	**Welcome (Chair)** Anton Edwards
10.10	**Introduction to BBSRC and NERC** Faith Smith and Jodie Clarke, BBSRC & NERC
10.20	**Overview of Sector:** **Industrial Perspective** Lee Cocker, *Domestic Aquaculture Manager, Seafish* John Webster, *Scottish Salmon Producers Organisation* **Academic Perspective** Professor Kenny Black, *PI in Marine Ecology, The Scottish Association for Marine Science (SAMS)* **Q&A**
11.10	Tea and coffee
11.20	**Breakout Session 1: Scoping industry challenges for a collaborative research and research translation programme**
12.55	Lunch
13.40	**Scottish Aquaculture Innovation Centre** Heather Jones, *CE of SAIC*
13.50	**Industry/Academia collaboration in Aquaculture** Louise Buttle, *EWOS*
14.05	**BBSRC/NERC Funding Models** Faith Smith, *BBSRC*
14.15	**Breakout Session 2: Understanding barriers to collaboration and brainstorming possible funding mechanisms**
15.00	Tea and coffee
15.15	**Chair's summary and next steps**
15.30	Meeting close

APPENDIX 2 List of Delegates

Name	Organisation	Position
Mr Alex Adrian	The Crown Estate	Aquaculture Operations Manager
Miss Beth Appleyard	Benchmark Animal Health	Project Manager
Ms Angela Ashby	Fish Vet Group	Veterinary Surgeon
Prof Janet Bainbridge	UKT Agri tech organisation	CEO
Mrs Nindy Bhari	Scottish Development International	Senior International Executive
Prof Kenneth Black	SAMS	Principal Investigator
Mr Alan Bourhill	Skretting UK	Marketing Manager
Mr Steve Bracken	Marine Harvest (Scotland) Ltd	Business Support Manager
Mr Stephen Bridges	CP Foods UK Ltd	Company Technical Services Manager
Mr Philip Brown	Aqualife Services Ltd	Technical director
Mr Craig Burton	Seafood Scotland / Sea Fish Industry Authority	Inshore Manager
Dr Louise Buttle	EWOS Innovation	Scientist
Mr Stephen Cameron	Scottish Shellfish Marketing Group	Managing Director
Mr Grant Campbell	Scot-Hatch Limited	Director
Stuart Cannon	Kames Fish Farming	
Mr John Carmichael	BioMar	Sales Support Manager
Miss Jodie Clarke	NERC	Knowledge and Innovation Manager
Lee Cocker	Seafish	
Dr Charis Cook	BBSRC	Innovation Manager
Chris Copping	Ocean Range	
Mr Chris Corden	Scottish Enterprise	Senior Executive
Dr Corinne Critchlow-Watton	Scottish Aquaculture Innovation Centre	Head of Skills and Knowledge Exchange
Mr Alastair Dingwall	Sainsbury's	Aquaculture and Fisheries Manager
Mr Anton Edwards		Rector
Prof Mike Elliott	IECS University of Hull	Director
Prof Carlos Garcia de Leaniz	Swansea University	Director of Fish & Fisheries Research
Dr Alastair Hamilton	Landcatch Natural Selection	Head of Molecular Biology
Mr Callum Harvey	The Knowledge Transfer Network	Knowledge Transfer Manager - Animal Agriculture
Mrs Dale Hill	Lyons Seafoods/Farne Salmon and Trout	Head of Aquaculture
Mr Tom Hind	Tesco	Agriculture Director

Dr Ross Houston	The Roslin Institute, University of Edinburgh	Senior Lecturer
Mr David Hutchens	W & J Knox Ltd	General Manager & Director
Mr Douglas Johnson	Akva Group Scotland Ltd	Director
Dr Huw Jones	The Knowledge Transfer Network	Head of Agriculture
Ms Heather Jones	Scottish Aquaculture Innovation Centre	CEO
Nick Joy	Loch Duart	
Dr Sophie Laurie	Natural Environment Research Council	Head of Innovation and Translation
Prof Lewis Le Vay	Bangor University	Director, Centre for Applied Marine Sciences
Dr Matt Longshaw	Benchmark Animal Health	Product Development Manager
Dr Hazel Macleod	Scottish Environment Protection Agency (SEPA)	Aquaculture Specialist
Mr Thomas Macrae	Akva Group Scotland Ltd	Business Development Manager
Prof Samuel Martin	University of Aberdeen	University Professor
Mr Michael Mason	NeemCo Limited	CEO
Prof Brendan McAndrew	University of Stirling	Professor of Aquaculture Genetics
Mr Ian Michie	Young's Seafood Ltd	Aquaculture Manager
Dr Peter Miller	Plymouth Marine Laboratory	Principal Earth Observation Scientist
Mr Christopher Mitchell	PHARMAQ Ltd	National Sales Manager
Mr Michael Montague	Scottish Environment Protection Agency (SEPA)	Specialist II
Sandy Murray	Marine Scotland Science	
Mr Andy Noble	BBSRC	Strategy and Policy - Agriculture & Food Security / Animal Health & Welfare
Mr Neil Robertson	Elanco Animal Health	European Manager
Professor Chris Secombes	Head, Scottish Fish Immunology Research Centre	Head, Scottish Fish Immunology Research Centre
Mr Richard Slaski	Scottish Aquaculture Research Forum (SARF)	Secretariat
Professor Patrick Smith	Tethys Aquaculture Limited	Manging Director
Mr Andrew Smith	British Trout Association	Executive Officer
Dr Faith Smith	BBSRC	Senior Business Interaction Manager
Dr Vladimir Stoiljkovic	Satellite Applications Catapult	Head of Agri-tech Programme
Mr Iain Sutherland	Highlands and Islands Enterprise	Senior Development Manager, Food and Drink
Mr Kelsey Thompson	Seasalter (Walney) Ltd	MD
Dr Kim Thompson	Moredun Research Institute	Principal Investigator

Dr Alan Tinch	Landcatch	Genetics Director
Dr John Tinsley	BioMar ltd.	Researcher
Miss Sheena Warnock	Scottish Sea Farms Limited	Environment Manager
Dr John Webster	Scottish Salmon Producers' Organisation	Technical Director
Dr Simon Wheeler	UK Trade & Investment	Agritech Specialist
Mr James Wilson	Deepdock Ltd / Bangor Mussel Producers Ltd	Director

APPENDIX 3

Research and research translation challenges faced by the UK aquaculture industry

Health & Disease	Methods for control and eradication of shellfish viruses and diseases e.g. Listeria, norovirus, PRV virus, oyster herpes virus Shellfish toxin monitoring Evaluation/ risk assessment and rapid detection methods for emerging diseases in relation to regulations – which do we need to investigate? E.g. Amoebic Gill Disease (AGD), white spot, Saprolegnia. Gill health: understanding epidemiology and immunology Understanding pathogen epidemiology, pathogen transmission to salmon, vaccine, reproduction Understanding dynamics of co-infections Better genomic information for farmed species and their parasites Multi-factor control of disease – especially where diseases continue to evolve Reduction in use of chemotherapy antibiotics and anti-parasiticides Impact of feedstock on health (e.g. gut microbiome) Vaccines: Adjuvant development for vaccines; new vaccine delivery methods to replace injection administration *In vitro* bath release testing for fish vaccines- EU is demanding replacement of *in vivo* testing. Use of synthetic biology in the control of endo/ecto parasites Non-genetic (epigenetic) mechanisms for stress resistance and disease
Sea lice	Eradication of sea lice: physical controls (wrasse, skirts), biological (cleaner fish, feed additives), genetics (breeding resistant fish) and vaccines. Prevention of sea lice settlement: understanding epidemiology better Practical 'at the farm' ability to detect/treat/manage sea lice
Welfare	Cleaner fish: health and welfare Monitoring welfare of farmed fish (including stress) Humane, stress-free slaughter process Welfare in exposed environments
Breeding/ Genetics	Developing (multi-species) hatcheries for shellfish to support the industry Assisting hatcheries with triploid production of pacific oysters Provide a sustainable supply of commercial mussel spat (via hatchery or other) Selective breeding of shellfish for e.g. increase in production (larger shellfish), lower levels of norovirus etc. Diversification and domestication in aquaculture – strains and species Development of sterile lines for mainstream production of salmon (beyond triploidy) Stock improvement Genetics to improve disease resistance: selection programmes
Product Quality	Flesh quality- understanding of processes leading to fillet problems is limited Improving production efficiency whilst maintaining quality
Sustainable Feed	Sustainable feed development with focus on maintaining omega-3 content (and omega-3 vs. omega-6) ratio Alternative protein sources (insects, algae, food waste, GM plants) Basic fish metabolism research to ensure better healthier diets for fish and people Negative retail consumer perception to use of novel fish feed ingredients Social responsibility and eliminating issues in the supply chain for fishmeal and fish oils
Environmental	Better predictive tools of the effects of aquaculture on the natural system and vice versa -

Effects	predictive tools to determine carrying and assimilative capacity Resilience to climate change and extreme events Understanding the impact of rising sea water temperature on diseases and algal growth Predictive models and warning systems for the formation and movement of harmful algal blooms and jellyfish swarms to allow control and mitigation Biocontainment/escapees/exotic species in aquaculture Re-use/recycling fish manure to reduce environmental impact and re-use nutrients lost Effects of waste (plastic, clinical, packaging) on the environment Wild cleaner fish impact assessment
Water Quality	Water quality: understanding the source of problems and developing strategies to deal with them
Spatial Planning	Economic, social and governance aspects of aquaculture amongst all users/uses: marine spatial planning. Maximise production with minimal disease spread risk (within and between farms) Identification of new sites, land-based, co-location, off-shore production, integrated multi-trophic aquaculture, full-integrated systems. Recirculation systems for peri-urban areas (rural-urban transition zone)
Social	Improving public perception of aquaculture Production costs vs. customer price expectations
Knowledge & Technology Transfer	Need for cross-disciplinary research Development of realistic integrated management structures that incorporate health, welfare, growth, environment, food safety Transfer of technology from research to business and between disciplines Technology transfer from land animals to salmon Sensors (sound, UV light) to farm management Communication between agri-tech strategy and aquaculture community Translation of diagnostic tools to practical application Tools to promote and give evidence to social licences for aquaculture
New Facilities & Technologies	Fish and shellfish farm modelling to aid site selection and environmental challenges Appropriate infrastructure and equipment for exposed locations e.g. mooring systems Containment of stocks and the use of different materials in net construction Physical protection from algal blooms Real time and remote monitoring Trial/experimental facilities, particularly for disease Systems support
Policy	Legislative burden and unpredictable regulations More efficient regulatory frameworks Need for underpinning science and data to address restrictive regulations e.g. norovirus load. Confidence in decision-making Need for English aquaculture strategy Understanding the issues that contribute to achieving social licence for aquaculture development Interactions with conservation legislation in coastal areas Addressing IUU fishing
Other	Developing UK knowhow in order to become a leading aquaculture training provider Why is shellfish production limited and what can we do to increase this?

APPENDIX 4

Understanding barriers to collaboration and suggesting possible funding mechanisms

Question	Answers
What are the **benefits** to your business collaborating with academia?	Willingness of academia and industry to network/joint collaborative approaches REF metrics mean that academics are required to think about the economic and social impact of their research, more than they have before – and this is beneficial to business. There is interest in a holistic integrative approach Academia provides a different skillset Academia can provide infrastructure Benefits of in-kind funding (facilities etc.) gives mutual motivation and ensure KE Industry gets access to wider academic knowledge and expertise through partnerships Long-term relationships can be built and contact can become more informal Pre-competitive projects can benefit whole supply chains Industry may learn of other funding opportunities through HEIs Instead of working with SMEs, look at working with industry/levy bodies that have technical understanding that may be lacking in SMEs Academics/students get real life commercial experience
What are the **barriers** to your business collaborating with academia	Lack of aquaculture engineers in academia It is difficult to identify the right person/department to talk to in academia Lack of access to academic publications Language – academics need to talk and present their work to industry in plain English. Academics and industry can have a different idea of success – academic papers vs. practical solutions. Some academics have a negative view of applied research. Agreeing working relationships – Universities technology transfer offices can be restrictive around IP and contract terms and conditions, including how to agree what is foreground and background IP Competition between companies Patents Agreements for what is publishable Risks in duplication of work Timing of funding calls – budgets and priorities of industry change. It takes a long time for a project to be funded. And it takes a lot of planning to take part in long-term projects. Paperwork associated with funding applications. Takes a lot of administration time. The application process itself is difficult. Universities administrative and overheads costs bring up the overall project budget which therefore increases the amount of match-funding industry has to find. Difficulty of finding match-funding – many companies don't have an R&D budget and can only provide in-kind resource There is no funding available to pilot scale-up studies Many funding calls don't distinguish between shellfish and finfish sectors Some funding calls can be too specific Academics often overlook retailers as partners Retailers may not see themselves as being a help/service for academics
Which funding mechanisms could enable your	Club mechanisms are effective but need to be more open and flexible for industry membership Flexibility is required in monetary requirements from industry, e.g. in-kind There are lots of SMEs in the aquaculture sector so a club mechanism is not appropriate

business to work with academia?	In-kind contributions should be recognised: staff time, data, facilities, platforms, supply chains The valuation of in-kind contributions needs to be clear to industry Leeway in terms of themes and priorities so as to not restrict interested companies This is a diverse sector with varying scales of production and different issues Appropriate outreach, so that companies are aware when there is a funding mechanism to engage them Is there an opportunity to bring in expertise from outside of the UK? KE between other academic sectors and industry, including engineering and social science Engagement of early career researchers Research Councils should use/complement SAIC and Marine Scotland priorities and coordinate with other funders/ use established networks Funding should be UK-wide supporting small industries as well as large