AQUAEXCEL

Aquaculture Infrastructures for Excellence in European Fish Research

Project number: 262336

Combination of CP & CSA
Seventh Framework Programme
Capacities

Deliverable D2.5

Inventory of research infrastructure gaps

Due date of deliverable: M42

Actual submission date: M48

Start date of the project: March 1st, 2011 **Duration**: 48 months

Organisation name of lead contractor: NTNU

Revision: V2

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)	
Dissemination Level	
PU Public	**X**
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

AQUAEXCEL: Aquaculture Infrastructures for Excellence in European Fish Research

RI: Research Infrastructure, i.e. a site-specific cluster of research groups and tools that provide services for basic or applied research

EATIP: the European Aquaculture Technology and Innovation Platform

SRIA: a Strategic Research and Innovation Agenda

TA: Thematic Area. The EATIP SRIA consists of 8 TA's.

TA matrix: Thematic Areas matrix is a spreadsheet built upon the EATIP SRIA. There is a TA matrix for each TA showing the research goals and subgoals against the fields of expertise and RI properties. The latter are identical to those listed on the AQUAEXCEL online RI map.

RI matrix: Research Infrastructures (RI) matrix shows the 107 RIs from the AQUAEXCEL online RI map (see www.aquaexcel.eu/rimap) against the field of expertise and RI properties. Each RI has been given a unique identity number for easy tracking.

Summary

Objectives: D2.5 identifies the main Research Infrastructure gaps in Europe, based on the European aquaculture research needs and the inventory of available Research Infrastructures.

Rationale:
AQUAEXCEL aims to integrate key aquaculture research infrastructures across Europe, in order to promote their coordinated use and development. The objective of WP2 is to evaluate the appropriateness of the pool of existing research infrastructures in Europe compared with the needs for research and development expressed by the European aquaculture industry and research community. A consolidated list of needs and suggested actions was created through multi-stakeholder workshops and consultations under the coordination of the European Aquaculture Technology and Innovation Platform, and by strong involvement of AQUAEXCEL. At the same time, the AQUAEXCEL online RI map was launched, providing the aquaculture society with a new tool to provide and retrieve information about existing facilities and fields of expertise.

In order to avoid infrastructure duplication in the planning of new tools and services for future aquaculture development in Europe, a gap analysis was carried out. This in-depth study was based on the conclusions found in the EATIP SRIA and on the currently available expertise and properties in existing RIs in Europe. Conclusions show that European RIs cover a large part of the expertise that is needed to comply with the main challenges in the aquaculture sector. However, several specific goals that were set by the EATIP in its strategic agenda were found not to be sufficiently covered by current RIs in Europe and rely on expertise and/or facilities from 3rd countries or on the development of new research teams and infrastructure.

Teams involved: NTNU (P10) carried out the gap analysis. IFREMER (P7) updated the online RI map with missing RIs that were identified during the analysis. All partners provided input to the TA matrix based on their own expertise.

Geographical areas covered: All European Union Member States and Associated Countries. The study identified also relevant RIs in non-European countries, but these were not described in detail.

Introduction

AQUAEXCEL aims to integrate key aquaculture research infrastructures across Europe, in order to promote their coordinated use and development. Through collaboration between 17 partners and 23 facilities, AQUAEXCEL offers top class research infrastructures for both basic and applied research, giving aquaculture research groups the opportunity to utilise AQUAEXCEL's facilities.

WP2 looks at Infrastructure mapping, strategic planning and sustainability. Through this WP, AQUAEXCEL aims at addressing the present lack of interface between research needs and infrastructure opportunities, while promoting synergies across scientific fields, systems and species. It will also identify the need for specific infrastructures and services to cope with future trends, and enhance the awareness of problem owners about the available tools.

Task 2.2 will result in an inventory of the main Aquaculture research needs (based on available SRIA's), the types of Research Infrastructures identified as appropriate tools to address the respective needs and an identification of Research Infrastructure gaps, including recommended actions.

After having collected information on existing RIs throughout Europe using the online RI-map (D2.2) and having identified the research needs (D2.3), this deliverable is the final step in the analysis of gaps.

Methodology

The gap analysis was done in a series of steps, as shown in
Figure 1. At the beginning two foundational matrices were created. The Thematic Area (TA) matrix is a spreadsheet built upon the EATIP SRIA (Goals and subgoals are listed in the Annex). It has the research goals categorized by thematic area, goals and subgoals in the X-axis. The Y-axis lists the different fields of expertise and RI properties, which are identical to those listed on the AQUAEXCEL online RI map. The TA matrix is shown in Table 1.

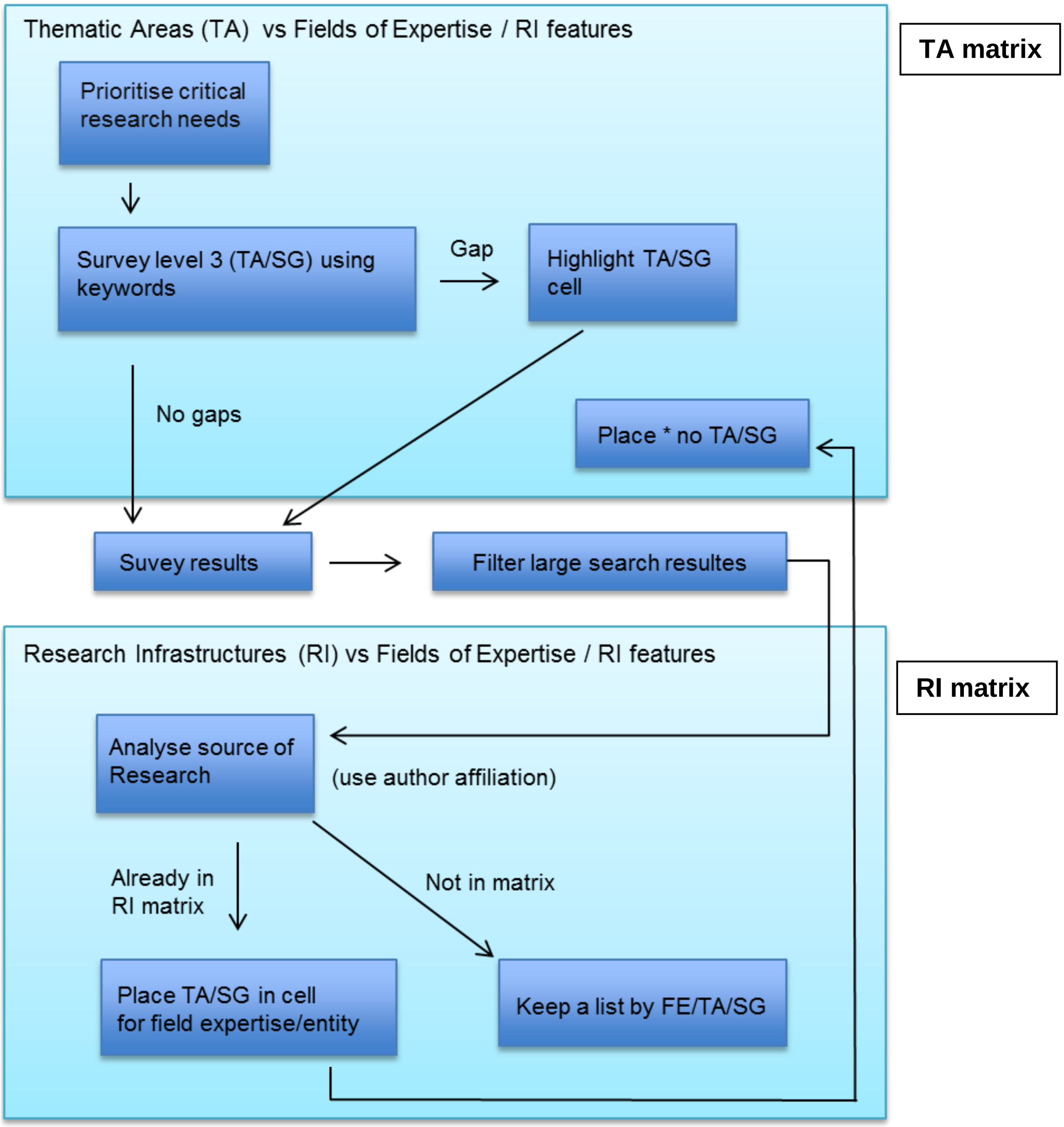

Figure 1: Flow chart of the gap analysis methodology.

Table 1. Outline of the TA matrix (only a small part is shown)[1].

TA Matrix																				
FIELDS OF EXPERTISE		TA 4. Sustainable Feed Production																		
1. The need for research is not critical		Goal 1						Goal 2			Goal 3				Goal 4			Goal 5		
2. There is a potential need for research, but not critical		Subgoal						Subgoal			Subgoal				Subgoal			Subgoal		
3. The need for research is critical		1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	5.1	5.2	5.3
Genetics	Quantitative														3	1	2	2	2	
	Molecular														3	1	2	2	2	
Nutrition	Feeding and digestion	1	3	1	3	3	2	3	1	2	2								3	3
	Defecation and excretion	1	3*	1	3	3*	2	1	1									3		3*
	New feed resources		3	2				3	2		1							2		
	Product quality		3	1	3	3	1	3			1									
Physiology	Reproduction	1	3	1	3	3*	2				1							2		
	Growth and development	1	3	1	3	3*	2	3	2	2	2			3					2	
	Metabolism	1	3	1	3	3	2		2		2	2		2				3	2	
	Endocrinology	1	3	1					2			2		2				3	2	
	Other physiologcal aspects of domestication																			
Welfare	Behaviour					3*								1						
	Handling												2	2						
	Stress					3						2	2	1						
Health and pathology	Bacteriology											2	2							
	Virology											2	2							
	Parasitology											2								
	Microbial ecology																			
	Other issues																			
Aquaculture system engineering	Flow through systems																			
	Recycling systems																			
	Cage systems																			
	Long-line systems																			
	Pond systems																			
	Control systems																			
	Mathematical modelling																			
Environmental interactions and impacts	Eutrophication					1													1	
	Wildlife interactions					1														
	Inorganic components																			
	Benthic and pelagic impacts					1														
	Biofouling					1														
Processing	Transport																			
	Harvesting and slaughtering							2												
	Thermic processes (freezing, cooling, heating)							2												
	Other processes (smoking, salting)																			
	Packaging																			
	Traceability																			
	Waste management																			
Main species	Marine species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Fresh water species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Diadrome fish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Shellfish																			
	Planktonic organisms																			
	Ornamental fish																			
	Macroalgae																			
Fish lines																				
Type of site	Land based					x														
	Sea based					x														
	Off-score cages					x														
	Ponds					x														
	Resirculation					x														
Type of water	Sea water																			
	Fresh water																			
	Brachish water																			
Instrumentation	Monitoring						x													
	Robots																			
	Cameras																			
	Control systems						x													
	Communication system																			

[1] 3 = critical areas of expertise; pink = expertise largely covered by current RIs; yellow with * = limited coverage by European RIs; yellow without * = area with no expertise from RIs included in the AQUAEXCEL online RI map; x = relevant RI properties

To point out where there might be need for further research and possible knowledge gaps in the different Thematic areas the respective chair persons and/or facilitators in EATiP were contacted. Because of limited response from the EATIP chair persons, experts working directly in the relevant fields (each Thematic area) were consulted. The degree of criticality in each field of expertise and for each subgoal was determined in dialogue with these experts.

For each cell in the matrix where expertise was required to reach a specific goal and subgoal, the experts ranged the importance from 1 to 3, with:

- 1. The expertise is relevant, but not considered essential
- 2. There is a potential need for research, but it is not critical
- 3. The need for research is considered as critical

When cells under subgoals were left empty, this indicated that the expertise was not relevant for the gap analysis of that specific subgoal.

The following experts worked through the subgoals in each Thematic area; senior scientist Ulf Erikson, SINTEF Fisheries and Aquaculture (TA 1, Product quality, Consumer Safety & Health), senior scientist Gunnar Senneset, SINTEF Fisheries and Aquaculture (TA 2, Technology & Systems), Professor Elin Kjørsvik, Dept.of Biology, NTNU (TA 3, Managing the Biological Lifecycle and TA 7, Aquatic Animal Health and Welfare) and Professor Yngvar Olsen, Dept. of Biology, NTNU (TA 4, Integration with the Environment). During the WP2 workshop at the final AQUAEXCEL annual meeting, the preliminary results of the gap analysis were presented and discussed. Feedback from the partners was collected and incorporated into the final deliverable.

The Research Infrastructures (RI) matrix (Table 2) shows the 107 RIs from the AQUAEXCEL online RI map (see www.aquaexcel.eu/rimap) as of September 10th 2014. Each RI has been given a unique identity number which is identical to the one in the TA matrix. Three colors were used to indicate the areas of expertise that were selected by the RIs when filling out the AQUAEXCEL RI online map:

- Green: main field of expertise
- Yellow: second field of expertise
- Red: third field of expertise

The properties of the research facilities at the RIs were indicated with an “x”.

Table 2. Outline of the RI matrix (only a small part is shown).

Main field		Name of Research Infrastructure (RI)										
Second field		50	58	59	63	64	65	66	67	68	69	70
Third Field		NTNU-Sealab	IATS	ACE/SEALAB SSO	RIFCH	IPFA	DLO-IMARES	ARC	INRAP	WWSSU	MBS	FITU
Genetics	Quantitative											
	Molecular											
Nutrition	Feeding and digestion											
	Defecation and excretion											
	New feed resources											
	Product quality											
Physiology	Reproduction											
	Growth and development											
	Metabolism											
	Endocrinology											
	Other physiologcal aspects of domestication											
Welfare	Behaviour											
	Handling											
	Stress											
Health and pathology	Bacteriology											
	Virology											
	Parasitology											
	Microbial ecology											
	Other issues											
Aquaculture system engineering	Flow through systems											
	Recycling systems											
	Cage systems											
	Long-line systems											
	Pond systems											
	Control systems											
	Mathematical modelling											
Environmental interactions and impacts	Eutrophication											
	Wildlife interactions											
	Inorganic components											
	Benthic and pelagic impacts											
	Biofouling											
Processing	Transport											
	Slaughtering											
	Thermic processes (freezing, cooling, heating)											
	Other processes (smoking, salting)											
	Packaging											
	Traceability											
	Waste management											
Main species	Marine species	x	x	x		x	x	x		x	x	x
	Fresh water species				x		x		x			
	Diadrome fish	x										
	Shellfish		x				x			x		x
	Planktonic organisms	x	x				x					
	Ornamental fish									x	x	
	Macroalgae			x								
Fish lines	Genetic		x		x				x			
Type of site	Land based	x	x		x		x		x	x	x	x
	Sea based			x								
	Cages			x								
	Ponds				x							
	Resirculation	x	x		x		x		x		x	x
Type of water	Sea water	x	x	x			x			x	x	x
	Fresh water	x	x		x		x		x			
	Brachish water						x					
Instrumentation	Monitoring	x	x	x	x		x		x	x	x	x
	Robots	x			x					x	x	x
	Cameras	x		x	x		x		x			
	Control systems	x	x	x	x		x		x	x	x	x
	Communication system	x	x	x					x	x	x	x

The first step of the gap analysis itself was a preliminary literature search. With the prioritization put forth by experts, the critical subgoals (3-scores) were translated into a search string of approximately six terms, which were entered in the search engine of Google

Scholar. The number of relevant publications since 2010 was noted and used to determine whether a research gap exists. The searches that found less than 25 results were highlighted as potential gap areas. Only these gap areas (indicated as yellow cells) were pursued further.

The next step was to determine those institutions that were affiliated with the articles that appeared in each search query. This information was used to verify the RI matrix and to link institutions with particular research subgoals in the TA matrix. Also, this served to identify potential partners which were not yet registered in the AQUAEXCEL online RI map, but which were putting forth important studies in critical areas.

For the finalization of the gap analysis, the information from the following three important documents was combined:

1. The completed TA matrix, indicating the critical subgoals and expertise areas, and showing the extent to which RIs in the AQUAEXCEL online RI map are covering these topics. In a glance, the reader can obtain an idea of the importance of certain TAs, goals, subgoals and expertise areas. The matrix also provides information on where research is lacking, in particular from the European RIs being part of the AQUAEXCEL online map. In the TA matrix, the following distinction model was used:

    a. The critical areas of expertise (marked with a 3) were highlighted (yellow or pink) in case of a potential gap area was revealed.
    b. A yellow area represents a gap and a pink area represents an expertise field largely covered.
    c. A yellow field with an asterix (*) denotes limited coverage by European RIs from the AQUAEXCEL RI online map.
    d. A yellow field without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map.

2. The completed RI matrix, not only listing the RIs with their expertise and properties, but also linking specific RIs to particular gap areas.

3. The document resulting from the gap analysis: a list of RIs which were not included in the AQUAEXCEL RI online map, but appeared in gap area search results. This list can be sorted according to geography (EU and non-EU countries), Country and Gap Area Expertise (all institutions from Eu and non-EU countries are listed in the Annex). Subgoal and expertise identifiers were added to the list each time a particular RI appeared in the results, giving a clear view of how often an institution had relevant publications and which areas they were relevant to. This will enable AQUAEXCEL to pursue the efforts on completing the European aquaculture RI online map.

Results: identification of gaps per Thematic Area

The EATIP SRIA has categorized the aquaculture research needs in 8 different TAs:

- TA 1. Product quality, Consumer Safety & Health
- TA 2. Technology & Systems
- TA 3. Managing the Biological Lifecycle
- TA 4. Sustainable Feed Production
- TA 5. Integration with the Environment
- TA 6. Knowledge Management
- TA 7. Aquatic Animal Health and Welfare
- TA 8. Socio-economics & Management

The results in D2.5 are classified according to the same structure as the EATIP SRIA, but only those TAs are taken into account which require the use of research infrastructures, its services or biological resources. As a consequence, TA6 and TA8 are not considered in the AQUAEXCEL RI gap analysis.

In the following section, each TA is discussed with regards to the critical areas, the gaps, and whether there are member RI's contributing to the research in identified gap areas. Each section therefore discusses the aim of the subgoal, its relevant subfields of expertise and the institutions publishing in that knowledge area. In addition, the results are visualized in a figure that shows the applicable portion of the TA matrix. The results are also summarized in an overview table at the beginning of each section, to demonstrate to the reader the gaps and coverage as compared to the number of critical areas.

TA 1. Product quality, Consumer Safety & Health

This thematic area has four goals and 16 subgoals, seeTable 3. Critical areas were especially found in goals 1 and 3. However, none represented gap areas. The critical fields of expertise required to fulfill the goals are Nutrition and Physiology. RIs covering most type of species and sites are needed to deal with the given challenges in TA1.

Table 3. TA matrix, TA1[2]

TA Matrix																	
FIELDS OF EXPERTISE		TA 1. Product quality, consumer safety and health															
1. The need for research is not critical		Goal 1				Goal 2				Goal 3					Goal 4		
2. There is a potential need for research, but not critical		Subgoal				Subgoal				Subgoal					Subgoal		
3. The need for research is critical		1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3
Genetics	Quantitative																
	Molecular																
Nutrition	Feeding and digestion	3	2	2	2				2	2							
	Defecation and excretion			2													
	New feed resources		1	2						2							
	Product quality	3	3		2	2	2			3		3			2		
Physiology	Reproduction	1			3						2						
	Growth and development	3				2			2	2	2			3			
	Metabolism	1												2			
	Endocrinology																
	Other physiologcal aspects of domestication																
Welfare	Behaviour													1			
	Handling													2	2		
	Stress										2			1	2		
Health and pathology	Bacteriology					1	2				2						
	Virology					1	2				2						
	Parasitology					1	2				2						
	Microbial ecology					1	2										
	Other issues					1	2			2		2					
Aquaculture system engineering	Flow through systems																
	Recycling systems																
	Cage systems																
	Long-line systems																
	Pond systems																
	Control systems																
	Mathematical modelling																
Environmental interactions and impacts	Eutrophication								2								
	Wildlife interactions						2		2								
	Inorganic components						2										
	Benthic and pelagic impacts																
	Biofouling																
Processing	Transport					1	1	2	2	1	1	1		1	1		
	Harvesting and slaughtering							2	2	1	2	1	1	2	1		
	Thermic processes (freezing, cooling, heating)								2	1	1	1	1	2	1		
	Other processes (smoking, salting)								2	1	1	1	1	2	1		
	Packaging					2	2	2	2	1	2	1			1		
	Traceability					2	2	2							2		3
	Waste management								2								
Main species	Marine species	x	x	x	x	x	x	x	x	x	x	x		x	x		
	Fresh water species	x	x	x	x	x	x	x	x	x	x	x		x	x		
	Diadrome fish	x	x	x	x	x	x	x	x	x	x	x		x	x		
	Shellfish	x	x	x	x					x	x	x			x		
	Planktonic organisms	x	x	x													
	Ornamental fish									x	x	x			x		
	Macroalgae	x	x	x	x												
Fish lines	Genetics																
Type of site	Land based				x	x	x		x								
	Sea based				x	x	x		x								
	Off-score cages				x	x	x		x								
	Ponds				x	x	x		x								
	Resirculation					x	x		x								
Type of water	Sea water								x								
	Fresh water								x								
	Brachish water								x								
Instrumentation	Monitoring						x					x					
	Robots																
	Cameras						x										
	Control systems						x					x					
	Communication system						x										

2 The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map.

This TA was relevant and deemed critical primarily in the following fields of expertise: Feeding and digestion, Product quality, Reproduction and Growth and development. Table 4 gives an overview over the criticality and gaps within this thematic area.

Table 4. Overview over TA 1 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.1		
Goal 1, subgoal 1.2		
Goal 1, subgoal 1.4		
Goal 3, subgoal 3.1		
Goal 3, subgoal 3.3		
Goal 3, subgoal 3.5		
Goal 4, subgoal 4.3		

<u>Goal 1: To maximize the health benefits of aquaculture products</u>

The first subgoal, 1.1, related to the identification of bioactive compounds in aquaculture products and it was critical for Feeding and digestion, Product quality and Growth and Development. A search including the terms “bioactive compounds”, “aquaculture products” and “human health” indicated no gaps related to this subgoal. Subgoal 1.2 also related to bioactive compounds but focused on the mechanisms and synergies underlying their health benefits. It was critical only for Product quality and no gaps were found. Subgoal 1.4 was a critical research area within Reproduction and explores the differences in health benefits between species and related to production methods and feed composition. This subgoal, also, was adequately covered in the relevant search.

<u>Goal 3: To deliver high quality aquaculture products to protect and grow the farmed fish market, fully meeting consumer expectations including appearance, taste, texture, nutrition and provenance.</u>

There are three critical areas under Goal 3, with 3.1 and 3.3 being critical for Product quality and 3.5 for Growth and Development. Subgoal 3.1 relates to defining and standardizing quality parameters for aquaculture products and received 50 relevant search hits, well above the gap threshold of 25. Subgoal 3.3 is related to new technologies in seafood processing to enhance quality and also appears to be well covered in academic literature. Subgoal 3.5 relates to Growth and development and proposes a product certification and labeling system for European aquaculture products based on provenance and quality. No gap was identified for this subgoal

<u>Goal 4: To better understand consumers precipitation and improve their attitude towards aquaculture products</u>

The critical field of expertise under this goal was subgoal 4.3 as it relates to Traceability. The subgoal aims to understand the dynamics of European seafood trade, and is well covered given the number of search results.

TA 2. Technology & Systems

This thematic area has four goals and 24 subgoals, with an above average amount of critical areas identified. With only one exceptions, each subgoal has between one and 10 critical fields of expertise, with 18 subgoals having three or more. The general fields of expertise covered are Aquaculture System Engineering, Environmental interactions and impacts and Processing, though some subgoals are relevant in additional fields. The extent of this TA's criticality can be seen in Table 5 and Table 6, along with which subgoals presented gaps and whether they were covered by RIs in AquaExcel's map.

Table 5. TA Matrix, TA 2[3]

TA Matrix																									
FIELDS OF EXPERTISE		TA 2. Technology and systems																							
1. The need for research is not critical		Goal 1						Goal 2								Goal 3					Goal 4				
2. There is a potential need for research, but not critical		Subgoal						Subgoal								Subgoal					Subgoal				
3. The need for research is critical		1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5
Genetics	Quantitative																								
	Molecular																								
Nutrition	Feeding and digestion						3										3								
	Defecation and excretion																								
	New feed resources						3*																		
	Product quality																2								
Physiology	Reproduction						3																		
	Growth and development																2								
	Metabolism																								
	Endocrinology																								
	Other physiologcal aspects of domestication																								
Welfare	Behaviour						3														1			1	
	Handling						3														3			3	
	Stress																				3			3	
Health and pathology	Bacteriology												2										3		
	Virology												2												
	Parasitology												2												
	Microbial ecology												2												
	Other issues																								
Aquaculture system engineering	Flow through systems	3		3	3		3		2				1	3			1	3	2						
	Recycling systems	3	3	3	3	3*	3			3			1	3*			3	3*			3				3
	Cage systems		3	3	2			3*	3		3		3	3			3	3	2		3				3
	Long-line systems							3	3		3		1	3				2							
	Pond systems			3	3		3		2				3	2											
	Control systems	3						3		3	3		3	3			3				3				3
	Mathematical modelling						3	3	3	3	3		3	3							3				
Environmental interactions and impacts	Eutrophication					3		3*		3	3			2											
	Wildlife interactions	2			2	3	2	3		2			2												
	Inorganic components					3																			
	Benthic and pelagic impacts				3	3*		3																	
	Biofouling					2		3*																	
Processing	Transport	3		3	3			3			3		3		3	3	2					2			3
	Harvesting and slaughtering			3	3		3	3			3	3			3	3*	2			2		3*			3
	Thermic processes (freezing, cooling, heating)											3			2	2				2		3			
	Other processes (smoking, salting)											2								2					
	Packaging															2						3			
	Traceability											3				3									
	Waste management																			3					
Main species	Marine species	x						x			x	x	x		x	x			x		x	x		x	x
	Fresh water species	x								x	x	x	x		x	x			x		x	x		x	
	Diadrome fish	x										x	x		x	x			x		x	x		x	
	Shellfish											x	x			x			x		x				
	Planktonic organisms						x			x		x				x					x				
	Ornamental fish												x		x				x		x			x	
	Macroalgae						x					x	x			x					x				
Fish lines	Genetics																								
Type of site	Land based	x	x	x	x	x				x	x	x						x							
	Sea based	x	x	x	x	x	x	x			x	x						x							
	Off-score cages	x	x	x	x	x	x				x	x						x							x
	Ponds	x	x	x	x	x												x							x
	Resirculation	x			x					x								x							
Type of water	Sea water				x	x		x			x							x							x
	Fresh water				x	x					x							x							
	Brachish water																	x							
Instrumentation	Monitoring	x			x	x	x	x	x	x	x	x		x	x		x	x		x	x		x	x	x
	Robots							x															x	x	x
	Cameras	x			x	x	x	x			x													x	x
	Control systems	x			x	x	x	x	x	x	x	x			x	x	x			x	x		x	x	x
	Communication system																			x					

3 The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map.

Table 6. Overview over TA 2 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.1		
Goal 1, subgoal 1.2		
Goal 1, subgoal 1.3		
Goal 1, subgoal 1.4		
Goal 1, subgoal 1.5	Goal 1, subgoal 1.5	
Goal 1, subgoal 1.6	Goal 1, subgoal 1.6	
Goal 2, subgoal 2.1		Goal 2, subgoal 2.1
Goal 2, subgoal 2.2		
Goal 2, subgoal 2.3		
Goal 2, subgoal 2.4		
Goal 2, subgoal 2.5		
Goal 2, subgoal 2.6		
Goal 2, subgoal 2.7	Goal 2, subgoal 2.7	
Goal 2, subgoal 2.8		Goal 2, subgoal 2.8
Goal 3, subgoal 3.1	Goal 3, subgoal 3.1	
Goal 3, subgoal 3.2		
Goal 3, subgoal 3.3	Goal 3, subgoal 3.3	
Goal 3, subgoal 3.5		
Goal 4, subgoal 4.1		
Goal 4, subgoal 4.2	Goal 4, subgoal 4.2	
Goal 4, subgoal 4.3		
Goal 4, subgoal 4.4		
Goal 4, subgoal 4.5		

<u>Goal 1: Ensure an environmentally sustainable industry by the application of new knowledge and technology innovations</u>

All of the subgoals under Goal 1 have critical fields of expertise. Subgoal 1.1 concerns the development of technology to prevent escapes and is relevant to different types of systems such as Flow though, Recirculation and Control systems, as well as Transportation. Subgoal 1.2 relates to development of renewable energy sources for aquaculture, especially for Recirculation and Cage systems. Subgoal 1.3 relates to improved waste management and reduced discharge to the environment and is critical for Flow through, Recirculation, Cage and Pond Systems as well as Transport and Harvest and Slaughtering. Subgoal 1.4 is also concerned with waste, namely reducing waste release from production. The critical fields of expertise for 1.4 are Flow through, Recirculation and Pond systems, as well as Benthic and Pelagic Impacts, Transport and Harvesting and Slaughtering. There was no research gaps found in these first four subgoals.

Subgoal 1.5 requests technologies for more efficient use of freshwater resources and is critical in Recirculation Systems and to Eutrophication, Wildlife interactions, Inorganic Components and Benthic and pelagic impacts. A research gap was evident with regard to Recirculation Systems and Benthic and Pelagic Impacts, where few results appeared, though member RIs are producing limited research. The Aquatic Research Facilities at Wageningen University (NL) perform research related to recirculation systems, whereas the French Institut National de la Recherche Agronomique (FR) was identified with expertise on benthic and pelagic impacts related to this subgoal.

Subgoal 1.6 relates to developing technology and systems to mass-produce aquatic organisms for industrial use. It was deemed critical in many fields of expertise, as can be seen
in Table 6. The RIs that were recognized as working on new feed resources were the University of Stirling (UK), the Association for Marine Aquaculture (DE), CIIMAR (PT), the

Leibnitz-Institute of Freshwater Ecology and Inland Fisheries (DE), the FAO Department of Fisheries and Aquaculture (IT), the Agricultural Research Organisation (IL), the National Center for Mariculture (IL), the Institute of Animal Nutrition and Physiology (DE), Hermetia Futtermittel GbR (DE) and the Institute of Animal Breeding and Husbandry (DE). In addition, 15 non-European RIs (see Annex 3) were registered with publications in this field of expertise. IFREMER (FR) reported on the start of a national project for the production of phytoplankton as ingredients for animal feed with low cost reactors.

Goal 2: Meet the demand for aquaculture products in the EU by the development of efficient technologies to support continued growth

All of the subgoals under Goal 2 were deemed critical in two or more fields of expertise.

Subgoal 2.1 was critical in nine different fields of expertise, with four of them presenting gaps. This subgoal is related to the development of offshore farming equipment and operational procedures and more research is needed in the fields of Cage systems, Eutrophication, Wildlife interactions and Biofouling. AQUAEXCEL RIs which searches show that they are conducting research in these areas are:

- Cage systems: NTNU (NO), University of Stirling (UK), the Finnish Game and Fisheries RI (FI), and the Atlantic Marine Aquaculture Centre (USA) and the Sustainable Aquaculture Laboratory (Australia)
- Eutrophication: the Ifremer platform in fish aquaculture (FR), INRA-PEIMA (FR), MARBEC (FR) and Matis ohf (IS)
- Biofouling: NTNU (NO), CIBIO (PT) and the Cawthron Institute (NZ).

Wildlife interactions in the field of offshore forming represented a real gap with no publications from European RIs. The only RI found to be working on this topic was the University of Ibadan (Nigeria).

In order to bridge the knowledge gap related to subgoal 2.1, there is a need for RIs working on marine species, offering access to sea cages and a range of instruments to monitor and control the experiments.

Subgoal 2.2 is critical to Cage and Long-line systems and also Mathematical modeling because it relates to the development of technology and systems for best site selection. This subgoal appears to be well covered in research.

Subgoal 2.3 calls for a maximization of the efficiency of Recirculation Aquaculture Systems and a reduced accumulation of persistent compounds. In addition to Recycling Systems, this subgoal was critical to Control Systems, Mathematical modeling and Eutrophication but no gaps were found.

Subgoal 2.4 calls for the development of integrated aquaculture systems and is relevant to the main fields of expertise of both Aquaculture System Engineering and Environmental Impacts.

In contrast to this demand for new systems, subgoal 2.5 asks for the development of new products and is critical is the areas of Harvest and Slaughter and also Traceability.

Subgoal 2.6 addresses the need to have technology and systems to prevent disease and it is critical to the closed system types, and to Control Systems and Mathematical Modeling. Subgoal 2.6 reveals no research gaps.

Subgoal 2.7 relates to the utilization of existing sites and it is critical for nearly all the subfields of expertise under Aquaculture Systems Engineering. There was a partially covered gap found when searching for research related to Recycling Systems, with the only RIs registered being the National Institute of Nutrition and Seafood Research (NO) and the

National Veterinary Institute Oslo (NO). IFREMER (FR) reported on upcoming activities in this field through the AQUASPACE H2020 project.

Subgoal 2.8 was the only subgoal where no relevant research was found. Multiple search strings were attempted but it seems that there is a serious gap relating to harvesting technology for planktonic organisms (Calanus) for use as a supplement in production of new fish feeds, and also for handling and stabilizing this raw material. This gap is relevant for all fish species. RIs with monitoring and control system technologies are needed to work on achieving this specific subgoal.

Goal 3: Ensure the profitability of the aquaculture industry by developing improved management systems and technology

Subgoal 3.1 relates to improving handling and slaughter technologies with considerations of welfare and ethics and will be discussed in the next section because it is the same as Subgoal 4.2.

The next subgoal, 3.2 is concerned with automating all production stages and is relevant to Feeding and Digestion and the Recycling, Cage and Control systems. In this case, no gaps were found.

Subgoal 3.3 relates to biofouling understanding and systems of control and is considered critical in Flow through, Recirculation and Cage systems. A gap was revealed in terms of Recirculation Systems, with some coverage as 16 relevant publications from European RIs came up as contributors. These were NTNU (NO), Center for Tropical Marine Ecology (DE), Institute for Marine Resources IMARE (DE), University of Birmingham (UK), Bremerhaven University of Applied Sciences (DE), University College Cork, BEES (IE), University of Genoa DIFI (IT), Tyndall National Institute (IE), IBF-CNR (IT), CNR-ISMAR Marine Sciences Institute in Genoa (IT).

Subgoal 3.5 calls for a total utilization of farmed fish and was critical in the area of waste management, but no gap was identified.

Goal 4: Ensure ethical and healthy production of fish

This goal has critical elements in all but one of its five subgoals, but only one identified gap.

The first subgoal relates to integrating biology and technology management to prevent disease outbreaks and improve general fish welfare. It is critical to the Handling and Stress experienced by the fish in Recycling and Cage systems. Also Control systems and mathematical modeling are critical.

Subgoal 4.2 considers improving technology for transfer, handling and slaughtering with respect to welfare and ethics. There is a gap concerning Harvesting and Slaughtering where there is moderate representation of AQUAEXCEL RIs in the search results, with five research infrastructures contributing publications: the IMARES Institute for Marine Resources and Ecosystem Studies (NL), the Aquatic Research Facilities at Wageningen University (NL), the NOFIMA Aquaculture Research Station in Tromsø (NO), the Institute of Marine Research (NO) and NTNU (NO). The Marine Resources Centre (China) was also identified as a contributor to this field.

Subgoal 4.3 is concerned with human health and developing standardized detection methods for the pathogens that affect it. It is critical for Bacteriology.

In contrast, subgoal 4.4 is concerned with developing procedures and technology for monitoring fish welfare at all production stages. It is especially important for Handling and Stress, but does not present any gaps.

Subgoal 4.5 relates to protecting shellfish from human pathogens by use of technology. The critical areas of expertise are Recycling, Cage and Control systems, as well as Transport and Harvesting and Slaughtering. All areas showed adequate coverage within the search results.

In addition to member RI coverage in gap areas, there were over 70 institutions presenting relevant publications. Of these, 36 were based in Europe.

TA 3. Managing the Biological Lifecycle

Thematic area three has four different goals and 22 subgoals. Goal 4, dealing with "new" species, was not included in the study for different reasons. Non-experimental issues were excluded from the analysis. The remaining two other subgoals constituted a serious challenge as "new species" covers a wide range of marine and freshwater animals and plants. This complexity was not possible to cover through a literature search. Comments received during the evaluation process revealed that many AQUAEXCEL partner institutes (e.g. NOFIMA, UoS, IMARES, ULPGC, VURH, HAKI, HCMR) are involved in projects specifically dedicated to managing the lifecycle of new species. Therefore, it is not expected that there are significant gaps in the experimental approaches to the development of new species, and goal 4 was not further analysed. An overview of critical areas and gaps in the other three remaining goals can be seen in Table 7 below. Critical areas are related to quite a variety of expertise areas, as can be seen in Table 8, but the most important goal-wide are Quantitative Genetics, Reproduction and Growth and Development.

Table 7. TA Matrix, TA 3[4]

[4] The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map.

TA Matrix

FIELDS OF EXPERTISE		TA 3. Managing the biological lifesycle																
1. The need for research is not critical		Goal 1					Goal 2					Goal 3						
2. There is a potential need for research, but not critical		Subgoal					Subgoal					Subgoal						
3. The need for research is critical		1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	3.6	3.7
Genetics	Quantitative						3	3	3					2	2		2	3
	Molecular																	
Nutrition	Feeding and digestion													2			2	
	Defecation and excretion																	
	New feed resources																	
	Product quality																	
Physiology	Reproduction		2			2		2	2		3	3	3	3	2	2	2	3
	Growth and development		2			2		2	2		3	3		3	2		2	3
	Metabolism																	
	Endocrinology																	
	Other physiologcal aspects of domestication		1			3												
Welfare	Behaviour													2			1	2
	Handling																	
	Stress							2	3									
Health and pathology	Bacteriology			2				2	2				2					2
	Virology			2									2					
	Parasitology			2									2					
	Microbial ecology			2														
	Other issues																	
Aquaculture system engineering	Flow through systems	3			2	1												
	Recycling systems	1			1	1												
	Cage systems	3			2	1												
	Long-line systems	3			1	1												
	Pond systems	2			3	1												
	Control systems																	
	Mathematical modelling	3				2												
Environmental interactions and impacts	Eutrophication	1			2									1	2			
	Wildlife interactions	1			2									1	1			
	Inorganic components	1																
	Benthic and pelagic impacts	1																
	Biofouling																	
Processing	Transport																	
	Harvesting and slaughtering																	
	Thermic processes (freezing, cooling, heating)																	
	Other processes (smoking, salting)																	
	Packaging																	
	Traceability																	
	Waste management																	
Main species	Marine species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Fresh water species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Diadrome fish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Shellfish	x	x	x	x	x	x	x	x	x	x	x	x			x		
	Planktonic organisms																	
	Ornamental fish	x	x	x	x	x	x	x	x	x	x		x			x	x	
	Macroalgae	x	x	x	x	x	x	x	x	x	x		x			x		
Fish lines	Genetic						x	x						x				
Type of site	Land based		x	x														
	Sea based		x	x														
	Off-score cages		x	x														
	Ponds		x	x														
	Resirculation																	
Type of water	Sea water			x														
	Fresh water			x														
	Brachish water			x														
Instrumentation	Monitoring	x			x													
	Robots																	
	Cameras																	
	Control systems	x			x													
	Communication system																	

Table 8. Overview over TA 3 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.1		
Goal 1, subgoal 1.4		
Goal 1, subgoal 1.5		
Goal 2, subgoal 2.1		
Goal 2, subgoal 2.2		
Goal 2, subgoal 2.3		
Goal 2, subgoal 2.5		
Goal 3, subgoal 3.1		
Goal 3, subgoal 3.2		
Goal 3, subgoal 3.3		
Goal 3, subgoal 3.7		Goal 3, subgoal 3.7

<u>Goal 1: Establish predictability and improve output at every production stage of the lifecycle.</u>
Subgoal 1.1 has to do with developing performance indicators for farms and measuring current variation levels. It was deemed critical for Flow through, Cage and Long Line systems, and in relation to Mathematical Modeling. No gaps were found under this subgoal.

Subgoal 1.4 is related to improving technological performance by standardizing protocols and it is especially relevant to Pond Systems.

The final critical area under Goal 1 relates to Other Physiological aspects of domestication under subgoal 1.5. The subgoal is concerned with promoting a competent and highly skilled workforce along the value chain.

<u>Goal 2: Genetic improvement of productive, health and animal welfare traits.</u>
There are six critical areas under Goal 2, with half of them related to Quantitative Genetics. Subgoals 2.1 through 2.3 are complex and relate to selective breeding.

Subgoal 2.3 was also deemed critical for the field of expertise relating to Stress and it calls for identification of genetic correlations between productive and unwanted traits.

The other two critical areas fall under subgoal 2.5, which relates to informing industry and policy makers about selective breeding programs. The critical areas are Reproduction and Growth and Development but neither is considered a gap.

<u>Goal 3: Improve broodstock management methods and control of sex and reproduction in captivity.</u>
The final goal in this TA has critical areas primarily relating to Reproduction and Growth and Development.

Subgoals 3.1 to 3.3 do not present any gaps and relate to identifying reproduction problems and knowledge gaps, welfare impact of sexual maturation and spawning high quality gametes respectively.

Subgoal 3.7, however, does present several important gaps. The subgoal relates to developing new sterilization methods as an alternative to triploidy, or methods to allow production of triploids at an industrial scale for species usually propagated with mass spawning. Search results requiring the term “sterilization” to be included in the title found more than 20 results, but none from AQUAEXCEL member RIs. It appeared that research relating to sterilization in aquaculture is limited. This was an uncovered gap for the fields of expertise of Quantitative Genetics, Reproduction and Growth and Development. This is related to all fish species (marine, freshwater and diadrome). No European institutions appeared in the publication results, but there were five non-EU institutions or universities located in the USA, Australia, China and Korea.

TA 4. Sustainable Feed Production

Thematic Area 4 relates to sustainable feed production, containing five goals and 19 subgoals. The fields of expertise relevant to the subgoals in this TA were primarily under the main fields of Nutrition and Physiology (Table 9). An overview of the critical and gap areas for this TA can be seen in Table 10.

Table 9. TA Matrix, TA 4[5]

TA Matrix																				
FIELDS OF EXPERTISE		**TA 4. Sustainable Feed Production**																		
1. The need for research is not critical		Goal 1						Goal 2			Goal 3				Goal 4			Goal 5		
2. There is a potential need for research, but not critical		Subgoal						Subgoal			Subgoal				Subgoal			Subgoal		
3. The need for research is critical		1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	3.1	3.2	3.3	3.4	4.1	4.2	4.3	5.1	5.2	5.3
Genetics	Quantitative														3	1	2	2	2	
	Molecular														3	1	2	2	2	
Nutrition	Feeding and digestion	1	3	1	3	3	2	3	1	2	2								3	3
	Defecation and excretion	1	3*	1	3	3*	2	1	1									3		3*
	New feed resources		3	2				3	2		1							2		
	Product quality		3	1	3	3	1	3			1									
Physiology	Reproduction	1	3	1	3	3*	2				1							2		
	Growth and development	1	3	1	3	3*	2	3	2	2	2			3					2	
	Metabolism	1	3	1	3	3	2		2		2	2		2				3	2	
	Endocrinology	1	3	1					2			2		2				3	2	
	Other physiologcal aspects of domestication																			
Welfare	Behaviour					3*								1						
	Handling												2	2						
	Stress					3						2	2	1						
Health and pathology	Bacteriology											2	2							
	Virology											2	2							
	Parasitology											2								
	Microbial ecology																			
	Other issues																			
Aquaculture system engineering	Flow through systems																			
	Recycling systems																			
	Cage systems																			
	Long-line systems																			
	Pond systems																			
	Control systems																			
	Mathematical modelling																			
Environmental interactions and impacts	Eutrophication					1													1	
	Wildlife interactions					1														
	Inorganic components																			
	Benthic and pelagic impacts					1														
	Biofouling					1														
Processing	Transport																			
	Harvesting and slaughtering							2												
	Thermic processes (freezing, cooling, heating)							2												
	Other processes (smoking, salting)																			
	Packaging																			
	Traceability																			
	Waste management																			
Main species	Marine species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Fresh water species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Diadrome fish	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Shellfish																			
	Planktonic organisms																			
	Ornamental fish																			
	Macroalgae																			
Fish lines	Genetic																			
Type of site	Land based					x														
	Sea based					x														
	Off-score cages					x														
	Ponds					x														
	Resirculation					x														
Type of water	Sea water																			
	Fresh water																			
	Brachish water																			
Instrumentation	Monitoring						x													
	Robots																			
	Cameras																			
	Control systems						x													
	Communication system																			

[5] The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map

Table 10. Overview of TA 4 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.2		Goal 1, subgoal 1.2
Goal 1, subgoal 1.4		
Goal 1, subgoal 1.5	Goal 1, subgoal 1.5	
Goal 2, subgoal 2.1		
Goal 3, subgoal 3.4		
Goal 4, subgoal 4.1		
Goal 5, subgoal 5.1		Goal 5, subgoal 5.1
Goal 5, subgoal 5.2		
Goal 5, subgoal 5.3	Goal 5, subgoal 5.3	

<u>Goal 1: Base formulation of Future Fish Feeds on solid knowledge of fish nutritional requirements, and expand the number of well characterized and sustainable raw materials which can be used</u>

The first goal sets out to build a foundational knowledge on fish nutritional requirements and the nutritional content of potential alternative feed ingredients. Subgoals 1.2, 1.4 and 1.5 were deemed critical through expert consultation. These address nutrient characterization of feed ingredients, their effects on consumer health and optimized feeding procedures respectively.

Subgoal 1.4 was well covered, but in both 1.2 and 1.5, research was found to be lacking in the areas of Defecation and Excretion, and Reproduction. In addition, 1.5 was lacking coverage in Growth and Development and Behavior. RIs were found to be contributing to all but one of the gap areas. The Nofima Centre for Recirculation in Aquaculture and Nofima Marin in Ås (NO), the Aquatic Research Facilities at Wageningen University (NL) and the Department of Pharmaceutical Bioscience at the University of Oslo (NO) were covering Defecation and Excretion under both 1.2 and 1.5. The INRA Fish Nutrition RI in St Pée sur Nivelle (FR) reported to also to contribute with research in this area. Internationally, research is performed mainly in China and USA.

In subgoal 1.2, additional European RIs have the following expertise in the gap areas:
- Defecation and Excretion: University of Yalova (TUR), Katip Çelebi University (TUR), University of Plymouth (UK), SLU Department of Food Science (SE), University of Oslo (NO)
- Reproduction: Aquaculture Protein Centre (NO)

In subgoal 1.5, further research was conducted in the following European RIs:
- Defecation and Excretion: University of Nordland (NO), NIFES (NO), EWOS (NO), CCMAR (PT), University of Sinop (TUR), Aarhus University (DK), University of Almeria (ES)
- Reproduction: University of Ghent GART (BE), University of Nordland (NO), CCMAR (PT), University of Sinop (TUR), University of Perugia (IT), University of Almeria (ES), Ministry of Food (TUR), University of Padova (IT), University of Camerino (IT), Pesca Lagunare GR (IT)
- Growth and development: University of Marche (IT), Aquaculture Protein Centre (NO), University of Padova (IT), University of Camerino (IT), University of Perugia (IT), Pesca Lagunare GR (IT), University of Oslo (NO)
- Behaviour: University of Stirling (UK), Institute Research & Technology Food & Agriculture (ES), University of Marche (IT), Andalusian Institute for Research and Training in Agriculture, Fisheries, Foods and Organic Production (ES), CCMAR (PT), Aarhus University (DK), KWR Watercycle Research Institute (NL), UNESCO-IHE

(NL), TU Delft (NL), ICMAN-CSIC (ES), IPMA (PT), Universidade do Algarve CRIA (PT)

Goal 2: Advanced novel feed technologies to produce cost effective feed with improved quality

The second goal in TA 4 relates to novel feed technologies and has several critical categories under subgoal 2.1, which relates to technological development. It was determined to be critical in the four categories, but no gaps were identified.

Goal 3: Understand and minimize negative effects of alternative diets on fish health and welfare

The third goal relates to the effects of alternative feed ingredients on fish welfare. There is only one critical designation, found under subgoal 3.4, related to Growth and Development. Search results showed that this issue is adequately covered.

Goal 4: Adapt and utilize advanced methods to understand and model nutritional responses

Goal four is concerned with understanding and modeling nutritional responses. Critical areas were related to Genetics under subgoal 4.1, but these did not represent a gap area.

Goal 5: Resolve strategic research problems in fish nutrition

The final goal in the thematic area calls for the resolution of strategic research problems in fish nutrition. The goal presented critical areas under all three subgoals and also some gaps. The subgoals under Goal 5 were more extensive and complex than the other subgoals in TA 4, making relevant searches more difficult.

Subgoal 5.1 relates to developing feeds that maximize protein accretion, minimize lipid deposition and achieve optimal product composition promoting human health. Of the three critical categories, Endocrinology appeared to be a gap where no RIs from the online map were found to be contributing. The European RIs which appeared in the search hits were the National Institute of Nutrition and Seafood Research (NIFES- Norway) and EWOS Innovation AS (Norway). These will be urged to enter their data into the AQUAEXCEL map. The Nutrigenomics and Fish Growth Endocrinology Group at CSIC reported its activity in this field through the ARRAINA European Project, which has just recently started.

Subgoal 5.3 is linked to the formulation of targeted feed compounds, feeding and fish management practices that condition farmed species to novel feeds, increase adaptability, reduce stress and increase biological efficiency. It was found critical to both Feeding and Digestion, and Defecation and Excretion. The latter appeared to be a gap, though several AQUAEXCEL RIs appeared in the search results, including INRA – St. Pée (FR), the Aquatic Research Facilities at Wageningen University (NL), and the Nofima research institutes in Sunndalsøra and in Ås(NO). Others RI contributing are INRA – GABI (FR), University of Southern Denmark (DK), Swedish University of Agriculture Studies (SE), University of Gothenburg (SE), Humboldt-University of Berlin (DE), and DTU (DK).

TA 5. Integration with the Environment

This thematic area consists of five goals and 17 subgoals. An overview of the critical areas and gaps can be seen in Table 11 and Table 12. The critical areas in this goal mainly fell under the main field of expertise called Environmental Interactions and Impacts, and in particular Eutrophication and Inorganic Components. This can easily be seen in the Table 11 below.

Table 11. TA Matrix, TA 5[6]

TA Matrix																		
FIELDS OF EXPERTISE		**TA 5. Integration with the environment**																
1. The need for research is not critical		Goal 1			Goal 2				Goal 3			Goal 4			Goal 5			
2. There is a potential need for research, but not critical		Subgoal			Subgoal				Subgoal			Subgoal			Subgoal			
3. The need for research is critical		1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	4.2	4.3	5.1	5.2	5.3	5.4
Genetics	Quantitative																	
	Molecular																	
Nutrition	Feeding and digestion				2													
	Defecation and excretion				2													
	New feed resources																	
	Product quality																	
Physiology	Reproduction																	
	Growth and development				2													
	Metabolism																	
	Endocrinology																	
	Other physiologcal aspects of domestication																	
Welfare	Behaviour																	
	Handling																	
	Stress																	
Health and pathology	Bacteriology												1					
	Virology												1					
	Parasitology												1					
	Microbial ecology												2					
	Other issues																	
Aquaculture system engineering	Flow through systems																	
	Recycling systems																	
	Cage systems							3										
	Long-line systems																	
	Pond systems																	
	Control systems								2							1		
	Mathematical modelling						3		2			2			2	2	3	
Environmental interactions and impacts	Eutrophication	3	2	3	3	3	3	3							2	3	2	2
	Wildlife interactions								3	1	2	3	2	2				2
	Inorganic components	3	2	3	3	2		1	3	3	3				2	2	2	2
	Benthic and pelagic impacts	2	1	2	3	3	3*	2	2	1	1	2	2	2	2	2	2	2
	Biofouling	1	1					2				2	2					
Processing	Transport																	
	Harvesting and slaughtering																	
	Thermic processes (freezing, cooling, heating)																	
	Other processes (smoking, salting)																	
	Packaging																	
	Traceability																	
	Waste management																	
Main species	Marine species	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Fresh water species	x	x	x					x	x	x	x	x	x	x	x	x	x
	Diadrome fish		x	x					x			x	x	x	x	x	x	x
	Shellfish	x		x								x	x	x	x	x	x	x
	Planktonic organisms		x										x	x				
	Ornamental fish												x	x				
	Macroalgae	x		x				x					x	x				
Fish lines	Genetic																	
Type of site	Land based	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Sea based	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Off-score cages	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Ponds	x	x									x	x					
	Resirculation																	
Type of water	Sea water	x		x	x		x		x		x							
	Fresh water		x	x	x		x		x		x							
	Brachish water	x	x	x	x		x		x		x							
Instrumentation	Monitoring			x	x	x									x	x		x
	Robots																	
	Cameras					x												
	Control systems			x	x	x									x	x		
	Communication system														x		x	x

6 The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map

Table 12. Overview of TA 5 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.1		
Goal 1, subgoal 1.3		
Goal 2, subgoal 2.1		Goal 2, subgoal 2.1
Goal 2, subgoal 2.2		
Goal 2, subgoal 2.3	Goal 2, subgoal 2.3	
Goal 2, subgoal 2.4		
Goal 3, subgoal 3.1		
Goal 3, subgoal 3.2		
Goal 3, subgoal 3.3		
Goal 4, subgoal 4.1		
Goal 5, subgoal 5.2		
Goal 5, subgoal 5.3		

Goal 1: To establish fundamental scientific knowledge on the assimilation capacity of biogenic wastes from aquaculture in benthic and pelagic ecosystems (Biogenic waste assimilation in ecosystems)

The critical fields of expertise under Goal 1 are Eutrophication and Inorganic Components and they are critical to both subgoal 1.1 and subgoal 1.3. The former is related to the management of biogenic waste emissions and the latter is concerned with multiple considerations into siting of aquaculture installations. Neither represented gaps.

Goal 2: To establish technology to minimise emission of biogenic matter from aquaculture and to minimize the potential impacts of the actual emissions by means of management tools and integrated multi-trophic culture (Technology to minimise biogenic impacts)

Each of the subgoals under Goal 2 is critical with regards to Eutrophication.

Subgoal 2.1 looks to minimize the biogenic emissions of fish by improving feed technology, composition and procedures. In regards to Benthic and Pelagic Impacts there is a gap in research that no member RIs are currently addressing, according to the search results. Ten research infrastructures contributed to the publications that came up in the search. Two of these were located in Italy (Università degli Studi di Torino and Centro Interdipartimentale NatRisk) and the others outside of Europe, including North America, China and Japan. This issue is specially related to marine fish, with a need for both sea-based and land-based facilities, equipped with monitoring and control systems.

Subgoal 2.2 relates to minimizing emissions but with the use of improved siting and environmental management. It is also critical to Benthic and Pelagic impacts but no gap was found.

Subgoal 2.3 changes the focus from minimizing impacts to creating environmental benefits from aquaculture. In addition to its importance to Eutrophication, it is also critical in Mathematical modelling and Benthic and Pelagic impacts, where a gap exists. Expertise in this area lies within several AQUAEXCEL members: the Hellenic Centre for Marine Research (GR), the University of Stirling (UK) and SINTEF Sealab (NO). Others RIs contributing to knowledge are the University of Crete (GR), the Scottish Association for Marine Science (UK) and the University of New Brunswick (Canada).

The final subgoal (2.4) explores potentials of using waste from cage fish farms. This is related to Cage systems and Eutrophication and the search received adequate hits.

Goal 3: To understand the fate and cumulative effects of synthetic agents used in aquaculture and minimizing their impact on the environment (Fate of persistent agents in ecosystems)

Beneath this goal, there are four critical areas of expertise with three of them related to Inorganic Components, applying to each of the subgoals.

The first two subgoals relate to antifouling chemicals. The third, subgoal 3.3, pulls it together asking for a transparent surveillance and reporting network for disease outbreaks and pharmaceutical chemical use. None of the above critical areas are considered to be gap areas.

Goal 4: To establish more fundamental knowledge to reduce the negative interactions between farmed and wild stocks, including wildlife (Interactions of farmed and wild stocks)

The sole critical area in Goal 4 is under subgoal 4.1, which demands a better understanding of both the positive and negative interactions that aquaculture may have with fisheries and ecosystems. This is critical in the field of expertise of Wildlife Interactions but does not present a research gap.

Goal 5: To develop or adapt tools and measures in support of appropriate environmental governance for aquaculture (Tools for environmental governance)

The issue of Eutrophication is critical to subgoal 5.2, as it requests management tools and measure for environmental monitoring and minimizing impact.

Subgoal 5.3 addresses the need for a harmonization of environmental regulation and legislation across the European Union. It was considered critical in regards to mathematical modelling but was not a gap area.

TA 7. Aquatic Animal Health and Welfare

Thematic area seven contains four main goals with 16 subgoals. They mainly relate to the Welfare and Pathology fields but Table 13 shows the larger picture. An overview of critical areas and gap can also be achieved from Table 14 below.

Table 13. TA Matrix, TA 7[7]

TA Matrix																	
FIELDS OF EXPERTISE		**TA 7. Aquatic animal health and welfare**															
1. The need for research is not critical		Goal 1			Goal 2					Goal 3					Goal 4		
2. There is a potential need for research, but not critical		Subgoal			Subgoal					Subgoal					Subgoal		
3. The need for research is critical		1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3
Genetics	Quantitative																
	Molecular	3	3												3		
Nutrition	Feeding and digestion															3	
	Defecation and excretion																
	New feed resources																
	Product quality																
Physiology	Reproduction															3	
	Growth and development														3	3	
	Metabolism																
	Endocrinology																
	Other physiologcal aspects of domestication																
Welfare	Behaviour						2								3		
	Handling						2								3	3	1
	Stress						2			3					3	2	1
Health and pathology	Bacteriology	3	3	2	2					2	2			2			
	Virology	3		2	2					2	2			2			
	Parasitology	3			2									2			
	Microbial ecology	3	2														
	Other issues																
Aquaculture system engineering	Flow through systems									2							
	Recycling systems									2					3*		2
	Cage systems									2				3	2		2
	Long-line systems																2
	Pond systems																
	Control systems																
	Mathematical modelling				2										2		3
Environmental interactions and impacts	Eutrophication																
	Wildlife interactions		2								1						
	Inorganic components																
	Benthic and pelagic impacts									2							
	Biofouling																
Processing	Transport				2	2	2	1		1	1						
	Harvesting and slaughtering				2	2	2	1			1						
	Thermic processes (freezing, cooling, heating)				1	1		1			2						
	Other processes (smoking, salting)					1											
	Packaging					1		1									
	Traceability				3	1		1		1							
	Waste management				2	1											
Main species	Marine species	x	x	x	x		x	x		x	x			x	x	x	x
	Fresh water species	x	x	x	x		x	x		x	x				x	x	x
	Diadrome fish	x	x	x	x		x	x		x	x				x	x	x
	Shellfish	x						x								x	
	Planktonic organisms	x															
	Ornamental fish	x															
	Macroalgae																
Fish lines	Genetic																
Type of site	Land based				x	x	x	x		x	x						x
	Sea based				x	x	x	x		x	x			x			x
	Off-score cages				x	x	x	x		x	x			x			x
	Ponds				x	x		x									
	Resirculation																
Type of water	Sea water				x	x				x							
	Fresh water				x	x				x							
	Brachish water				x					x							
Instrumentation	Monitoring				x												
	Robots																
	Cameras																
	Control systems																
	Communication system																

[7] The critical areas of expertise are all marked with a 3. A Yellow area represents a gap and a pink area represents an expertise field largely covered. Yellow field with an asterix (*) denotes limited coverage by European RIs, yellow fields without an asterix signifies an area with no expertise from RIs included in the AQUAEXCEL RI online map

Table 14. Overview of TA 7 Results

Critical Subgoals	Gaps with Some Coverage	Gaps without coverage
Goal 1, subgoal 1.1		
Goal 1, subgoal 1.2		
Goal 2, subgoal 2.1		Goal 2, subgoal 2.1
Goal 3, subgoal 3.1		
Goal 3, subgoal 3.5		
Goal 4, subgoal 4.1	Goal 4, subgoal 4.1	
Goal 4, subgoal 4.2		
Goal 4, subgoal 4.3		

Goal 1: Improve fish health by increasing understanding of host pathogen interactions and to have access to effective vaccines and immunomodulators

Goal 1 has three subgoals, with a total of 7 critical areas.

Subgoal 1.1 deals with improving understanding of host pathogen interactions and is critical in the main field of expertise of Health and pathology, and also to Molecular Genetics. None of these five critical areas reveal a research gap.

The other two critical areas fall under subgoal 1.2, which deals with the development of new vaccines and improvement of existing vaccines. This is critical to both Molecular Genetics and Bacteriology but they are not considered gap areas.

Goal 2 Application of epidemiological principles to minimise the threat from existing, emerging and exotic diseases

This goal has only one critical area, but it reveals a serious gap that is not addressed by member RIs.

The relevant subgoal is 2.1 which necessitates an improved understanding of transmission mechanisms of pathogens out from the farm. It was deemed critical for Traceability and a mere 17 relevant results were found, with no member representation. Eleven non-AQUAEXCEL RIs were noted, six of whom are located in the EU, i.e. the Molecular Ecology and Fisheries Genetic Laboratory, Bangor University (UK), the Fish Lab at the University of Pisa (IT), the University of Iceland (ISL), and Matis Ohf (ISL). These will be invited directly to enter their RI properties into the AQUAEXCEL online RI map. It is important that there is a range of different facilities accessible for all types of fish species, sites and types of water, with adequate monitoring equipment.

Goal 3: Use and develop best practice to optimize efficacy of treatments and prevention methods

Subgoal 3.1 is critical in the area of Stress and requires a minimization of treatment by use of best practices. Subgoal 3.5 is concerned with the effective delivery of treatments in novel systems such as large off-shore cages. It was given a 3-score with regards to cage systems. Neither of the above subgoals was found to be a research gap.

Goal 4: Measure welfare and understand its consequences if compromised in order to incorporate welfare as core component of production management

Each of the three subgoals under Goal 4 has associated critical fields of expertise but only one gap exists. Subgoal 4.1 relates to developing and improving existing welfare and stress indices. The critical areas are Molecular Genetics, Growth and Development, Behaviour, Handling, Stress and Recycling Systems. Only Recycling Systems presents a gap, with only 16 relevant search results but with four member RIs contributing. They include the French Ifremer platform in fish aquaculture, the Institute for Marine Resources and Ecosystem

Studies (DLO-IMARES, Netherlands), the Institute of Marine Research (IMR) and Nofima, Norway.

Subgoal 4.2 aims to understand and quantify both the short and long term effects of compromised welfare and is relevant to Feeding and Digestion, Reproduction, Growth and Development and Handling. All of these fields of expertise are well represented according to search results. Subgoal 4.3 concentrates on incorporating welfare/low stress management into decision making and risk analysis. This was deemed critical for mathematical modelling but is not a gap area.

Conclusions

The gap analysis revealed a number of knowledge gaps and research infrastructures dealing with gap areas in the thematic areas listed below. The RIs in italics did not appear as results of the gap analysis but are included on the basis of feedback provided during the AQUAEXCEL networking activities
The full names of the RIs that were identified during the gap analysis are listed in Annex 3. They include both European RIs included in the AQUAEXCEL map, European RIs not included in the AQUAEXCEL map and non-European RIs.

The list below shows a summary of the gap analysis results per thematic area.

Technology and systems:

More efficient use of freshwater resources (subgoal 1.5)
Recirculation Systems: WU (NL), Stanford (US)
Benthic and Pelagic Impacts: INRA (FR)

Mass production of aquatic organisms (plankton, algae) (subgoal 1.6)
New Feed Resources: UoS (UK), GMA (DE), CIIMAR (PT), Leibnitz Instit (DE), FAO (IT), Agricultural Research Org (IL), National Center for Mariculture (IL), Instit of Animal Nutrition and Physiology (DE), Hermetia Futtermittel (DE), Instit. Of Animal Breeding and Husbandry (DE), CIMTAN (CA), CSIRO (AUS), UoQueensland (AU), Novus Intl (US), Auburn Uni (US), State Uni of Maranhao (BR), UoConnecticut (US), DFO (CA), Research Instit for Mariculture (ID), Integrated Service for Dvlpmt of Aquaculture (PH), Network of Aquaculture Centre in Asia-Pacific (TH), Research Instit for Mariculture (VN), UoAdelaide (AU), UoHongKong (CN), Khon Kaen Uni (TH), *IFREMER (FR)*

Development of offshore farming equipment and operational procedures (subgoal 2.1)
Cage Systems: NTNU (NO), UoStirling (UK), Finnish Game and Fisheries RI (FI), Atlantic Marine Aquaculture Centre (US), SALTT (Aus)
Eutrophication: Ifremer (FR), INRA-PEIMA (FR), MARBEC (FR), Matis ohf (IS)
Wildlife Interactions: U.o.Ibadan (NG)
Biofouling: NTNU(NO), CIBIO (PT), Cawthron Institute (NZ)

Improved utilization of existing sites (subgoal 2.7)
Recirculation Systems: NIFES (NO), National Veterinary Institute Oslo (NO), *IFREMER (FR)*

Support production of new fish feeds (subgoal 2.8)
Harvesting
Transport

Control Biofouling (subgoal 3.3.)
Recirculation Systems: NTNU (NO), ZMT (DE), IMARE (DE), UoBirmingham (UK), Bremerhaven Uni (DE), BEES (IE), DIFI (IT), Tundall National Instit (IE), IBF-CN (IT), CNR-ISMAR (IT), RMIT (AU), BARC (IN), CSIRO (AU), SALTT (AU), Cawthorn Instit (NZ), ICFAI Uni (IN), East Chian Sea Fisheries Research Instit (CN), Zhanjiang Normal Uni (CN), MACRO (AU), Long Island Uni (US), Cornell Coop Extension (US), Southern Cross Uni (AU)

Welfare and Ethics (subgoal 4.2)
Harvesting and Slaughtering: DLO-IMARES (NL), NOFIMA (NO), IMR (NO), NTNU (NO), Marine Resources Centre (CN)

Managing the biological life cycle

New sterilization methods (subgoal 3.7)

Quantitative Genetics: Auburn Uni (US), CSIRO (AU), Purdue Uni (US), Pukyong Uni (KR), Jiangnan Uni (CN), Fort Valley Uni (US)

Reproduction: Auburn Uni (US), CSIRO (AU), Purdue Uni (US), Fort Valley Uni (US)

Growth and development: Auburn Uni (US), CSIRO (AU), Purdue Uni (US), Pukyong Uni (KR), Fort Valley Uni (US)

Sustainable feed production

Nutritional value of alternative raw materials (subgoal 1.2)

Defecation and Excretion: VURH (CZ), Nofima (NO), WU (NL), Nofima Marin (NO), UoYalova (TR), Celebi Uni (TR), UoPlymouth (UK), SLU (SE), UoOslo (NO), Ocean Uni (CN), Payame Noor Uni (IR), Kochi Uni (JP), Islamic Azad Uni (IR), Hannan R+D (JP), South Dakota Dpt of Game, Fish and Parks (US), Iowa State Uni (US), Nutraferma Inc (US), SANRU (IR), U.o.Ilorin (NG), National Aquatic R&D Agency (LK), *IFREMER (FR*), *INRA (FR)*

Reproduction: CoE (NO), Ocean Uni (CN), Payame Noor Uni (IR), UoSask (CA), Islamic Azad Uni (IR), South Dakota Dpt of Game, Fish and Parks (US), South Dakota State Uni (US), Iowa State Uni (US), Nutraferma Inc (US), National Aquatic R&D Agency (LK), Huazhong Normal Uni (CN), *INRA (FR)*

Optimal feeding procedures (subgoal 1.5)

Defecation and Excretion: Nofima (NO), WU (NL), UoNordland (NO), NIFES (NO), EWOS (NO), Nofima Marin (NO), UoOslo (NO), CCMAR (PT), UoSinop (TR), Aarhus Uni (DK), UoAlmeria (ES), Aquafin CRC (AU), UTS (AU), Beijing Nutrition Resources Instit (CN), Port Stephens Fisheries Instit (AU), USDA (US), South China Normal Uni (CN), UoAdo Ekiti (NG), UdeGoias (BR), UNESP (BR), UNESP-CAUNESP (BR), Can Tho Uni (VN)

Reproduction: GART (BE), Nofima (NO), WU (NL), UoNordland (NO), Nofima Marin (NO), UoOslo (NO), CCMAR (PT), UoSinop (TR), UoPerugia (IT), UoAlmeria (ES), Min. of Food (TR), UoPadova (IT), UofCamerino (IT), GR (IT), USDA (US), Beijing Nutrition Resource Instit (CN), Can Tho Uni (VN), South China Normal Uni (CN), UoAdo Ekiti (NG), Yunnan Ag. Uni (CN), Jimei Uni (CN), Marine Fishery Instit. Of Zhejiang Province (CN)

Growth and development: Nofima (NO), UoMarche (IT), Nofima Marin (NO), CoE (NO), UoPadova (IT), UofCamerino (IT), UoPerugia (IT), GR (IT), UoOslo (NO), UdeGoias (BR), Jimei Uni (CN), UoLagos (NG), UNESP (BR), UNESP-CAUNESP (BR), Yunnan Ag. Uni (CN), Jimei Uni (CN), Huazhong Ag. Uni (CN), Chinese Acad of Fisheries Science (CN), Fed Uni of Tech Yola (NG)

Behaviour: UoStirling (UK), WU (NL), IRTA (ES), UoMarche (IT), IFAPA (ES), CCMAR (PT), Aarhus Uni (DK), KWR (NL), UNESCO-IHE (NL), Delft (NL), ICMAN-CSIC (ES), IPMA (PT), Sparos Lda-CRIA (PT), Aquafin CRC (AU), UTS (AU), Hong Kong Uni of Science and Tech (CN), Port Stephens Fisheries Instit (AU), Can Tho (VN), Chinese Acad of Sciences (CN), Zhejiang Uni (CN), Uni Fed de Minas Gerais (BR), Uni Fed de Vicosa (BR)

Develop feeds with optimal composition to promote human health (subgoal 5.1)

Endocrinology: NIFES (NO), EWOS (NO), *CSIC (ES)*

Feed and feeding practices to increase biological efficiency (subgoal 5.3)

Defecation and Excretion: Nofima (NO), WU (NL), INRA-STPEE (FR), GABI (FR), UoSouthernDenmark (DK), Swedish Uni of Ag. Studies (SE), Nofima Marin (NO), UoGothenburg (SE), Humboldt-UoBerlin (DE), DTU (DK), Dartmouth (US), UoGuelph (CA), DFO (CA), UoLaval (CA), Taplow Feeds (CA)

Environmental Interactions and Impacts

Minimize biogenic emission (subgoal 2.1)

Benthic and Pelagic Impacts: NatRisk (IT), UoTorino (IT), NIWA (NZ), Xiamen Uni (CN), UoGuelph (CA), Memorial Uni (CA), Chinese Academy of Fishery Sciences (CN), National Research Instit of Aquaculture (JP), UoTokyo (JP)

Aquaculture in exposed areas (subgoal 2.3)

Benthic and Pelagic Impacts: HCMR- Aqualabs (GR), UoStirling (UK), NTNU (NO), ACE/SeaLab (NO), UoCrete (GR), Scottish Assoc. for Marine Science (UK), UNB (CA)

Welfare and Pathology

Transmission mechanisms of pathogens (subgoal 2.1)

Traceability: Bangor Uni (UK), Greenpeace (UK), Fishlab (IT), U.o.Iceland (IS), Matis ohf (IS), Suranaree Uni of Tech (TH), UoNhatrang (VN), Khon Kaen Uni (TH), Guangxi Institute for Food and Drug Control (CN)

Improve welfare/stress indices (subgoal 4.1)

Recirculation Systems: IFREMER (FR), DLO-IMARES (NL), WU-Wageningen (NL), IMR (NO), Inst Superior de Psicologia Aplicada (PT), COISPA (IT), Univ Jean Monnet (FR), Polish Academy of Sciences (PO), Univ Bordeaux (FR), Anglia Ruskin Univ (UK), Univ Autònoma de Barcelona (ES), PAS (ES), Ethics Institute (NL), Uo Murcia (ES), National Veterinary Inst Oslo (NO), Trans-National Consulting Partnership Glasgow (UK), St George's Univ of London (UK), Stazione Zoologica Anton Dohrn (IT), Univ de Caen (FR), Animals in Science Regulation Unit (UK), RSPCA (UK), UoCambridge (UK), UoSussex (UK), UoSt. Andrews (UK), The Boyd Group (UK), Tohoku University (JP)

The overall conclusions from this work show that European RIs cover a large part of the expertise and RI properties that are needed to comply with the main challenges in the aquaculture sector. However, as shown above, several important research needs are not sufficiently covered by European RIs. These gaps can be filled by establishing the facilities, services, expertise as specified above, and through collaboration with RIs outside Europe. The list of all RIs working in the gap areas is listed in Annex 3.

Annex 1

Deliverable Check list (to be completed by Deliverable leader)

	Check list		Comments
BEFORE	I have checked the due date and have planned completion in due time	X	*Please inform Management Team of any foreseen delays*
	The title corresponds to the title in the DOW	X	*If not please inform the Management Team with justification*
	The dissemination level corresponds to that indicated in the DOW	X	
	The contributors (authors) correspond to those indicated in the DOW	X	
	The Table of Contents has been validated with the Activity Leader	X	*Please validate the Table of Content with your Activity Leader before drafting the deliverable*
	I am using the AQUAEXCEL deliverable template (title page, styles etc)	X	*Available in "Useful Documents" on the collaborative workspace*
The draft is ready			
AFTER	I have written a good summary at the beginning of the Deliverable	X	*A 1-2 pages maximum summary is mandatory (not formal but really informative on the content of the Deliverable)*
	The deliverable has been reviewed by all contributors (authors)	X	*Make sure all contributors have reviewed and approved the final version of the deliverable. You should leave sufficient time for this validation.*
	I have done a spell check and had the English verified	X	*Ask a colleague with a good level of English to review the language of the text and do a spell-check too.*
	I have sent the final version to the Activity Leader and to the 2nd Reviewer for approval	X	*Send the final draft to your Activity Leader and the 2nd Reviewer and leave 2 weeks for feedback and final changes before the due date. Once validated by the 2 reviewers, the draft is ready to be sent to the Management Team that will ask for the Coordinator validation and then transfer it to the EC.*

Annex 2: EATIP Thematic Areas.

From: "European Aquaculture, Technology and Innovation Platform (EATIP).The Future of European Aquaculture. A strategic Agenda for Research & Innovation, 2012."
(TA 6 and TA 8 were not considered in the AQUAEXCEL RI gap analysis and are not listed)

THEMATIC AREA 1 (TA 1): PRODUCT QUALITY, CONSUMER SAFETY AND HEALTH

GOAL 1: Maximize the health benefits of aquaculture products

Subgoal 1.1 Identify relevant bioactive compounds present in aquaculture products.
Subgoal 1.2 Better understand the mechanisms and synergies underlying the health benefits of bioactive components from aquaculture products in the promotion of human health.
Subgoal 1.3 Investigate the specific effects of aquaculture products in sub-groups of the population with specific dietary needs.
Subgoal 1.4 Explore the differences in terms of health benefit between species and production methods including feed composition.

GOAL 2: Ensure the continuing safety of aquaculture products

Subgoal 2.1 Identify, manage and eliminate existing and potential physical, chemical and biological new hazards and emerging risks; including virus, bacteria, toxins, persistent organic pollutants (POPs), toxin substances etc.
Subgoal 2.2 Make available to producers of aquaculture products user-friendly methods to monitor and control the safety of the production, targeting known and emerging hazards.
Subgoal 2.3 Ensure the manufacture of authentic aquaculture products, regarding the species, quality, processing additives, production method and geographic origin.
Subgoal 2.4 Better understand the mechanisms and synergies underlying the health risks of undesirable compounds potentially present in aquaculture products for risk management purposes.

GOAL 3: Deliver high quality European aquaculture products - fully meeting consumer expectations including appearance, taste, texture, nutrition and provenance claims

Subgoal 3.1 Define and standardize quality parameters of aquaculture products.
Subgoal 3.2 Develop and validate practical tools and fast methods for processors to measure aquaculture product quality, including physical/chemical parameters such as texture, color, fat content and to mimic organoleptic parameters such as juiciness.
Subgoal 3.3 Develop and/or implement new technologies and materials in the seafood processing industry which enhance quality, including that of products to be sold alive.
Subgoal 3.4 Define and describe the parameters that can be manipulated to create differentiated products targeted at particular markets and consumer groups.
Subgoal 3.5 Develop and establish the foundations for successful commercial implementation of a robust product certification and a consumer-friendly labelling system for European aquaculture products, based on provenance and quality.

GOAL 4: Understand the dynamics of European seafood markets

Subgoal 4.1 Issue clear recommendations and guidelines for informed policy making on recommended consumption levels.
Subgoal 4.2 Identify and close harmful gaps in consumers' precipitation about aquaculture products and the current scientific knowledge.
Subgoal 4.3 Understand the dynamics of European seafood trade.

THEMATIC AREA 2 (TA 2): TECHNOLOGY AND SYSTEMS

GOAL 1: Ensure an environmental sustainable industry by the application of new knowledge and technology innovations

Subgoal 1.1 Development of technology preventing escapes of fish and eggs from production system.
Subgoal 1.2 Development of renewable energy sources for aquaculture production facilities.
Subgoal 1.3 To effectively manage waste nutrients cycling in production systems in order to increase its retention in aquaculture products (polyculture, IMTA, integrated aquaculture).
Su3bgoal 1.4 Reduce waste release from aquaculture production.
Subgoal 1.5 Develop and upgrade of existing technologies for more efficient use of freshwater resources.
Subgoal 1.6 Develop T&S for the mass production of aquatic organisms (e.g. plankton, seaweed) for industrial use.

GOAL 2: Meet the demand for aquaculture products in Europe by the development of efficient technologies to support continued growth

Subgoal 2.1 Develop technology and systems for best site selection.
Subgoal 2.2 Develop farming equipment and operational procedures for off-shore sites.
Subgoal 2.3 Maximize efficiency of Recirculation Aquaculture Systems (RAS) and reduce accumulation of persistent compounds.
Subgoal 2.4 Develop marine and freshwater integrated aquaculture systems (e.g. polyculture, IMTA) for production of present and new species and environmental services.
Subgoal 2.5 Develop production systems for new aquaculture products (e.g. new species, premium class and/or certified products) for changing markets.
Subgoal 2.6 Reduce the incidence of diseases by developing T&S.
Subgoal 2.7 Develop T&S for improved utilization of existing sites.
Subgoal 2.8 Development of technology to support production of new fish feeds (formulated, live feed etc.).

GOAL 3: Ensure the profitability of the aquaculture industry by developing improved management systems and technology

Subgoal 3.1 To improve technology for transfer, handling and slaughtering of aquaculture products with respect to welfare and ethics.
Subgoal 3.2 Development of automation for all stages of production (hatcheries, on growing, processing) for all present and future production system.
Subgoal 3.3 Improve or develop novel systems to control biofouling of aquaculture equipment.
Subgoal 3.4 Develop technologies for improved quality of seed for all present and future production system.
Subgoal 3.5 Developing technologies for total utilisation of farmed products.

GOAL 4: Ensure technology for ethical and healthy production of high quality aquatic products

Subgoal 4.1 Integration of technology management and biology to improve welfare and prevent disease outbreaks.
Subgoal 4.2 To improve technology for transfer, handling and slaughtering of aquaculture products with respect to welfare and ethics.
Subgoal 4.3 Develop standardized detection and quantification methods for pathogens affecting humans.

Subgoal 4.4 Develop technology and procedures for monitoring of welfare status of aquatic animals during all production stages.
Subgoal 4.5 Develop technology to prevent contamination of shellfish from external sources of human pathogens.

THEMATIC AREA 3 (TA 3): MANAGING THE BIOLOGICAL LIFECYCLE

GOAL 1: Establish predictability and improve output at every production stage of the lifecycle

Subgoal 1.1 Develop indicators and tools to estimate/measure predictability and establishing the current variation level in farms.
Subgoal 1.2 Improve animal performance at all stages, including egg and larval quality and its effects on performance during grow-out.
Subgoal 1.3 Improve sanitary control by better understanding the microbial environment (biotic & abiotic).
Subgoal 1.4 Ameliorate technological performance (protocols standardization / amended technology).
Subgoal 1.5 Support and promote a competent, highly skilled workforce across value chain.

GOAL 2: Genetic improvement of productive, health and animal welfare traits

Subgoal 2.1 Selective breeding to target important traits e.g. adaptation to alternative feed sources, disease resistance, feed efficiency, fillet yield, flesh quality, nutritional profile and human health factors.
Subgoal 2.2 Develop efficient tools (genetic, molecular, genomics) or adapt existing tools from other sectors, to introduce disease resistance in breeding programs and obtain robust animals, resistant to disease, stress, changing environment.
Subgoal 2.3 Identify and quantify genetic correlations between productive, disease resistance and welfare traits that will enforce synergies between traits and avoid unwanted effects of selective breeding for productivity traits.
Subgoal 2.4 Identification of the fields for transnational' –omic' research with clear potential benefit for industry (e.g. metabolomic indices of juvenile quality and develop strategies to utilize these in breeding programmes).
Subgoal 2.5 Increase industry and policy makers awareness and competence about potential gains and implementation of selective breeding programs.

GOAL 3: Improve broodstock management methods and control reproduction in captivity

Subgoal 3.1 Identify reproduction related problems, and knowledge gaps for each major aquaculture species in Europe (finfish and molluscs).
Subgoal 3.2 Evaluate the impact of sexual maturation on the welfare and potential risk of disease susceptibility.
Subgoal 3.3 Understand the role of genetic, physiological, nutritional, behavioural and environmental factors on the spawning of gametes of high quality and the timing of spawning to (i) facilitate year-round supply (for mass spawning) or (ii) to reproduce selected broodstock (for implementation of breeding programmes).
Subgoal 3.4 Control puberty by understanding the role of genetic and physiological factors, including the effects of environment, husbandry practices and nutrition.
Subgoal 3.5 Cryopreserve for biosecurity, predictability, distribution and bio-banking including reference libraries of natural populations.
Subgoal 3.6 Understand the basis sex determination and sex differentiation (genetic, environmental and physiological) to enable sex-ratio control measures.

Subgoal 3.7 Develop new sterilization methods as an alternative to triploidy, and when not possible methods to allow production of triploids on an industrial scale for species usually propagated with mass spawning (such as cod, sea bass, sea bream).

THEMATIC AREA 4 (TA 4): SUSTAINABLE FEED PRODUCTION

GOAL 1: Base formulation of Future Fish Feeds on solid knowledge of fish nutritional requirements, and expand the number of well characterized and sustainable raw materials which can be used

Subgoal 1.1 Improve knowledge on nutritional requirements of fish commonly farmed in Europe and for promising new species.
Subgoal 1.2 Characterize the nutritional value of alternative raw materials, particularly for new promising or underutilized sustainable marine or terrestrial sources, to increase flexibility in formulating highly nutritious feeds, of low environmental impact and appropriate for different aquaculture systems.
Subgoal 1.3 Clarify the potential of commonly used and novel micro-ingredients to optimize efficiency of diet utilization by fish.
Subgoal 1.4 Evaluate the effects of using alternative feed ingredients to the content of key bioactive compounds of aquaculture products and understand how to optimize their nutritional value in order to tailor aquaculture products for maximizing the consumer health benefits.
Subgoal 1.5 Adapt feeding procedures to ensure optimal feed utilization and minimize environmental impact.
Subgoal 1.6 Provide necessary information to support/change regulatory measures.

GOAL 2: Advanced novel feed technologies to produce cost effective feed with improved quality

Subgoal 2.1 Develop novel technology and improved processing routes for cost effective and sustainable fish feed production.
Subgoal 2.2 Novel and improved larval feed technology for better survival, larval growth performance and quality.
Subgoal 2.3 Improved understanding of the interactions between ingredient properties and processing conditions affecting physical feed quality and utilization of nutrients.

GOAL 3: Understand and minimize undesirable effects of alternative diets on fish health and welfare

Subgoal 3.1 Response of alimentary system in farmed fish to alternative feeds and development of methods and markers for assessing dietary effects.
Subgoal 3.2 Role of nutrition, diet and feed additives on the gastrointestinal and systemic immune system and disease susceptibility.
Subgoal 3.3 Evaluation of the relation of dietary changes to the aetiology of production diseases.
Subgoal 3.4 Evaluation of diet involvement in stress, behavioural and feeding responses of fish and methods for remediating possible adverse effects and optimizing performance.

GOAL 4: Adapt and utilize advanced methods to understand and model nutritional responses

Subgoal 4.1 In vivo and in vitro models to examine physiological responses to nutrients.
Subgoal 4.2 Integrative tools and ‘omic’ tools.
Subgoal 4.3 Mathematical modeling of nutritional responses and possible contaminant accumulation in fish.

GOAL 5: Resolve strategic research problems in fish nutrition

Subgoal 5.1 Develop feeds to i) maximize protein accretion and minimize lipid deposition, ii) achieve optimal product composition that will promote human health.
Subgoal 5.2 Development of selection tools for improving nutrient utilization and protein/lipid deposition contributing to biological efficiency of aquaculture species via selective breeding and via choice of broodstock material (species or strains).
Subgoal 5.3 Formulate targeted feed and feeding practices that condition farmed species to novel feeds, increase adaptability, reduce stress, and increase biological efficiency.

THEMATIC AREA 5 (TA 5): INTEGRATION WITH THE ENVIRONMENT

GOAL 1: Establish fundamental scientific knowledge on the assimilation capacity of biogenic wastes from aquaculture to determine acceptable emission rates for benthic and pelagic ecosystems (Biogenic waste assimilation in ecosystems)

Subgoal 1.1 Establish a scientific-based concept for the management of biogenic waste emission to open waters and relevant indicators for assessing chemical and ecosystem state as a contribution for the implementation of the Water Framework Directive (WFD).
Subgoal 1.2 Determine assimilative capabilities and the environmentally-acceptable critical loading rates of biogenic wastes per volume and per area of sea floor, including the contribution or ecological services of shellfish and macro-algae farmed in aquaculture locations.
Subgoal 1.3 Establish integrated management tools for waste emission which consider assimilation capabilities, hydrodynamic energy and presence of sensitive habitats as a tool for siting, spatial planning and ecosystem-based management of aquaculture.

GOAL 2: Establish technology to minimize emission of biogenic matter from aquaculture and to minimize the potential environmental influence of the actual emissions by means of environmental management and integrated multi-trophic aquaculture (Technology to minimize biogenic impacts).

Subgoal 2.1 Improve feeding technology, feeding management and feed composition in order to minimise biogenic emission from aquaculture installations per unit fish produced.
Subgoal 2.2 Learn how optimal siting and the best available technology for environmental management can minimize the potential environmental influence of emissions per unit fish produced.
Subgoal 2.3 Explore the potential environmental benefits of an expansion of marine aquaculture of fish, shellfish and macro-algae to exposed Atlantic and European marginal seas.
Subgoal 2.4 Explore potentials of utilising wastes from existing and new European fish farms in exposed waters for combining feed and extractive aquaculture (IMTA), with a focus on co-farming of fish, macro-algae and vulnerable non-fed invertebrates.

GOAL 3: To understand the fate and cumulative effects of synthetic agents used in aquaculture and minimizing their impact on the environment (Fate of Synthetic agents in ecosystem)

Subgoal 3.1 Understand better mechanisms and risks for harmful ecosystem interactions of pharmaceuticals and chemical antifouling agents.
Subgoal 3.2 Study cumulative effects and fate of pharmaceuticals, chemical antifouling agents, and new feed ingredients that are introduced in their ecosystem interaction in the near site and far-field environments.

Subgoal 3.3 Improve access to field data with the possibility of building a transparent surveillance and reporting network of the fish infections and volumes and classes of pharmaceuticals used by fish farms to regulatory agencies in order to minimize their usage and their impact into the environment.

GOAL 4: To establish more fundamental knowledge to understand the interactions between farmed and wild stocks, including wildlife (Interactions of farmed and wild stocks)

Subgoal 4.1 Improve knowledge of the potential positive and negative aquaculture interactions with fisheries and ecosystems, including wild life, predators and exotic species.
Subgoal 4.2 Enhance knowledge and understanding the genetic interactions between wild and farmed stocks.
Subgoal 4.3 Understand better disease and parasite interactions between farmed and wild organisms.

GOAL 5: Develop or adapt tools and measures in support of appropriate environmental governance for aquaculture (Tools for environmental governance)

Subgoal 5.1 Develop new planning tools and adapt existing tools used for site selection, based on ecosystem assimilative capacity and spatial planning for further aquaculture development.
Subgoal 5.2 Develop new management tools and adapt existing tools and measures used for environmental monitoring, production optimization and minimizing aquaculture influence.
Subgoal 5.3 Harmonize environmental regulations and legislation, implementing common regulations between European countries.
Subgoal 5.4 Develop techniques and procedures for quantification of environmental and ecological services provided by aquaculture farms and encourage voluntary farmer-based contributions to environmental management.

THEMATIC AREA 7 (TA 7): AQUATIC ANIMAL HEALTH AND WELFARE

GOAL 1: Improve fish health by increasing the understanding of host pathogen interactions and to have access to effective vaccines and immunomodulators

Subgoal 1.1 Improving understanding of host pathogen interactions.
Subgoal 1.2 Development of new vaccines & improvement of existing vaccines and diagnostic tests, including their application to all stages of finfish life cycle.
Subgoal 1.3 Research required on mode of action and use of immunomodulators.

GOAL 2: Appy epidemiological principles to minimize the threat of existing, emerging and exotic diseases

Subgoal 2.1 Improve understanding of transmission mechanisms of pathogens at all levels from farm, through country, to Europe wide.
Subgoal 2.2 Understand the industry structure (network) and its vulnerabilities to endemic and epidemic diseases.
Subgoal 2.3 Development of framework (model) for evaluating the relative importance of health and welfare threats, including bio-economic modeling, risk assessment and biosecurity.
Subgoal 2.4 Improve strategic data availability through standardization.
Subgoal 2.5 Turn understanding into strategies through industry, government and academic participation in research and consultation.

GOAL 3: Use and develop best practice to optimize efficacy of treatments and prevention methods

Subgoal 3.1 Minimise treatment when possible by using best practice.
Subgoal 3.2 Investigate alternative remedies and methods such as probiotics and biological control.
Subgoal 3.3 Improve and streamline the medicine and vaccine licensing system.
Subgoal 3.4 Improve application of management measures with emphasis on alternative control measures.
Subgoal 3.5 Develop methods for effective delivery of treatments in novel systems e.g. large off-shore cages, well boats etc.

GOAL 4: Measure welfare/stress and understand its consequences if compromised in order to incorporate welfare as core component of production management

Subgoal 4.1 Develop and Improve existing welfare/stress indices.
Subgoal 4.2 Understand and quantify short and long term consequences of compromised welfare, such as reduced growth, reduced feed efficiency, health, treatment effects, product quality.
Subgoal 4.3 Incorporate welfare/low stress management as a major factor in production and legislation decisions and in on-going risk, cost and gap analysis.

Annex 3: Identified RI institutions with expertise in gap areas

Country	RI Institution	Gap Areas and related expertise
Czech Republic	University of South Bohemia in Ceske Budejovice, Faculty of Fisheries and Protection of Waters	4.1.1.2 Defecation and Excretion
Denmark	Aller Aqua A/S	4.5.5.3 Defecation/Excretion
	Department of Biochemistry and Molecular Biology,University of Southern Denmark	4.5.5.3 Defecation/Excretion
	Division of Industrial Food Research, National Food Institute, Technical University of Denmark	4.5.5.3 Defecation/Excretion
	National Food Institute, DTU	4.5.5.3 Defecation/Excretion
	National Institute of Aquatic Resources, Technical University of Denmark, Charlottenlund Castle, Charlottenlund, Denmark	4.5.5.3 Defecation/Excretion
	National Veterinary Institute, Technical University of Denmark, Bülowsvej 27, 1790 Copenhagen V, Denmark	2.2.2.7 Recycling Systems
	Zoophysiology Section, Department of Bioscience, Aarhus University	4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
Faroe Islands	Food, Veterinary and Environmental Agency, Falkavegur 6, FO-110 Torshavn, Faroe Islands	2.2.2.7 Recycling Systems
Finland	Finnish Food Safety Authority (EVIRA), Mustialankatu 3, FI-00790 Helsinki, Finland	2.2.2.7 Recycling Systems
	Finnish Game and Fisheries Research Institute, Helsinki	2.2.2.1 Cage Systems
France	Station Marine, Université Bordeaux 1, CNRS, UMR 5805 EPOC, Place du Dr Peyneau, 33120, Arcachon, France	7.4.4.1 Recycling Systems
	Groupe Memoire et Plasticite comportamentale, University de Caen Basse-Normandie, F-14032, Caen cedex, France	7.4.4.1 Recycling Systems
	IFREMER	2.1.1.6 New Feed Resources
		2.2.2.1 Eutrophication
		2.2.2.7 Recycling Systems
		2.4.4.2 Slaughtering
		4.1.1.2 Defecation and Excretion
		4.1.1.5 Reproduction
		7.4.4.1 Recirculation Systems
	Institut National de la Recherche Agronomique (INRA)	2.1.1.5 Benthic and Pelagic Impacts
		2.2.2.1 Eutrophication
		4.1.1.2 Defecation and Excretion
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Metabolism
		4.1.1.5 Reproduction
		4.5.5.3 Defecation and Excretion

		5.2.2.3 Benthic and Pelagic Impacts
	Laboratoire Ecologie et Neuro-Ethologie Sensorielles (EA3988), Université Jean Monnet, 23 rue Dr Paul Michelon, 42023, Saint-Etienne Cedex 02, France	7.4.4.1 Recycling Systems
	MARBEC, Université des sciences et Techniques du Languedoc, Place Eugène Bataillon, CC093, F-34095 Montpellier, France	2.2.2.1 Eutrophication
Germany	Association for Marine Aquaculture (GMA)	2.1.1.6 New Feed Resources
	Bremerhaven University of Applied Sciences, Applied Marine Biology, An der Karlstadt 8, 27568, Bremerhaven, Germany	2.3.3.3 Recycling Systems
	Center for Tropical Marine Ecology (ZMT), Fahrenheitstrasse 6, 28359, Bremen, Germany	2.3.3.3 Recycling Systems
	Faculty of Agriculture and Horticulture, Humboldt-Universität zu Berlin	4.5.5.3 Defecation/Excretion
	Hermetia Futtermittel GbR, Baruth/Mark, Germany	2.1.1.6 New Feed Resources
	Institute for Marine Resources (IMARE), Bussestrasse 27, 27570, Bremerhaven, Germany	2.3.3.3 Recycling Systems
	Institute of Animal Breeding and Husbandry, Dep. Marine Aquaculture, Christian-Albrechts Universität zu Kiel, Germany	2.1.1.6 New Feed Resources
	Leibnitz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany	2.1.1.6 New Feed Resources
	nstitute of Animal Nutrition and Physiology, Christian-Albrechts Universität zu Kiel, Germany	2.1.1.6 New Feed Resources
	ttz Bremerhaven	2.1.1.6 New Feed Resources
Greece	Marine, Ecology Lab, Biology Department, University of Crete	5.2.2.3 Benthic/Pelagic Impacts
Iceland	Matis ohf, Vínlandsleið 12, 113 Reykjavik, Iceland	2.2.2.1 Eutrophication
		7.2.2.1 Traceability
	University of Iceland, Sæmundargötu 2, 101 Reykjavik, Iceland	7.2.2.1 Traceability
	Icelandic Food and Veterinary Authority, Austurvegur 64,800 Selfoss, Iceland	2.2.2.7 Recycling Systems
Ireland	BEES, University College Cork, Cooperage, Distillery Fields, North Mall, Cork, Republic of Ireland	2.3.3.3 Recycling Systems
	Tyndall National Institute, Lee Maltings, Dyke Parade, Cork, Republic of Ireland	2.3.3.3 Recycling Systems
Israel	Agricultural Research Organization, Volcani Center, POB 6, Bet Dagan 50250 Israel	2.1.1.6 New Feed Resources
	Department of Civil & Environmental Engineering Technion Israel Institute of Technology, Haifa	2.1.1.6 New Feed Resources
	The National Center for Mariculture, Israel Oceanographic and Limnological Research, P.O. Box	2.1.1.6 New Feed Resources
Italy	COISPA Tecnologia & Ricerca, via dei Trulli, 18-20, 70126, Bari, Italy	7.4.4.1 Recycling Systems
	Centro Interdipartimentale NatRisk	5.2.2.1 Benthic/Pelagic Impacts
	CNR – ISMAR – Marine Sciences Institute in Genoa, Via De Marini 6, Genova 16129, Italy	2.3.3.3 Recycling Systems

	Department of Fisheries and Aquaculture, Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, Rome, Italy.	2.1.1.6 New Feed Resources
	DIFI – University of Genoa, Via Dodecaneso 33, Genova 16146, Italy	2.3.3.3 Recycling Systems
	Dip. Scienze Economico-Estimative e degli Alimenti, Sez. Chimica Bromatologica, Biochimica, Fisiologia e Nutrizione, Università degli Studi di Perugia, Perugia, Italy	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	Dipartimento di Biomedicina Comparata e Alimentazione, Università degli Studi di Padova, Legnaro (PD), Italy	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	FishLab, Department of Veterinary Sciences, University of Pisa, Via delle Piagge 2, 56124 Pisa, Italy	7.2.2.1 Traceability
	IBF – CNR Genoa, Via De Marini 6, Genova 16129, Italy	2.3.3.3 Recycling Systems
	Pesca Lagunare, Orbetello (GR), Italy	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	Polytechnic University of Marche	4.1.1.5 Behaviour
		4.1.1.5 Growth and Metabolism
	Scuola di Bioscienze e Biotecnologie, Università di Camerino, Camerino (MC), Italy	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	Stazione Zoologica Anton Dohrn, Villa Comunale, 80121, Napoli, Italy	7.4.4.1 Recycling Systems
	Università degli Studi di Torino, Dipartimento di Chimica	5.2.2.1 Benthic/Pelagic Impacts
Netherlands	Ethics Institute, Janskerkhof 13A, 3512 BL, Utrecht, The Netherlands	7.4.4.1 Recycling Systems
	Institute of Environmental Sciences (CML), Department of Industrial Ecology, Leiden University, 2333 CC, Leiden, the Netherlands	2.1.1.5 Eutrophication
	KWR Watercycle Research Institute, Groningenhaven 7, 3433 PE, Nieuwegein, The Netherlands	4.1.1.5 Behaviour
	TU Delft, Julianalaan 67, 2628 BC, Delft, The Netherlands	4.1.1.5 Behaviour
	UNESCO-IHE, Westvest 7, 2611 AX, Delft, The Netherlands	4.1.1.5 Behaviour
	Wageningen University, Animal Science Group	2.1.1.5 Recirculation Systems
		2.4.4.2 Slaughtering
		4.1.1.2 Defecation and Excretion
		4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
		4.5.5.3 Defecation and Excretion
		7.4.4.1 Recirculation Systems
Norway	Aquaculture Protein Centre, CoE, Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences,	4.1.1.2 Reproduction
		4.1.1.5 Growth and Dvlpmt
	Department of Biology, University of Bergen, High Technology Centre, N-5020, Bergen, Norway	2.4.4.2 Harvest and Slaughter

	Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Science, 1432, Ås, Norway	2.4.4.2 Harvest and Slaughter
	Department of Pharmaceutical bioscience, School of Pharmacology, University of Oslo, Oslo, Norway	4.1.1.2 Defecation and Excretion
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	EWOS Innovation AS, Dirdal	4.1.1.5 Defecation and Excretion
		4.5.5.1 Endocrinology
	Institute of Marine Research (IMR)	2.4.4.2 Slaughtering
		7.4.4.1 Recirculation Systems
	Lerøy Fossen, Osterøy, Norway	2.4.4.2 Harvest and Slaughter
	National Institute of Nutrition and Seafood Research (NIFES)	2.2.2.7 Recycling Systems
		4.1.1.5 Defecation and Excretion
		4.5.5.1 Endocrinology
	National Veterinary Institute Oslo	2.2.2.7 Recycling Systems
		7.4.4.1 Recycling Systems
	NOFIMA and University of Tromsø	2.4.4.2 Slaughtering
	Nofima Marin- Ås	2.4.4.2 Harvest and Slaughter
		4.1.1.2 Defecation and Excretion
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
		4.5.5.3 Defecation/Excretion
		7.4.4.1 Recycling Systems
	NOFIMA Norconserv, Box 327, N-4002 Stavanger, Norway	2.4.4.2 Harvest and Slaughter
	Norwegian University of Science and Technology (NTNU)	2.2.2.1 Biofouling
		2.2.2.1 Cage Systems
		2.2.2.7 Transport
		2.3.3.3 Recirculation Systems
		2.4.4.2 Slaughtering
		5.2.2.3 Benthic and Pelagic Impacts
	SINTEF Fisheries and aquaculture	5.2.2.3 Benthic and Pelagic Impacts
	University of Nordland	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
Poland	Institute of Oceanology, Polish Academy of Sciences, 81-712, Sopot, Poland	7.4.4.1 Recycling Systems
	PAS, Institute of Ichthyobiology and Aquaculture, ul. Kalinowa 2, 43-520, Zaborze, Poland	7.4.4.1 Recycling Systems
Portugal	CCMAR — Centro de Ciências do Mar do Algarve, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal	4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
		7.4.4.1 Recycling Systems

	CIBIO- Department of Biology, Universidade dos Acores, Acores	2.2.2.1 Biofouling
	Instituto Superior de Psicologia Aplicada, Unidade de Investigação em Eco-Etologia, Rua Jardim do Tabaco 34, 1149-041, Lisbon, Portugal	7.4.4.1 Recycling Systems
	Interdisciplinary Centre of Marine and Environmental Research	2.1.1.6 New Feed Resources
	IPMA, Av. Brasilia, 1449-006 Lisboa, Portugal	4.1.1.5 Behaviour
	Sparos Lda-CRIA, Universidade do Algarve, 8005-139 Faro, Portugal	4.1.1.5 Behaviour
Serbia	University of Belgrade, Faculty of Agriculture, Faculty of Veterinary Medicine	7.4.4.1 Recycling Systems
Spain	Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC), Apartado Oficial, 11510 Puerto Real, Cádiz, Spain	4.1.1.5 Behaviour
	Department of Physiology, Faculty of Biology, University of Murcia, 30100, Murcia, Spain	7.4.4.1 Recycling Systems
	Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC)	4.5.5.1 Endocrinology
	Andalusian Institute for Research and Training in Agriculture, Fisheries, Foods and Organic Production (IFAPA)	4.1.1.5 Behaviour
	Department of Applied Biology, University of Almeria	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
		7.4.4.1 Recycling Systems
	IRTA (Institute Research & Technology Food & Agriculture)	4.1.1.5 Behaviour
	Universitat Autònoma de Barcelona, 08193, Cerdanyola del Vallés, Barcelona, Spain	7.4.4.1 Recycling Systems
Sweden	Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences	4.5.5.3 Defecation/Excretion
	Department of Biological and Environmental Sciences, University of Gothenburg	4.5.5.3 Defecation/Excretion
	Department of Food Science, SLU, Uppsala, Sweden	4.1.1.2 Defecation and Excretion
	Department of Wildlife, Fish and Environmental Studies, Swedish University of Agricultural Sciences	4.5.5.3 Defecation/Excretion
	National Veterinary Institute, Department of Animal Health and Microbial Strategies, Division of Fish, S-751 89 Uppsala, Sweden	2.2.2.7 Recycling Systems
UK	International Paint Ltd. (a division of Akzo-Nobel) , Felling , Gateshead , NE10 0JY , UK	2.3.3.3 Recycling Systems
	Scottish Oceans Institute, Gatty Marine Laboratory, School of Biology, University of St. Andrews, St. Andrews, Fife, KY16 8LB, Scotland, UK	7.4.4.1 Recycling Systems
	Anglia Ruskin University, East Road, Cambridge, CB1 1PT, UK	7.4.4.1 Recycling Systems
	Aquaculture and Fish Nutrition Research Group, School of Biological Sciences, The University of Plymouth, Plymouth, Devon, UK,	4.1.1.2 Defecation and Excretion
	Division of Biology, Imperial College London, Ascot, UK	2.1.1.5 Eutrophication

	Division of Biomedical Sciences, St George's University of London, Cranmer Terrace, London, SW17 0RE, UK	7.4.4.1 Recycling Systems
	Greenpeace UK	7.2.2.1 Traceability
	Home Office, Animals in Science Regulation Unit, Dundee, DD1 9WW, Scotland, UK	7.4.4.1 Recycling Systems
	Molecular Ecology and Fisheries Genetics Laboratory, Bangor University, Bangor, Wales, UK	7.2.2.1 Traceability
	RSPCA Research Animals Department, Southwater, RH13 9RS, West Sussex, UK	7.4.4.1 Recycling Systems
	School of Biosciences, University of Birmingham , Birmingham , B12 2TT , UK	2.3.3.3 Recycling Systems
	School of Life Sciences, University of Sussex, Brighton, BN1 9QG, UK	7.4.4.1 Recycling Systems
	Scottish Association for Marine Science, Scottish Marine Institute	5.2.2.3 Benthic/Pelagic Impacts
	Sunday Times, London, UK	7.2.2.1 Traceability
	The Boyd Group, Hereford, UK	7.4.4.1 Recycling Systems
	Trans-National Consulting Partnership Glasgow	7.4.4.1 Recycling Systems
	University of Cambridge, Department of Zoology, Cambridge, CB2 1TN, UK	7.4.4.1 Recycling Systems
	University of Stirling	2.1.1.6 New Feed Resources
		2.2.2.1 Cage Systems
		4.1.1.5 Behaviour
		5.2.2.3 Benthic and Pelagic Impacts
USA	Fort Valley State University, Fort Valley, GA 31030, USA	3.3.3.7 Growth and Development
		3.3.3.7 Quantitative Genetics
		3.3.3.7 Reproduction
	South Dakota Department of Game, Fish and Parks	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	South Dakota State University	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	Iowa State University	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	Nutraferma Inc	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	United States Department of Agriculture, Agricultural Research Service, National Cold Water Marine Aquaculture Center	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	Emmett Interdisciplinary Program in Environment and Resources, Stanford	2.1.1.5 Benthic
		2.1.1.5 Recycling Systems
	Center on Food Security and the Environment, Stanford University, Stanford, California 94305-6055;	2.1.1.5 Benthic
		2.1.1.5 Recycling Systems
	Environmental Studies Program, Dartmouth College,	4.5.5.3 Defecation/Excretion
	United States Department of Agriculture, Agricultural Research Service, National Center for Cool and Cold Water Aquaculture	4.1.1.5 Defecation and Excretion

	Novus International Inc., 5 Tomotley Ct. Charleston SC 29407 USA.	2.1.1.6 New Feed Resources
	Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, AL	2.1.1.6 New Feed Resources
		3.3.3.7 Growth and Development
		3.3.3.7 Quantitative Genetics
		3.3.3.7 Reproduction
	Dept. of Ecology and Evolutionary Biology, University of Connecticut, 1 University Place, Stamford,	2.1.1.6 New Feed Resources
	Atlantic Marine Aquaculture Center, University of New Hampshire	2.2.2.1 Cage Systems
	C.W. Post Campus, Long Island University, Brookville, NY, USA	2.3.3.3 Recycling Systems
	Stony Brook-Southampton, Southampton, NY, USA	2.3.3.3 Recycling Systems
	Cornell Cooperative Extension of Suffolk County, Southold, NY, USA	2.3.3.3 Recycling Systems
	Department of Animal Sciences, Purdue University, West Lafayette, Indiana, United States of America	3.3.3.7 Growth and Development
		3.3.3.7 Quantitative Genetics
		3.3.3.7 Reproduction
Korea	Department of Ecological Engineering, Pukyong National University, Busan, Republic of Korea	3.3.3.7 Growth and Development
		3.3.3.7 Quantitative Genetics
Canada	Fish Nutrition Research Laboratory, Department of Animal and Poultry Science, University of Guelph	4.5.5.3 Defecation/Excretion
		5.2.2.1 Benthic/Pelagic Impacts
	Department of Fisheries and Oceans (DFO), Centre for Aquaculture and Environmental Research, UBC	4.5.5.3 Defecation/Excretion
	Department of Animal Science, Université Laval	4.5.5.3 Defecation/Excretion
	Taplow Feeds	4.5.5.3 Defecation/Excretion
	Department of Fisheries and Oceans Canada (DFO), Ottawa	4.5.5.3 Defecation/Excretion
	Ocean Sciences Centre, Memorial University of Newfoundland	5.2.2.1 Benthic/Pelagic Impacts
	Department of Biology and Canadian Rivers Institute, University of New Brunswick,	5.2.2.3 Benthic/Pelagic Impacts
	Department of Animal and Poultry Science, University of Saskatchewan, 51 Campus Drive, Saskatoon, SK, S7N 5A8, Canada	4.1.1.2 Reproduction
	Canadian Integrated Multi-Trophic Aquaculture Network (CIMTAN), University of New Brunswick, P. O.	2.1.1.6 New Feed Resources
	Department of Fisheries and Oceans, Biological Station, St. Andrews, New Brunswick, Canada	2.1.1.6 New Feed Resources
China	Key Laboratory of Aquaculture Nutrition and Feed, Ministry of Agriculture, and the Key Laboratory of Mariculture Ministry of Education, Ocean University of China	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	Key Laboratory of Ecology and Environment Science in Guangdong Higher Education,	4.1.1.5 Defecation and Excretion

	Guangdong Provincial Key Laboratory for Healthy and Safe Aquaculture, College of Life Science, South China Normal University, Guangzhou, China	4.1.1.5 Reproduction
	Beijing Nutrition Resources Institute, Beijing, China	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	Clinical Laboratory, The Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	College of Animal Science and Technology, Yunnan Agricultural University, Kunming, China	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	College of Fisheries, Jimei University, Xiamen, China	4.1.1.5 Growth and Dvlpmt
		4.1.1.5 Reproduction
	Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences	5.2.2.1 Benthic/Pelagic Impacts
	Environmental Science Research Center , Xiamen University , Xiamen , 361005 , P. R. China	5.2.2.1 Benthic/Pelagic Impacts
	State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences,	5.2.2.1 Benthic/Pelagic Impacts
	Hubei Key Laboratory of Genetic Regulation and Integrative Biology, College of Life Science, Huazhong Normal University, Wuhan, China	4.1.1.2 Reproduction
	Marine Fishery Institute of Zhejiang Province, Key Lab of Mariculture and Enhancement of Zhejiang Province, Zhoushan	4.1.1.5 Reproduction
	College of Fishery, Huazhong Agricultural University, Wuhan, Hubei Province 430070, China	4.1.1.5 Growth and Dvlpmt
	Key Laboratory of Freshwater Biodiversity Conservation, Ministry of Agriculture of China, Yangtze River Fisheries Research Institute, Chinese Academy of Fisheries Science, Wuhan 430223, China	4.1.1.5 Growth and Dvlpmt
	Institute of Oceanology, Chinese Academy of Sciences, Tsingtao 266071, China	4.1.1.5 Behaviour
	University of Chinese Academy of Sciences, Beijing 100871, China	4.1.1.5 Behaviour
	Ningbo Institute of Technology, Zhejiang University, 1 Qianhu Road, Ningbo 315100, China	4.1.1.5 Behaviour
	Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong SAR	4.1.1.5 Behaviour
	Guangxi Institute for Food and Drug Control, Nanning, Guangxi, PR China	7.2.2.1 Traceability
	School of Biological Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong, P. R. China	2.1.1.6 New Feed Resources
	Key and Open Laboratory of Marine and Estuary Fisheries (Ministry of Agriculture), East China Sea Fisheries Research Institute, Chinese Academy of Fisheries Science, Shanghai, 200090, China	2.3.3.3 Recycling Systems
	Institute of Life Science and Technology, Zhanjiang Normal University, Zhanjiang, 524048, China	2.3.3.3 Recycling Systems

	Marine Resources and Nutrition Biology Research Center, School of Food Science and Biotechnology, Zhejiang Gongshang University, Hangzhou 310035, China	2.4.4.2 Harvest and Slaughter
	College of Physics and Electronic Information and Department of Chemistry, Wenzhou University, Wenzhou 325035, China	2.4.4.2 Harvest and Slaughter
	State Key Laboratory of Food Science and Technology, School of Food Science and Technology, Jiangnan University, Wuxi, Jiangsu, P.R. China	3.3.3.7 Quantitative Genetics
Iran	Department of Marine Chemistry, Faculty of Marine Science and Technology, North Tehran Branch, Islamic Azad University	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	Department of Biology, Faculty of Science, Payame Noor University	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
	Department of Fisheries, Faculty of Animal Science and Fisheries, Sari Agricultural and Natural Resources University (SANRU), Sari, Iran	4.1.1.2 Defecation and Excretion
	Department of Clinical Sciences, Faculty of Veterinary Medicine, Shahid Bahonar University of Kerman, P.O. Box: 76169133, Kerman, Iran	2.4.4.2 Harvest and Slaughter
	Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, University of Tehran, P.O. Box: 14155-6453, Tehran, Iran	2.4.4.2 Harvest and Slaughter
Sri Lanka	National Aquatic Resource Research and Development Agency, Mattakkuliya,	4.1.1.2 Defecation and Excretion
		4.1.1.2 Reproduction
Nigeria	Department of Forestry, Wildlife and Fisheries Management, Faculty of Agricultural Sciences, University of Ado Ekiti	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	Department of Zoology, University of Ilorin	4.1.1.2 Defecation and Excretion
	Department of Marine Sciences, University of Lagos, Akoka, Lagos State, Nigeria.	4.1.1.5 Growth and Dvlpmt
	Deparment of Fisheries and Aquaculture, Federal University of Technology Yola, Adamawa State, Nigeria	4.1.1.5 Growth and Dvlpmt
	Department of Wildlife and Fisheries Management, Faculty of Agriculture and Forestry , University of Ibadan , Ibadan, Nigeria	2.2.2.1 Wildlife Interactions
Brazil	Universidade Federal de Goiás, Departamento de Zootecnia, Jataí, Goiás, Brasil	4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Dvlpmt
	Departamento de Melhoramento e Nutrição Animal, Faculdade de Medicina Veterinária e Zootecnia - UNESP, Botucatu, SP, Brasil	4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Dvlpmt
	Doutoranda do PPG em Aquicultura do Centro de Aquicultura da UNESP - CAUNESP, Jaboticabal, SP, Brasil	4.1.1.5 Defecation and Excretion
		4.1.1.5 Growth and Dvlpmt
	Laboratório de Aquacultura, Escola de Veterinária, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil	4.1.1.5 Behaviour

	Centro Integrado de Recursos Pesqueiros e Aquicultura de Três Marias - CODEVASF, Três Marias, MG, Brazil	4.1.1.5 Behaviour
	Departamento de Biologia Animal, Universidade Federal de Viçosa, Viçosa, MG, Brazil	4.1.1.5 Behaviour
	Dept. of Fish Engineering, State University of Maranhão, São Luis, Brazil.	2.1.1.6 New Feed Resources
Turkey	University of Sinop, Faculty of Aquaculture and Fisheries, Department of Aquaculture, 57000 Sinop, Turkey	4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	Department of Aquaculture, Armutlu Vocational College, University of Yalova	4.1.1.2 Defecation and Excretion
	Department of Aquaculture, Faculty of Fisheries, İzmir Katip Çelebi University	4.1.1.2 Defecation and Excretion
	Ministry of Food, Agriculture and Livestock, General Directorate of Fisheries and Aquaculture, Ankara, Turkey	4.1.1.5 Reproduction
	University of Gorgan, Agriculture Sciences and Natural Resources, Departeman of Fishery.	2.4.4.2 Harvest and Slaughter
Vietnam	College of Aquaculture and Fisheries, Can Tho University	2.4.4.2 Harvest and Slaughter
		4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
		4.1.1.5 Reproduction
	University of Nhatrang, 2 Nguyen Dinh Chieu, Nha Trang,	7.2.2.1 Traceability
	Research Institute for Aquaculture No. 1	2.1.1.6 New Feed Resources
Australia	CSIRO Marine Research	2.1.1.6 New Feed Resources
		2.3.3.3 Recycling Systems
		3.3.3.7 Growth and Development
		3.3.3.7 Quantitative Genetics
		3.3.3.7 Reproduction
	NSW Department of Primary Industries, Port Stephens Fisheries Institute, Australia	4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
	Aquafin CRC for the Sustainable Culture of Finfish, Australia	4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
	University of Technology (UTS), Sydney, NSW, Australia	4.1.1.5 Behaviour
		4.1.1.5 Defecation and Excretion
	Algae Biotechnology Laboratory, School of Agriculture and Food Sciences, The University of Queensland, St Lucia, QLD, 4072, Australia	2.1.1.6 New Feed Resources
	New South Wales Department of Primary Industries, Locked Bag 1, Nelson Bay, NSW 2315 Australia	2.1.1.6 New Feed Resources
	School of Chemical Engineering, The University of Adelaide, Adelaide, South Australia	2.1.1.6 New Feed Resources
	Sustainable Aquaculture Laboratory- Temperate and Tropical (SALTT) Department of Zoology, University of Melbourne, Victoria 3010, Australia	2.2.2.1 Cage Systems
		2.3.3.3 Recycling Systems
	School of Civil, Environmental and Chemical Engineering, RMIT University , Melbourne , Australia	2.3.3.3 Recycling Systems

	MACRO – the Centre for Macroalgal Resources and Biotechnology, School of Marine and Tropical Biology, James Cook University, Townsville, Queensland, Australia	2.3.3.3 Recycling Systems
	School of Environment, Science and Engineering, Marine Ecology Research Centre, Southern Cross University, Lismore, Australia	2.3.3.3 Recycling Systems
New Zealand	National Institute of Water and Atmospheric Research, NIWA, Christchurch	5.2.2.1 Benthic/Pelagic Impacts
	Cawthron Institute , Nelson , New Zealand	2.2.2.1 Biofouling
		2.3.3.3 Recycling Systems
Japan	National Research Institute of Aquaculture, Fisheries Research Agency,	5.2.2.1 Benthic/Pelagic Impacts
	Atmospheric and Ocean Research Institute, The University of Tokyo	5.2.2.1 Benthic/Pelagic Impacts
	Laboratory of Fish Nutrition, Facultuy of Agriculture, Kochi University	4.1.1.2 Defecation and Excretion
	Fuji Oil Co. Ltd. Hannan Research and Development Cener	4.1.1.2 Defecation and Excretion
	Department of Applied Biosciences, Faculty of Agriculture, Tohoku University, Amamiya 1-1, Sendai, 981-8555, Japan	7.4.4.1 Recycling Systems
Thailand	School of Biotechnology, Institute of Agricultural Technology, Suranaree University of Technology, 111 University Avenue, Nakhon Ratchasima 30000, Thailand	7.2.2.1 Traceability
	Embryo Technology and Stem Cell Research Center, Suranaree University of Technology, 111 University Avenue, Nakhon Ratchasima 30000, Thailand	7.2.2.1 Traceability
	Department of Microbiology, Faculty of Science, Khon Kaen University, Khon Kaen 40002, Thailand	7.2.2.1 Traceability
	Network of Aquaculture Centres in Asia-Pacific, Bangkok	2.1.1.6 New Feed Resources
	Applied Taxonomic Research Center, Department of Biology, Faculty of Science, Khon Kaen University	2.1.1.6 New Feed Resources
Indonesia	Research Institute for Mariculture, Gondol, Bali	2.1.1.6 New Feed Resources
Philippines	Integrated Services for Development of Aquaculture and Fisheries, Oloilo	2.1.1.6 New Feed Resources
India	Department of Biotechnology , The ICFAI University , Dehradun , 248197 , India	2.3.3.3 Recycling Systems
	Biofouling and Biofilm Processes Section, Water and Steam Chemistry Division, BARC Facilities , Kalpakkam , 603 102 , India	2.3.3.3 Recycling Systems
	Engineering Simulation Studies Section, Water and Steam Chemistry Division, BARC Facilities , Kalpakkam , 603 102 , India	2.3.3.3 Recycling Systems
Lebanon	Lebanese University, Faculty of Agricultural Engineer and Veterinary Medicine, Beirut, Dekwaneh, Lebanon	2.4.4.2 Harvest and Slaughter