

Report from the Aquaculture Workshop: Multidisciplinary approaches to fish health and disease research

Date: March 18th-19th 2014

Venue: Hilton Metropole, Birmingham

Background and Aims

Aquaculture is a rapidly growing component of global food supplies. In 2012 Aquaculture was predicted to exceed capture fisheries as a global food source. An improved understanding of the basic biology and health of farmed fish and shellfish is needed to support the continued development of sustainable production. Aquaculture research was identified as a significant gap in the BBSRC portfolio with a current annual spend of £1M compared to £40M in animal health (compared to a farm gate value in the UK of £643M per annum for aquaculture and £2 billion for the cattle industry) . The Animal Disease Working Group identified the need to build basic research capacity in the area.

Multidisciplinary expertise from a diverse range of scientific areas may provide insight into some of the problems and provide a method of increasing capacity and capability in the UK research community. Therefore this workshop **aimed** to:

- Identify community engagement and buy-in
- Prioritise the research gaps in fish and shellfish health and disease, including environmental interactions to Inform future activities
- Promote collaboration between the BBSRC, NERC and other relevant research communities
- Provide a focus for discussion on novel technologies/technology development
- Facilitate new multidisciplinary research partnerships that could lead to collaborative bids for funding
- Encourage the development of a strong UK wide research community

Structure

The workshop covered two days with a networking drinks and dinner. The programme is provided in Annex 1. The first day focused on identifying research priorities while day two focused on research council funding and developing collaborations. Applicants to the workshop were asked to identify research and expertise gaps and this information was presented as part of the introductory talks on the first day. Presentations are available on the [website](#)

Attendees

BBSRC and NERC have been working together to develop initiatives in this area and NERC contributed £5K to this workshop. Both research communities were invited through email and advertisement through the BBSRC website and community mailing lists and although most attendees were from the BBSRC community a considerable proportion were from the NERC field. The Devolved Administrations and their MRPs were also invited and representatives from Scottish government, Marine Scotland, Defra and Cefas attended. The pharmaceutical, veterinary and production companies with interest in the aquaculture area were also invited and a reasonable number attended, particularly on the first day. The full list of attendees is provided in Annex 2

International Collaboration

In November 2013, DFID, RCUK and India's Department of Biotechnology signed a letter of intent which set out plans to develop a global research partnership to support collaborative, trilateral research between institutions and academics in the UK, India and low-income

countries (LICs). BBSRC and DBT are keen to scope out aquaculture as a potential area for collaboration between the UK, India and LICs within Food and Nutrition Security theme of the Global Research Partnership. As part of this process representatives from DBT and the Indian research community were invited to the workshop and gave presentations. This was followed by a successful round table discussion about working with India.

Outcomes

The workshop was very successful with almost a hundred attendees and sixty four institutions, businesses and organisations represented. We received a lot of positive feedback about the workshop particularly the networking and collaboration building components suggesting that the workshop achieved its first aims.

Multidisciplinarity:

There was a lot of interest in giving presentations with more requests than space in the timetable. Seventeen attendees, including three Indian academics, gave three minute presentations in the first session and covered the breadth of the scientific remit from zebrafish to automatic movement tracking in people through immunology, epidemiology, human vaccine adjuvants, the gut microbiome and mathematical modelling. There was a keen interest expressed by many speakers and delegates in developing multidisciplinary methods to address aquaculture issues.

Priorities

Attendees were asked to provide research and expertise gaps on the registration forms. This was collated and used to bring some extra expertise (mucosal immunology, the gut microbiome, novel vaccine/ adjuvant production) to the workshop and as the basis for the discussion. The full results are provided in Annex 3. Seven broad topics were identified with the top three:

1. Immunology and vaccines,
2. Tools and reagents
3. Role of nutrition on health/ immunity

During the workshop the attendees broke up into groups to discuss research needs and gaps. Each group recorded their discussion on wall charts and at the end of the discussion were asked to identify three priority areas. The discussion brought out several general points.

- Despite every group finding some priority areas more important than others it was widely felt that all topics had considerable overlap and holistic multidisciplinary approaches were required to address most remaining problems.
- The shellfish field was considered both very important for the future and currently under researched/resourced.
- The requirement for tools, resources and reagents came up in every discussion and topic, some examples were:
 - a. the lack of annotated reference genomes for relevant species,
 - b. fish immunology tool kits as most reagents for mammals do not cross react,
 - c. appropriate cell culture models as fish cells require very different culture conditions,
 - d. The lack of transgenic fish.

All of the priority topics identified (30 in total) were placed on lists for the attendees to vote on. There was considerable overlap in topics so the results (Annex 4) were collated into five priority areas. In priority order:

1. Environmental System Interactions (host-pathogen- (changing) environment)
2. Fundamental Host-Pathogen Interactions
3. Immunology and Immunological Tools (including vaccine delivery)

4. Nutrition and the Microbiome
5. Genetic resistance

The two other tools which made the priority list were annotated reference genomes and integrated omics analysis. This agreed with the new expertise requests where integrative proteomics and transcriptomics was the most requested technology. Genomics expertise was relatively well represented at the workshop (thirteen attendees) so the genetic resources and information rather than expertise would appear to be the gap.

Key messages

- There is good community buy-in to a basic science activity in fish health.
- Holistic and multidisciplinary approaches are required and there seems to be community understanding of the benefits
- There was clear overlap with NERC interests in the identified priorities with Host-pathogen interactions in the context of the environment the top priorities.
- Immunology to underpin vaccinology and resistance was a big gap: as for other species vaccines have already been generated using standard techniques if it was possible.
- Mucosal immunity, nutrition and the microbiome were of particular interest
- *In vitro* tools and reagents for fish work are a requirement for advancing the field.
- Shell fish research is a big gap

Executive Summary

Aquaculture is a rapidly growing component of global food supplies. In 2012 Aquaculture was predicted to exceed capture fisheries as a global food source. An improved understanding of the basic biology and health of farmed fish and shellfish is needed to support the continued development of *sustainable* production. Aquaculture research was identified as a significant gap in the BBSRC portfolio. This workshop **aimed** to:

- Identify community engagement and buy-in
- Prioritise the research gaps in fish and shellfish health and disease, including environmental interactions to inform future activities
- Promote collaboration between the BBSRC, NERC and other relevant research communities
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Outcomes

The workshop was very successful with almost a hundred attendees from the BBSRC and NERC communities and sixty four institutions, businesses and organisations represented.

Identified Priorities: five overarching research priority areas were identified:

- Environmental System Interactions (host-pathogen- (changing) environment)
- Fundamental Host-Pathogen Interactions
- Immunology and Immunological Tools (including vaccine delivery)
- Nutrition and the Microbiome
- Genetic resistance

Key messages

- There is good community buy-in to a basic science activity in fish health.
- Holistic and multidisciplinary approaches are required and there seems to be community understanding of the benefits
- The shellfish field was considered both very important for the future and currently under researched/resourced.
- The requirement for tools, resources and reagents came up in every discussion and topic
- There was clear overlap with NERC interests in the identified priorities with Host-pathogen interactions in the context of the environment the top priorities.
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- Mucosal immunity, nutrition and the microbiome were of particular interest
- *In vitro* tools and reagents for fish work are a requirement for advancing the field.

These outcomes, together with previous consultations will be taken forward with NERC to plan our future activities in this area.

AGENDA

Day 1 – 18th March 2014		
Research Gaps and Priorities – Chaired by Professor Randolph Richards		
Time	Programme	Speaker
10:00 – 11:00	Registration and Tea and Coffee	
11:00 – 11:05	Welcome and BBSRC Aquaculture Strategy	Dr Paul Burrows – BBSRC Director
11:05 – 11:20	Fish Health Research Gaps – Consultation	Dr Merewyn Loder – BBSRC Programme Manager
11:20 – 11:40	Aims of the Workshop	Chair Prof Randolph Richards – University of Stirling
11:40 – 12:00	Aquaculture Research in the UK : Placing basic science in context of current activities	Prof Patrick Smith – Tethys Aquaculture
12:00 – 13:00	Short presentations from selected attendees	
13:00 – 13:45	Lunch with Tea and Coffee	
13:45 – 16:30	Breakout groups Aims: Identifying and prioritizing research gaps including: <ul style="list-style-type: none"> • Ways to address the issues • Technology and expertise needs 	
16:30 – 17:00	Tea and Coffee	
17:00 – 17:45	Reports from Groups	
17:45 – 18:15	Group discussion of prioritisation	
18:15 – 19:30	Networking Drinks	
19:30	Dinner	

Day 2 – 19th March 2014		
Multidisciplinary Working		
Time	Programme	Speaker
09:00 – 09:45	Research Council funding –‘hints and tips’ and funding schemes including training and international	Dr Merewyn Loder
	What does a Committee look for in a proposal?	Dr Tracey Coffey – University of Nottingham and BBSRC Committee A
09:45 – 10:30	Scene setting talks – Multidisciplinary and Multinational Research Examples and Available Technologies	Dr Iain Young – University of Liverpool, Prof Peter van West – University of Aberdeen Dr Herve Migaud – University of Sterling
10:30 – 12:30	Breakout groups including Tea and Coffee Aims: Consideration of mechanisms to address priorities/gaps identified on day 1	
12:30 – 13:00	Reports from Groups	
13:00 – 14:00	Lunch	
14:00 – 16:00	Breakout groups including Tea and Coffee Aims: Opportunity for groups to network to consider specific research opportunities and proposals Concurrent BBSRC and other funders ‘Grants and Funding ’ surgery	
16:00	Close and Thanks	Dr Lesley Heppell – BBSRC Head of Animal Health and Welfare Sector

LIST OF DELEGATES

NAME	ORGANISATION	EXPERTISE
Alexandra (Sandra) Adams	University of Stirling	Fish vaccinology, fish diagnostics, host pathogen interactions
Karen Alexander	Scottish Association for Marine Science (SAMS)	NERC/BBSRC KE Fellow in Sustainable Aquaculture
Neil Auchterlonie	Cefas	Aquaculture; science management
Mick Bailey	University of Bristol	Mucosal immunology, evolution of immune systems.
Iain Barber	University of Leicester	Host-parasite-environment interactions in fish Effects of parasites on fish behaviour, ecology and evolution Reproductive development and behaviour in fish Stickleback parasitology, behaviour, ecology and evolution
David Bass	University of Oxford	1) Protist phylogeny and biodiversity; 2) Environmental DNA (and RNA) sequencing (eDNA) approaches for assessing and discovering protist diversity and function, and community structure; 3) Taxonomy and systematics of protists.
Steve Bishop	The Roslin Institute, University of Edinburgh	Genetics and health
Alan S. Bowman	University of Aberdeen	Ectoparasites, including sea lice, ticks, varroa mites and cat fleas
Adam Brooker	Institute of Aquaculture	Fish parasitology, parasitic crustacean, monogeneans
Philip Brown	Aqualife Services Ltd	Fish Vaccination, Fish Welfare, Practical fish Farming
Jo Cable	Cardiff University	Infectious diseases of fish and invasive species.
Yin Chen	University of Warwick	Microbiology, functional metagenomics, biogeochemical cycles, trimethylamine (TMA) and trimethylamine oxide (TMAO) metabolism

Edward Codling	University of Essex	Mathematical modeling, theoretical ecology, movement analysis, behavior analysis, fisheries
Darren Green	University of Nottingham	Molecular immunology, host:pathogen interaction, bovine immune response, bovine mastitis/tuberculosis, molecular typing, MLST development
Lauren Hall		
Sonia Consuegra	Swansea University	Fish genetics, Evolutionary Ecology
Jon Cooper	University of Glasgow	Sensors, diagnostics, fluid dynamics, rheology
Simon Davies	Plymouth University (Editor- in- Chief of International Aquafeed)	Aquaculture Health and Nutrition/feed formulation of aquafeeds
Simeon Deguara	AquaBioTech Group	Biosecurity, animal welfare, land-based and offshore aquaculture, recirculating aquaculture systems.
Andrew Desbois	University of Stirling	Microbiology; antimicrobial agents; alternative infection models; host-pathogen interactions
Marc S Dionne	King's College London	Bacterial disease models, especially <i>Mycobacterium marinum</i>
Elisabeth Dyrinda	Heriot Watt University	Shellfish immunology, in particular adult and juvenile bivalves. Immunotoxicology of marine shellfish
David Eckersall	University of Glasgow	Proteomics, biomarker discovery & validation, serum protein in diagnosis, acute phase protein
Sharon Egan	The University of Nottingham	Genomic analysis of host/pathogen interactions, vaccine development
Christophe Eizaguirre	Queen Mary, University of London	Immunogenetics, host-parasite interactions, conservation biology
Lauren Ferrari	Marine Scotland Aquaculture Scottish Government	Policy and legislation development and delivery. Salmonid aquaculture, shellfish aquaculture, non-native species. notifiable and emerging diseases – in particular Oyster Herpes Virus. Sea lice and the biological control of sea lice.
Clive Fox	Scottish Association for Marine Science	Jellyfish impacts on caged finfish culture
Naomi Fox	SRUC	Disease ecology and epidemiological modelling

		ecological and evolutionary significance.
Shelagh Malham	Bangor University	Environmental effects on Shellfish. Shellfish immunology. Sustainable shellfish and climate change. Shellfish and human pathogens. Food Security and Water quality are key drivers of my work
John Marshall	Fish Vet Group Ltd	Medicine and Vaccine Development, Sales and Marketing
Samuel A M Martin	University of Aberdeen	Fish health and nutrition in aquaculture. Interactions between health and physiological performance. Genomics / transcriptomics
Brendan McAndrew	University of Stirling	Genetics and Genomics of farmed aquatic organisms
Imelda McGonnell	Royal Veterinary College	Zebrafish as a model of disease.
Herve Migaud	University of Stirling	
Kenton Lloyd Morgan	University of Liverpool	Aquatic Epidemiology; Chair of International Society of Aquatic Animal Epidemiology ISAAE 2006-12; Chaired review of Scottish Sea Lice Research
Julia Mullins	Skretting ARC (Aquaculture Research Centre)	Use of diet to mitigate the impacts of various pathogens upon fish health. For example in Amoebic gill disease, sea lice infestation, HSMI etc. The effects of hydrogen peroxide on fish skin and gills. Sea lice medicines. I have worked as an aquaculture veterinarian on both coasts of Canada.
Arjan Narbad	IFR (Institute of Food Research)	Gut microbiology
Arun Ninawe	DBT, Delhi	Aquaculture & Marine Biotechnology
Beth Okamura	Natural History Museum	1) Parasite life cycles, invertebrate hosts, ecology and risk of salmonid disease (proliferative kidney disease), implications for wild and farmed fish health. 2) eDNA approaches for assessing microbial endoparasites and disease risk, especially in shellfish (molluscs and crustaceans).
Giuseppe Paladini	University of Stirling	Aquatic Parasitology

Richard Paley	Centre for Environment Fisheries and Aquaculture Science (Cefas)	Fish and Shellfish Health and Disease: Virology; molecular biology; cell culture; in vitro culture of pathogens and bio-assays; in vivo disease challenge development; diagnostics; oomycete, mesomycetozoon and amoebae culture.
Devika Pillai	Kerala University of Fisheries and Ocean Studies, Kochi	Fish health (Molecular diagnosis and Stress management in aquaculture)
K V Rajendran	Central Institute of Fisheries Education, Mumbai	Crustacean Viral Diseases and Molecular Diagnostics. Crustacean immune genes and understanding shrimp innate immune response by RNA interference. Myxozoan parasites of fish. Toll-like receptors in aquatic animals
Mark Rawling	University of Plymouth	Fish Nutrition, Immunology, Hematology, Transcriptomics
Rob Raynard	Marine Scotland Science	Fish and shellfish disease diagnostics, epidemiology, notifiable and emerging diseases. Sea lice and amoebic gill disease. Salmonid aquaculture.
Randolph Richards	University of Stirling	Fish disease diagnosis, prevention and epidemiology
Ana Rodiles Guerrero	University of Plymouth	Genetics: DGGE, Next Generation Sequencing in 16s rRNA. Stress and digestive physiology in fish.
Jeanette Rotchell	University of Hull	Aquatic Toxicology
Pramoda Kumar Sahoo	Central Institute of Freshwater Aquaculture	Nineteen years of research experience in fish disease diagnosis and health management through application of immunological, pathological and molecular tools
Swati Saxena	RCUK India	Deputy Director RCUK India
Kieran Sharkey	University of Liverpool	Mathematical Modelling
Holly Sheils	University of Manchester	Fish cardiology and swimming kinematics and respirometry
Nathalie Simard	FishVet Group	Vaccines (primarily biotechnology derived)
Richard John Slaski	Scottish Aquaculture Research Forum	Commissioning aquaculture research

Annex 2

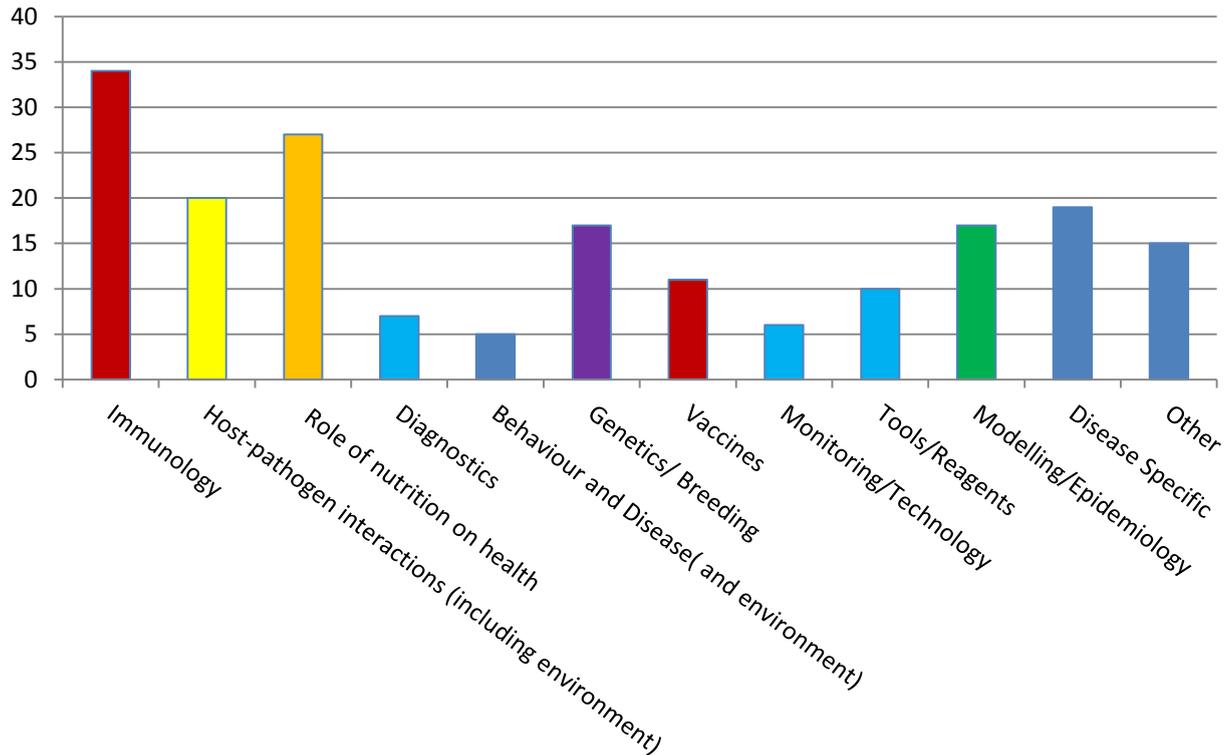
Valerie J Smith	University of St Andrews	Shellfish immunology and pathology. Fish immunology and related areas pertinent to disease control in aquaculture.
Patrick Smith	Tethys Aquaculture Ltd	Fish health/Fish pathology in general, fish vaccines/fish immunology in particular
Adam Stevens	University of Manchester	Genomics of growth and metabolism, gene: environment interaction, Developmental systems biology.
David Stone	Cefas	Molecular virology / molecular biology
Kim Thompson	University of Stirling	fish immunology; diagnostics; vaccine development;
John Tinsley	BioMar Ltd	Fish nutrition, raw materials, functional feed, immunology
Tardi Tjahjadi	University of Warwick	Image processing, pattern recognition and real-time computer vision.
Charles R. Tyler	University of Exeter	Fish - Physiology, Reproduction and Ecotoxicology
Pieter van West	University of Aberdeen	Oomycete plant and animal diseases (eukaryotic microbiology)
David Verner-Jeffreys	Cefas	I am an aquaculture health expert with particular expertise in bacterial diseases of fish and shellfish. I am also involved in the development and testing of therapeutants for the control of diseases of aquatic animals.
Robin Wardle	MSD Animal Health- Global Aquaculture Business	Aquaculture pharmaceuticals
John Webster	Scottish Salmon Producers' Organisation	
Manfred Weidmann	Institute of Aquaculture	Virology, Molecular Diagnostics
Phillip Whitfield	University of the Highlands and the Islands	Proteomic and lipidomic analysis of fish and fish feed.
John Whittall	Sustainable Agriculture and Food Technology Strategy Board	
Kezia Williamson	Biosciences KTN	Funding and industry needs in the UK and beyond
Iain Young	University of Liverpool	Aquaculture, Fish biology, Fish physiology, Proteomic approaches to fish biology, Added value production, sustainable
Ruth N. Zadoks	University of Glasgow	Molecular epidemiology, infectious diseases

Analysis of the Fish Health and Disease gaps from Workshop EOI forms

Responses:

- 90 responses with research and expertise gaps provided
- 70 from a purely academic perspective. 20 with policy or industry links
- 62 Institutions and Organisations

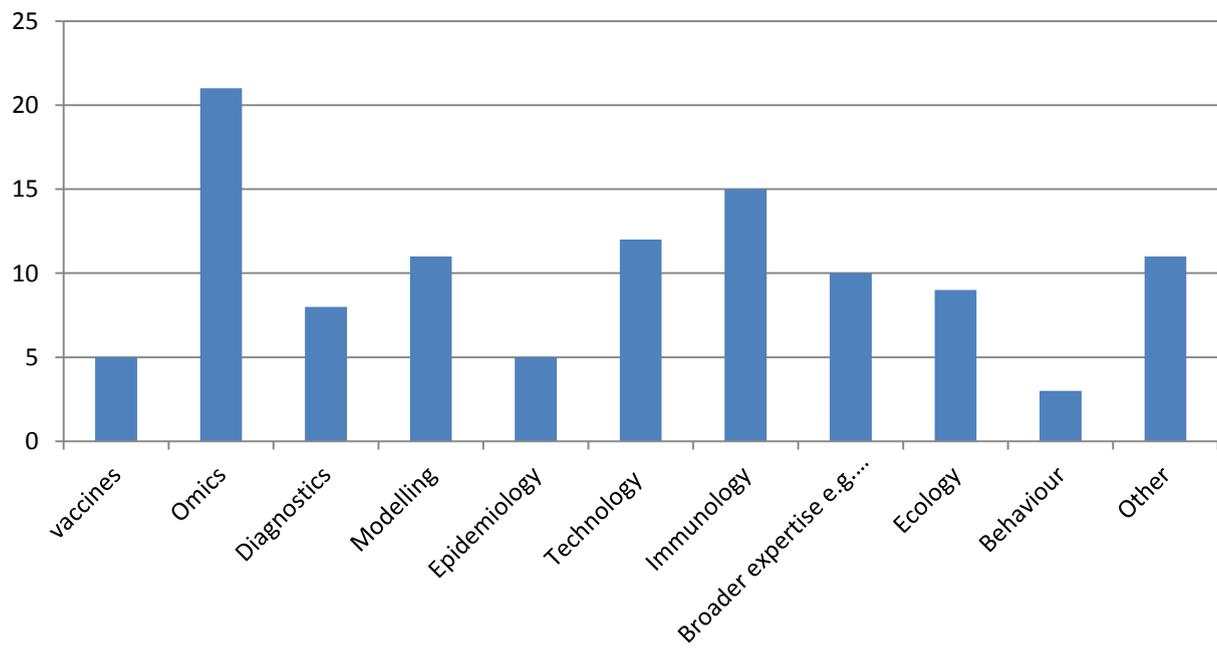
Gaps by overarching area



Specific textual analysis using Wordstat Software

- Only enough data for basic linkage analysis .
- As expected the top diseases are amoebic gill disease and sea lice in salmon and Viruses for shellfish
- Proximity analysis of the most common words suggest that the most obvious gaps are:
- Immunology – the immune response and the gut
- Shell Fish- resistance and active improvement in all areas
- Resistance – Genetics and vaccines
- Vaccines- Mucosal Immune response and effective delivery
- Pathogens: Environmental interaction of the host and pathogen and genetic resistance/ immunity

Expertise/ New areas requests



Annex 4

TOPIC	ISSUE	Votes	TOPIC votes
Environmental Systems Interactions	Host-pathogen-environment interactions (e.g. climate change)	20	98
	Interactions between host-pathogen/parasite and a changing environment	16	
	Disease spread in a changing environment	21	
	Environment & behaviour (monitoring, tools, tech dev, modelling)	16	
	Parasites as ecosystem components	4	
	Emerging diseases and predictive tools	21	
Fundamental Host Pathogen Interactions	Fundamental understanding of host-parasite/pathogen interactions	17	89
	Fundamental understanding of disease mechanisms and host response	16	
	Understanding host pathogen interactions and pathogen biology	14	
	Host-pathogen (omics, genetics, modelling, epidemiology)	11	
	Integrating immunology and host-pathogen interactions (holistic approach)	12	
	Proactive management and mechanistic understanding of main disease affecting aquaculture species	10	
	Fundamental biological and host response	9	
Immunology and Vaccines	Immunological tool box	16	81
	How does the protective response develop? High impact, medium feasibility. Genetic variation in response to disease.	16	
	Tools to modulate immune response for fish and shellfish to enhance disease resistance	12	
	Improved understanding of invertebrate immunity (e.g. shellfish)	10	
	Immunology (behaviour, host responses, immune system mechanisms)	9	
	Mucosal immunity vs active immunity blind spots	9	
	Need for vaccine development (delivery systems and adjuvants)	9	
Nutrition and the microbiome	The interactive role of nutrition and microbiome in health and disease	17	50
	How do new (vegetarian) diets affect health as well as productivity? Microbiome.	13	
	Feed development (alternative protein and lipid sources)	10	

Annex 4

	Health and sustainability of feed and food provision	8	
	Plant materials and enteritis	2	
Genetic Resistance	Genomically informed breeding selection for disease resistance	13	20
	Breeding for health & disease resistance	7	
Tools	Omics (integrated holistic analysis with modelling to leverage cluster/networks)	15	30
	Annotated reference genome (host species and pathogens, high impact, high feasibility)	15	
	Key to enable adoption of diagnostics (credibility, communication and training to support use)	5	5