SCAR
Standing Committee on Agricultural Research
FISH Fisheries and Aquaculture Research

EVALUATION OF THE FRESHWATER AQUACULTURE RESEARCH NEEDS IN EUROPE

Edited by

Péter Lengyel
Ministry of Agriculture, Hungary
Department of Fisheries Management

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Summary

As a result of the discussions about EU aquaculture research priorities during the meetings of the Strategic Working Group on Fisheries and Aquaculture of the Standing Committee on Agricultural Research (SCAR-Fish), it was realized that freshwater issues were strongly underrepresented in the fisheries and aquaculture research priority list. To determine the freshwater aquaculture priorities in the EU and strengthen this topic, an *ad-hoc* working group was established in the frame of SCAR-Fish at the 10th SCAR-Fish Meeting on 8 September 2015.

Altogether 15 Member States and 4 non-EU representatives of the main three sectors – governance, industry, research – took part in the prioritization work. As a result of the operation of the sub-group, a priority list was prepared on freshwater aquaculture research needs distinguishing the highest, medium-high and medium priorities.

The document was prepared on the basis of (1) the list of freshwater aquaculture research priorities collected within the frame of the "Freshwater aquaculture" sub-group of SCAR-Fish and discussed during subsequent SCAR-Fish and Friends of Freshwater Fisheries meetings; (2) an International workshop on freshwater aquaculture research priorities in Europe held in Tartu, Estonia, on 8-9 May 2019; and (3) prioritization questionnaires distributed at different aquaculture events.

Research topics of the highest priority

- Development of sustainable fish production technologies, sustainable intensification (Rercirculation Aquaculture Systems (RAS), Inetgrated Multi Trophic Aquauculture, Combined Intensive Extensive systems, aquaponics).
- Prevention and treatment of fish diseases including reducing of the use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for development of disease resistant strains.
- Profitability of aquatic production systems; production cost analysis of environmentally sustainable fish production technologies.

Research topics of medium-high priority

- Climate change studies.
- New aquaculture species and rearing technologies (both in ponds and RAS).
- Animal welfare in aquaculture systems.
- Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations.

Research topics of medium priority

- Optimizing the control and monitoring of water quality parameters and better end-of-pipe treatment of waste water before release to environment.
- Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers.
- Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand.

1. Background

As a result of the discussions about EU aquaculture research priorities during the meetings of the Strategic Working Group on Fisheries and Aquaculture of the Standing Committee on Agricultural Research (SCAR-Fish), it was realized that freshwater issues were strongly underrepresented in the fisheries and aquaculture research priority list. To determine the freshwater aquaculture priorities in the EU and strengthen this topic a prioritization work was initiated in the frame of SCAR-Fish. The results of these works are presented in this document that was prepared on the basis of:

- the collection of freshwater aquaculture research priorities collected within the frame of the "Freshwater aquaculture" sub-group of SCAR-Fish and discussed during subsequent SCAR-Fish and Friends of Freshwater Fisheries meetings;
- the freshwater aquaculture research priorities presented during the International workshop on freshwater aquaculture research priorities in Europe held in Tartu, Estonia, on 8-9 May 2019 (see Annex 1 and 2);
- the prioritization questionnaires distributed during the Tartu workshop and the 2019 General Assembly of the Network of Aquaculture Centres in Central and Eastern Europe (NACEE), held in Uzhhorod, Ukraine, on 23 May 2019.

2. Collection of freshwater aquaculture research priorities within the frame of SCAR-Fish

During the 10th SCAR-Fish Meeting on 8 September 2015, it was proposed to establish an *ad-hoc* working group for inland issues. During the 12th SCAR-Fish Meeting on 24 February 2016, an overview of the Central and Eastern European freshwater aquaculture was presented. During the 16th SCAR-Fish Meeting on 11 January 2017, the topic of freshwater aquaculture was included into the SCAR-Fish workplan with the objectives to prepare a summary of the freshwater aquaculture activities in Europe, to collect the research needs of the freshwater aquaculture sector and to compile recommendations to harmonise the legal backgrounds. Some (mostly unsuccessful) attempts were made to better involve the members of the informal „Friends of Freshwater Fisheries" (FFF) working group in the work of SCAR-Fish in order to strengthen the representation of inland aquaculture. An initial collection of freshwater aquaculture research priorities was launched by Hungary within the frame of FFF, whose results were presented at the 19th SCAR-Fish Meeting on 9 October 2017, along with an overview of freshwater aquaculture in Europe. During this exercise, the respondents (mostly from Hungary, the Czech Republic and Croatia), identified the following 9 priority topics of common interest:

- *New aquaculture species and rearing technologies in ponds and RAS.*
- *Prevention and treatment of fish diseases, reducing use of veterinary medicines through immune stimulants, breeding programmes for disease resistance.*
- *New, efficient fish feeds based on novel ingredients.*
- *Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics).*
- *Valorisation of ecosystem services of pond aquaculture, studying damages caused by protected fish-eating animals and ways of their prevention.*
- *Development of improved management and decision-making tools.*
- *Development of fish processing, new value-added fish products.*
- *Fish meat quality and human health impacts of fish consumption.*
- *Market studies.*

During the discussion of the topics at the 19th SCAR-Fish Meeting, several SCAR-Fish members indicated their willingness to include the freshwater research topics of their respective countries, too. Therefore, Hungary circulated the list once more among the members of SCAR-Fish and other countries interested in freshwater aquaculture, which proposed the inclusion of several additional research areas. A total of nine countries (Croatia, Czech Republic, Denmark, Finland, Germany, Hungary, Italy, Spain, Sweden) responded to the questionnaires this time. The proposed topics were once again merged into broader topics, resulting in the following list:

- *New aquaculture species and rearing technologies in ponds and RAS.*
- *Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance.*
- *Research on animal welfare in aquaculture systems.*
- *Research supporting the legalization of drugs for aquaculture including those for induced spawning.*
- *Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations.*
- *Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics).*
- *Valorisation of ecosystem and cultural services of pond aquaculture, studying damages caused by protected fish-eating animals and other nuisance species and ways of their prevention*
- *Development of improved management and decision support tools.*
- *Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers.*
- *Improving fish meat quality and its functional value for human consumption.*
- *Understanding market mechanisms and consumer preferences in European seafood markets.*
- *Profitability of aquatic production systems and innovations.*
- *Production cost analysis of environmentally sustainable fish production technologies.*
- *Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand.*
- *End of pipe treatment of waste water before release to environment.*
- *Optimizing the control and monitoring of water quality parameters.*
- *Microbial water quality.*
- *Better understanding of closed artificial ecosystems.*
- *Climate change studies.*

The updated and expanded list was further discussed at the FFF meeting on 4 December 2017, where it was suggested to prepare a shortlist of three or four priority topics for further elaboration and proposal for inclusion into the Horizon Europe programme, either through SCAR-Fish or the BIOEAST Initiative. The updated priority list was repeatedly presented within SCAR-Fish Meeting, where Estonia proposed to host and finance a prioritization workshop where participants could discuss the list of research topics and build consensus on which ones to propose for inclusion in further research programmes.

3. Research topics suggested during the Tartu workshop

The International workshop on freshwater aquaculture research priorities in Europe was held on May 8-9, 2019 at the Dorpat Convention Centre, Tartu, Estonia. The workshop was co-organized by the Ministry of Rural Affairs of Estonia and the Ministry of Agriculture of Hungary, and was hosted by the Fisheries Information Centre, University of Tartu, Estonia. The workshop was attended by 44 participants from 10 countries (Belgium, Bulgaria, Croatia, Czech Republic, Estonia, Finland, Germany, Hungary, Latvia, Poland), representing the sectors of aquaculture governance, research and production. During the workshop, the participants presented the status and challenges, as well as the research priorities of their national aquaculture sectors. The possibilities and obstacles of improving the efficiency and practical applicability of aquaculture research were also discussed. It became, however, clearly visible that the diversity of aquaculture practices and research needs made it extremely difficult to reach a consensus on the final shortlist of priorities. For this reason, it was decided to evaluate the views expressed during the workshop, as well as the answers to the questionnaires distributed to the participants, after the workshop and send it to participants, as well as SCAR-Fish and BIOEAST, for further consideration.

The topics proposed by the participant countries (as well as those who expressed their views in writing) are summarized in Table 1, with the closely related topics merged under more general titles.

Table 1. *Summary of the research priorities presented by the countries during the Tartu workshop*

Research topics	n	HR	CZ	DE	EE	FI	HU	LV	PL	BE	BG
Development of sustainable, cost- and resource-efficient RAS technologies: optimization of tank design, use of surface waters and improved water treatment technologies, innovations for medium-size RAS, etc.	7	+	+	+	+				+	+	+
Increasing the production volume and diversity of aquaculture species	7	+	+			+	+	+	+	+	
Development of sustainable, cost- and resource-efficient technologies and procedures for pond fish farming	6	+	+		+	+	+		+		
Development of sustainable combined and integrated aquaculture systems, multitrophic systems, aquaponics	6		+	+		+	+		+	+	
Physical, chemical and biological water quality and its influence on the environment, sustainable waste processing to decrease nutrient discharge	5	+	+	+		+		+			
Development of breeding technologies for new species with great aquaculture potential	4		+		+			+			+
Improvement of health management (all kinds of prevention, including optimization of environmental conditions and use of immune stimulators)	4	+	+						+		+
Food safety and quality issues (certification, standardisation, labelling. avoiding off-flavour and off-odour problems)	3	+				+	+				
Product diversification and development of new products (including by-product processing) to add value through the supply chain	3	+			+		+				
Optimization of fish feeding strategy and fish nutrition in different types of production systems using sustainable alternative and non-traditional feeds and additives	2		+				+				
Performance of different genetic stocks in RAS	2			+		+					
Assessment of the potential of selective breeding and epigenetic programming to improve adaptation to changing environmental conditions (temperature, oxygen, water quality, feed etc.);	2				+			+			
Gene banking of valuable species and breeds, genetic research for development of disease-resistant strains	2						+	+			
Strategic cross-border planning and modelling of the development of freshwater aquaculture under the impact of global climate change	2						+	+			
Technology development for broodstock rearing and propagation, fry and fingerling rearing	1		+								
Biosecurity	1	+									

Research topics	n	HR	CZ	DE	EE	FI	HU	LV	PL	BE	BG
Increasing the potential and synergy of aquaculture with other economic sectors	1				+						
Public acceptance of aquaculture	1						+				
Ecology of freshwater aquaculture species (pollution, plastics and nano-plastics, respiration, development under different conditions etc.)	1							+			
Invasive hydrobionts and freshwater aquaculture: identification by environmental DNA; management, epigenetics and triggers of invasion;	1							+			
Development of freshwater aquaculture technologies for rare species for nature conservation and ecosystem services	1							+			
Parasites and new parasite vectors in freshwater aquaculture and ecosystems	1							+			
Innovative education on freshwater aquaculture: professional education and consulting	1							+			
Management of freshwater aquaculture predators: birds, mammals, fishes	1							+			
Ethical killing of fish (e.g. in points of sale)	1								+		

It can be clearly seen that the research interests of most participating countries focus on production-related issues, i.e. applied research for technology development, including intensive and pond aquaculture as well as combined and integrated aquaculture technologies. A further important research topic is that of the development of rearing technologies for new species in order to diversify the species range of aquaculture. Fish health and food safety issues or research focusing on fish as food (processing, etc.) ranked lower, while the environmental and social issues of aquaculture were mentioned by only few countries.

4. Evaluation of the questionnaires

As a result of the participants' affiliation, the views presented during the Tartu workshop reflected mostly a governance perspective, and only to a smaller extent, the opinions of the research and production sectors. Therefore, in order to expand the coverage and obtain a more reliable picture, as well as to allow to differentiate between the views of the different aquaculture-related sectors, questionnaires containing the previously compiled list were distributed to all participants of the workshop with the request to evaluate the priority of the indicated research topics on a scale from 0 to 3 (0: no relevance; 1: low priority; 2: medium priority; 3: high priority). The same questionnaires were also distributed to the participants of the General Assembly of the Network of Aquaculture Centres in Central and Eastern Europe (NACEE), held in Uzhhorod, Ukraine, on 23 May 2019. They were also sent to the mailing list of SCAR-Fish.

Overall, 53 answers were received from 13 EU member states (BE, CZ, DE, EE, FI, HR, HU, IT, LT, LV, PL, RO, SE) and 4 non-EU countries, which are associated to Horizon programmes (Norway, Ukraine, Turkey and Belarus). Evaluating the individual replies and comparing them to the views presented during the Tartu workshop, the focus on technology development remains quite strong (two of the three top research areas were „Environmentally sustainable fish production technologies, sustainable intensification" and „New aquaculture species and rearing technologies in ponds and RAS" with average scores of 2.47 and 2.28, respectively). However, differently from the workshop, the highest-ranking topic was „Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance", ranking 2.53.

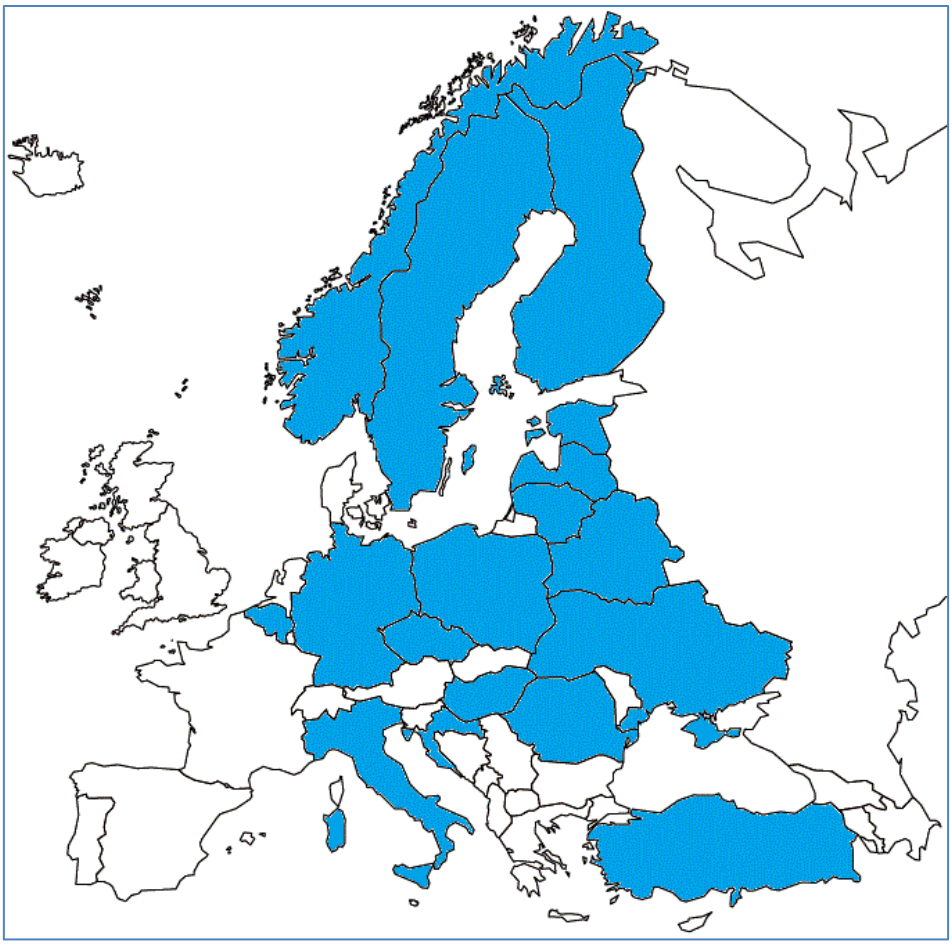

Figure 1. *Geographical coverage of the responses to the questionnaires.*

Comparing the results from EU and non-EU countries, the development of environmentally sustainable fish production technologies and sustainable intensification was seen as important by both groups (average score: 2.39 and 2.89, respectively). Technology development for the rearing of new aquaculture species and the development of rearing technologies in ponds and RAS was the top priority for non-EU countries (average score: 3.00), while the prevention and treatment of fish diseases was a higher priority for EU member states, although it was also seen as important by non-EU countries (average score: 2.55 vs. 2.44). In non-EU countries, the topic „Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients and elaboration of the corresponding feeding recommendations" ranked considerably higher than in EU countries (2.56 and 2.20, respectively). Further topics with relatively higher scores in non-EU countries but ranking lower in EU member states were „Optimizing the control and monitoring of water quality parameters" (2.33 vs. 2.00) and „Production cost analysis of environmentally sustainable fish production technologies" (2.22 vs. 2.11). On the other hand, climate change research received higher scores in EU member states (2.27 vs. 2.22).

However, it should be kept in mind that these data were mostly collected at individual workshops where the representatives of the host countries were clearly overrepresented (15 Estonian and 6 Ukrainian respondents from the total of 53). The responses to the questionnaires sent out to SCAR-Fish members also showed strong imbalance: while there were six answers from Italy, several other countries (BE, DE, FI, HR) are represented by only one respondent.

For this reason, it was considered more representative to evaluate the replies at the level of countries. The average scores by individual countries are shown in Table 2.

Table 2. *Summary of the replies to the questionnaires by countries*

	EU member states														Non-EU					Total
Topics	**BE**	**CZ**	**DE**	**EE**	**FI**	**HR**	**HU**	**IT**	**LT**	**LV**	**PL**	**RO**	**SE**	**Ave.**	**BY**	**NO***	**TR**	**UA**	**Ave.**	**Ave.**
New aquaculture species and rearing technologies in ponds and RAS.	1	2	2	2,2	3	0	2	1,5	3	3	2	2	2	***1,98***	3	3	3	3	***3,00***	***2,22***
Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance.	0	2,5	3	2,7	2	3	3	2,8	2	2,6	3	3	1,5	***2,39***	3	3	2	2,3	***2,58***	***2,44***
Research on animal welfare in aquaculture systems	3	2,5	2	2	1	3	1	2,3	1,3	2,4	1,8	3	3	***2,18***	2	3	2	1,7	***2,18***	***2,18***
Research supporting the legalization of drugs for aquaculture including those for induced spawning.	1	1	3	1,9	1	3	0	2,2	1	1,4	2,5	2	1	***1,62***	0	3	1	2	***1,50***	***1,59***
Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations	1	2	1	2,4	1	2	3	2,3	1,7	2,2	2	2	3	***1,97***	3	3	3	2,3	***2,83***	***2,17***
Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics)	1	3	2	2,5	3	3	3	2,2	2	2,2	2,3	2	2,5	***2,36***	3	3	3	2,8	***2,95***	***2,50***
Valorisation of ecosystem and cultural services of pond aquaculture, studying damages caused by protected fish-eating animals and other nuisance species and ways of their prevention	0	2	3	1,3	1	2,5	2	1,5	1,5	2,8	2,5	2	1	***1,78***	2	0	1	2,2	***1,30***	***1,66***
Development of improved management and decision support tools	1	1,5	3	1,5	1	3	1	0,8	1,3	1,4	1,3	1	1,5	***1,48***	1	3	2	1,3	***1,83***	***1,56***
Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers	1	3	2	2	1	3	3	1,7	1,3	1,2	1,8	2	1,5	***1,88***	1	3	3	1,7	***2,18***	***1,95***
Improving fish meat quality and its functional value for human consumption	1	2	1	2,2	1	3	0	1,3	2	1,4	1,5	2	1,5	***1,53***	1	3	3	2	***2,25***	***1,70***

	EU member states														Non-EU					Total
Topics	**BE**	**CZ**	**DE**	**EE**	**FI**	**HR**	**HU**	**IT**	**LT**	**LV**	**PL**	**RO**	**SE**	**Ave.**	**BY**	**NO***	**TR**	**UA**	**Ave.**	**Ave.**
Understanding market mechanisms and consumer preferences in European seafood markets	2	1	1	2	1	3	1	1,2	1,7	0,8	1	3	1,5	***1,55***	0	3	3	1,5	***1,88***	***1,63***
Profitability of aquatic production systems and innovations	2	2,5	2	2,3	3	3	3	1,3	2,3	2,2	1,5	3	2,5	***2,35***	3	3	2	1,8	***2,45***	***2,38***
Production cost analysis of environmentally sustainable fish production technologies.	2	3	2	2,1	2	3	3	2,3	2	1,6	2	3	2	***2,31***	3	3	2	2	***2,50***	***2,35***
Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand	1	2	1	1,9	1	3	3	1,7	2	1,8	2	2	2	***1,88***	2	3	2	1,3	***2,08***	***1,92***
End of pipe treatment of waste water before release to environment	2	1	2	2,4	3	3	2	2,3	2	1,8	2	1	2	***2,04***	1	3	1	2	***1,75***	***1,97***
Optimizing the control and monitoring of water quality parameters	2	2	1	2,2	3	3	1	1,8	1,7	2,2	2	3	1	***1,99***	2	3	3	2,2	***2,55***	***2,12***
Microbial water quality	1	2	1	2,1	2	3	1	1,5	1	2	1,8	3	2,5	***1,84***	0	3	1	1,8	***1,45***	***1,75***
Better understanding of closed artificial ecosystems	0	1,5	1	2,3	3	3	1	1,8	2	1,6	1,8	3	2	***1,85***	2	3	1	1,7	***1,93***	***1,86***
Climate change studies	0	2,5	2	2,3	3	3	2	2,7	2	2	2,3	3	2	***2,22***	3	3	2	2	***2,50***	***2,28***
n	**1**	**2**	**1**	**15**	**1**	**1**	**1**	**6**	**3**	**5**	**3**	**1**	**2**		**1**	**1**	**1**	**6**		

*No filled questionnaire, but replied that, in terms of the freshwater production period of salmon, almost all topics have high priority. Pond-related issues are not prioritised.

„Environmentally sustainable fish production technologies and sustainable intensification" (average score: 2.50) and „Prevention and treatment of fish diseases" (average score: 2.44) remain the highest-ranking topics. However, the economic research topic „Profitability of aquatic production systems and innovations" (average score: 2.38) has come up to the third place, while the previously third-ranking topic of „New aquaculture species and rearing technologies in ponds and RAS" has dropped to the 8th position.

Comparing the replies from EU and non-EU countries, it can be seen that the overall top three research topics are the same as the topics ranked highest by the EU member states. However, they were given high scores also by non-EU countries. The topics „Production cost analysis of environmentally sustainable fish production technologies" (2.31 and 2.50, respectively) and „Climate change research" (2.22 vs. 2.50, respectively) were also regarded as important by both groups. Notable differences in the scores were observed in the topics „New aquaculture species and rearing technologies in ponds and RAS" (1.98 in EU countries vs. 3.00 in non-EU countries), „Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients and elaboration of the corresponding

feeding recommendations" (1.97 vs. 2.83, respectively), and „Optimizing the control and monitoring of water quality parameters" (1.99 vs. 2.55).

It should be noted that there are regional differences within the group of EU countries. Most respondents are from countries with significant pond aquaculture, which obviously affects the answers. There are also countries with insignificant pond aquaculture and a strong focus on recirculating aquaculture systems. However, the low number of replies from these countries do not allow to evaluate the results by regions or applied technologies. The group of non-EU respondents is not homogeneous, either, it includes both major aquaculture producer countries (Norway and Turkey), and countries less advanced in terms of aquaculture (Ukraine and Belarus). A rough comparison of their replies show interesting differences in their replies, with a stronger focus on technology development, health management and feeding research in the latter group and a stronger interest in post-harvest processes (processing and marketing) and environmental issues. However, the small number of responses does not allow to draw meaningful conclusions from the results. The results were also compared by sectors (governance, research and production).

Table 3. *Summary of the replies to the questionnaires by governance representatives*

Topics	CZ	IT	EE	LT	LV	PL	SE	TR	Ave.
New aquaculture species and rearing technologies in ponds and RAS.	3	2	2,5	3	3	2	2	3	***2,56***
Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance.	2	3	2,5	2	3	3	2	2	***2,44***
Research on animal welfare in aquaculture systems	3	2,3	1,5	1	2	1	3	2	***1,98***
Research supporting the legalization of drugs for aquaculture including those for induced spawning.	1	2,3	1,5	1	1	3	1	1	***1,48***
Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations	2	2,5	3	1,5	3	2	3	3	***2,50***
Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics)	3	2,8	2,5	1,5	1	2	3	3	***2,35***
Valorisation of ecosystem and cultural services of pond aquaculture, studying damages caused by protected fish-eating animals and other nuisance species and ways of their prevention	3	1,3	1	1	2	3	1	1	***1,66***
Development of improved management and decision support tools	1	0,8	1,5	0,5	0	1	2	2	***1,10***
Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers	3	1,5	2	1	3	2	2	3	***2,19***
Improving fish meat quality and its functional value for human consumption	2	1,3	2,5	2	1	1	2	3	***1,85***
Understanding market mechanisms and consumer preferences in European seafood markets	1	1	1,5	1	0	1	2	3	***1,31***
Profitability of aquatic production systems and innovations	2	1,3	2	2,5	2	2	3	2	***2,10***
Production cost analysis of environmentally sustainable fish production technologies.	3	2,8	2	2,5	1	2	3	2	***2,29***
Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand	2	1,8	-	2	2	3	2	2	***1,85***
End of pipe treatment of waste water before release to environment	1	3	2	2	2	1	3	1	***1,88***
Optimizing the control and monitoring of water quality parameters	2	2,3	2,5	2	1	1	1	3	***1,85***
Microbial water quality	2	1,8	2,5	1	2	1	2	1	***1,66***
Better understanding of closed artificial ecosystems	1	2,3	2	2	1	1	2	1	***1,54***
Climate change studies	3	2,5	2	1,5	2	2	2	2	***2,13***
N	**1**	**4**	**2**	**2**	**1**	**2**	**1**	**1**	

From the governance sector, a total of 14 replies were received from 8 countries. The respondents regarded the species diversification and the development of aquaculture technologies as the most important research topic (average score: 2.56), closely followed by the development of fish feeds (average score: 2.56) and prevention and treatment of fish diseases (average score: 2.44). Development of decision support tools (average score: 1.10) and market research (average score: 1.31) were perceived as topics of least priority.

Table 4. *Summary of the replies to the questionnaires by research representatives*

	EU member states													Non-EU				Total
Topics	**BE**	**CZ**	**DE**	**EE**	**FI**	**HR**	**HU**	**IT**	**LT**	**LV**	**PL**	**RO**	**Ave.**	**BY**	**NO***	**UA**	**Ave.**	**Ave.**
New aquaculture species and rearing technologies in ponds and RAS.	1	1	2	2,3	3	0	2	1	3	3	2	2	***1,86***	3	3	3	***3,00***	***2,09***
Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance.	0	3	3	2,7	2	3	3	3	2	2,3	3	3	***2,50***	3	3	2,3	***2,77***	***2,55***
Research on animal welfare in aquaculture systems	3	2	2	1,8	1	3	1	2	2	2,7	2,5	3	***2,17***	2	3	1,7	***2,23***	***2,18***
Research supporting the legalization of drugs for aquaculture including those for induced spawning.	1	1	3	1,9	1	3	0	2	1	1,3	2	2	***1,60***	0	3	2	***1,67***	***1,61***
Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations	1	2	1	2,4	1	2	3	2	2	2	2	2	***1,87***	3	3	2,3	***2,77***	***2,05***
Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics)	1	3	2	2,4	3	3	3	1	3	2,7	2,5	2	***2,38***	3	3	2,8	***2,93***	***2,49***
Valorisation of ecosystem and cultural services of pond aquaculture, studying damages caused by protected fish-eating animals and other nuisance species and ways of their prevention	0	1	3	1,3	1	2,5	2	1	1	3	2	2	***1,65***	2	0	2,2	***1,40***	***1,60***
Development of improved management and decision support tools	1	2	3	1,4	1	3	1	1	3	1,7	1,5	1	***1,72***	1	3	1,3	***1,77***	***1,73***
Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers	1	3	2	2	1	3	3	2	2	0,7	1,5	2	***1,93***	1	3	1,7	***1,90***	***1,93***
Improving fish meat quality and its functional value for human consumption	1	2	1	2,2	1	3	0	1	2	1,3	2	2	***1,54***	1	3	2	***2,00***	***1,63***
Understanding market mechanisms and consumer preferences in European seafood markets	2	1	1	2	1	3	1	1	3	1	1	3	***1,67***	0	3	1,5	***1,50***	***1,63***
Profitability of aquatic production systems and innovations	2	3	2	2,3	3	3	3	2	2	2	1	3	***2,36***	3	3	1,8	***2,60***	***2,41***
Production cost analysis of environmentally sustainable fish production technologies.	2	3	2	2	2	3	3	1	1	1,7	2	3	***2,14***	3	3	2	***2,67***	***2,25***
Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand	1	2	1	1,9	1	3	3	1	2	1,7	1	2	***1,72***	2	3	1,3	***2,10***	***1,79***
End of pipe treatment of waste water before release to environment	2	1	2	2,4	3	3	2	1	2	2	3	1	***2,03***	1	3	2	***2,00***	***2,03***
Optimizing the control and monitoring of water quality parameters	2	2	1	2,2	3	3	1	1	1	2,7	3	3	***2,08***	2	3	2,2	***2,40***	***2,14***
Microbial water quality	1	2	1	1,9	2	3	1	1	1	2	2,5	3	***1,78***	0	3	1,8	***1,60***	***1,75***
Better understanding of closed artificial ecosystems	0	2	1	2,2	3	3	1	2	2	2	2,5	3	***1,98***	2	3	1,7	***2,23***	***2,03***
Climate change studies	0	2	2	2,6	3	3	2	3	3	2,3	2,5	3	***2,37***	3	3	2	***2,67***	***2,43***
n	**1**	**1**	**1**	**9**	**1**	**1**	**1**	**1**	**1**	**3**	**2**	**1**		**1**	**1**	**5**		

*No filled questionnaire, but replied that, in terms of the freshwater production period of salmon, almost all topics have high priority. Pond-related issues are not prioritised.

From the research sector, a total of 30 replies were received from 15 countries. In general, the representatives of this sector considered the research into prevention and treatment of fish diseases as the top priority (average score: 2.55), followed by the development of environmentally sustainable fish production technologies and sustainable intensification (average score: 2.49) and climate change research (average score: 2.43). All these topics were regarded as being of high priority by both EU and non-EU countries. However, there were some topics that were considered high-priority in non-EU countries but were assigned significantly lower scores by EU countries. In particular, considerable differences were observed in the ranking of species diversification and the development of aquaculture technologies, which received an average score of 3.00 from researchers of non-EU countries (making it a top-priority topic, similarly to the perception of governance representatives), but only 1.86 from EU researchers. Likewise, large differences were noted in the opinions on fish feed development research (2.77 in non-EU countries vs. 1.87 in EU countries).

Table 5. *Summary of the replies to the questionnaires by producers' representatives*

Topics	EE	IT	LV	SE	Ave.
New aquaculture species and rearing technologies in ponds and RAS.	1,5	0	3	2	***1,63***
Prevention and treatment of fish diseases, incl. reducing use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for disease resistance.	3	2	3	1	***2,25***
Research on animal welfare in aquaculture systems	3	3	2	3	***2,75***
Research supporting the legalization of drugs for aquaculture including those for induced spawning.	2	2	2	1	***1,75***
Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations	2	2	2	3	***2,25***
Environmentally sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics)	3	1	2	2	***2,00***
Valorisation of ecosystem and cultural services of pond aquaculture, studying damages caused by protected fish-eating animals and other nuisance species and ways of their prevention	1,5	3	3	1	***2,13***
Development of improved management and decision support tools	2	1	2	1	***1,50***
Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers	2	2	1	1	***1,50***
Improving fish meat quality and its functional value for human consumption	2	2	2	1	***1,75***
Understanding market mechanisms and consumer preferences in European seafood markets	2	2	1	1	***1,50***
Profitability of aquatic production systems and innovations	2,5	1	3	2	***2,13***
Production cost analysis of environmentally sustainable fish production technologies.	2,5	2	2	1	***1,88***
Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand	2	2	2	2	***2,00***
End of pipe treatment of waste water before release to environment	2,5	1	1	1	***1,38***
Optimizing the control and monitoring of water quality parameters	2	1	2	1	***1,50***
Microbial water quality	2,5	1	2	3	***2,13***
Better understanding of closed artificial ecosystems	2,5	0	1	2	***1,38***
Climate change studies	2	3	1	2	***2,00***
n	**2**	**1**	**1**	**1**	

From industry representatives, only five responses were received from four EU member states. A spectacular difference was that the respondents regarded animal welfare research as the topic of highest priority, with an average score of 2.75. (It scored only 2.18 among researchers and even less, 1.98 among governance representatives.) The other topics of highest priority, the prevention and treatment of fish diseases and the development of fish feeds (both with an average score of 2.25) were less surprising.

5. Conclusions

While there are differences in the freshwater aquaculture research priorities both among the individual countries, between the EU and non-EU countries, as well as between the representatives of different sectors, there are also remarkable agreements. Generally speaking, the research topics of greatest interest and **highest priority** for the largest number of respondents were the following.

- Development of sustainable fish production technologies, sustainable intensification (RAS, IMTA, CIE systems, aquaponics).
- Prevention and treatment of fish diseases including reducing of the use of veterinary medicines through immune stimulants, probiotics, vaccine development and breeding programmes for development of disease resistant strains.
- Profitability of aquatic production systems; production cost analysis of environmentally sustainable fish production technologies.

The following topics were classified as being of **medium-high priority**.

- Climate change studies.
- New aquaculture species and rearing technologies (both in ponds and RAS).
- Animal welfare in aquaculture systems.
- Development of new, efficient and innovative fish feeds based on novel, more environment-friendly ingredients (in particular, alternative protein sources) and elaboration of the corresponding feeding recommendations.

The following were seen as **medium-priority** topics.

- Optimizing the control and monitoring of water quality parameters and better end-of-pipe treatment of waste water before release to environment.
- Development of fish processing, storage and packaging technologies, as well as new value-added fish products focusing on different groups of customers.
- Social structure studies to provide strategies meeting the requirements of a modern aquaculture industry towards fish farmers' qualification on the one hand and to develop concepts to increase the attractiveness of the sector for skilled workers on the other hand.

The incorporation of the above highest-priority freshwater topics into European research programmes would be of primary importance to European freshwater aquaculture research. It is important to note that many of the topics included in the original list are not specific to freshwaters but are important for all aquaculture environments. This means that their support does not necessarily require specific calls, they can be funded in the frame of the same calls as, e.g. marine aquaculture. However, even in these cases, similar issues in marine and freshwater aquaculture systems may require different approaches, which must be taken into account in the calls (e.g formulating the eligibility rules inclusively).

There are also a number of research topics of priority that are mostly relevant to pond aquaculture (or, at least, extensive or semi-intensive aquaculture systems). In particular, topics of special relevance for these systems are those related to sustainable intensification, development of pond rearing technologies of new species for a diversified pond aquaculture, as well as the valorisation of ecosystem and cultural services of pond aquaculture. The specificities of these systems and topics would need to be either reflected in more general calls or be the subject of more specific calls or other funding schemes aiming at the support of research in these fields.

Minutes of the
International workshop on freshwater aquaculture research priorities in Europe
held in
Tartu, Estonia, 8-9 May 2019

The International workshop on freshwater aquaculture research priorities in Europe was held on May 8-9, 2019 at the Dorpat Convention Centre, Tartu, Estonia. The workshop was co-organized by the Ministry of Rural Affairs of Estonia and the Ministry of Agriculture of Hungary, and was hosted by the Fisheries Information Centre, University of Tartu, Estonia. The workshop was attended by 44 participants from 10 countries (Belgium, Croatia, Czech Republic, Estonia, Finland, Germany, Hungary, Italy, Latvia, Poland), representing the sectors of aquaculture governance, research and production. The programme of the workshop is attached in Annex 2.

The workshop was opened by Ms. Eve Külmallik (Ministry of Rural Affairs, Estonia), who made a brief overview of the process leading to the organisation of the event and welcomed all participants to Tartu. Then the floor was given to Mr. Peter Lengyel (Ministry of Agriculture, Hungary) who greeted the participants and regretfully mentioned that two countries, Greece and Lithuania, had to cancel their participation due to last-minute changes. He explained the main objectives of the workshop and expressed his hope for fruitful discussions and meaningful results.

After the opening, the first keynote presentation was made by Mr. Béla Halasi-Kovács (Research Institute for Fisheries and Aquaculture, Hungary). In his presentation, he evaluated the role of freshwater aquaculture within the broad context of bioeconomy, showing the importance of the sector in sustainable protein production, waste reuse and by-product utilization, as well as its important impact on upstream and downstream industries. He also elaborated on the most important challenges of the sector, highlighting the need for adequate balance between productivity and sustainability, and presented several existing technological solutions to improve both of these parameters in pond aquaculture.

Ms. Helena Pärenson (Ministry of Rural Affairs, Estonia) presented BIOEAST (Central-Eastern European Initiative for Knowledge-based Agriculture, Forestry and Aquaculture in the Bioeconomy), a strategic research and innovation framework working towards the development of sustainable bioeconomies in Central and Eastern Europe (CEE). She made an overview of the development of the BIOEAST Initiative, highlighting the potential of bioeconomy development for sustainable increase of biomass production, its circular processing and improving the viability of rural areas. She also invited the participants to get involved in the BIOEAST Thematic Working Group (TWG) on Freshwater Bioeconomy, which, together with the TWGs on forestry, sustainable yields and agro-ecological intensification, bioenergy and biomaterials and food systems, will work towards the development of a Strategic Research and Innovation Agenda at a macro-regional level.

Mr. Laszlo Varadi (Network of Aquaculture Centres in Central and Eastern Europe, NACEE) made an overview of freshwater aquaculture in the EU, highlighting the increasing need of the sector for innovation and investment in order to achieve its development targets. He reviewed the previous initiatives aiming at the identification of the research needs of the European fisheries and aquaculture sector, including the EATIP Strategic Research and Innovation Agenda, studies commissioned by the European Commission (Food 2030, Food from the Oceans), the BIOEAST position paper and other

strategic documents. While the current definitions of blue growth and blue bioeconomy are limited to marine environments, Mr. Varadi presented examples of existing technological solutions of sustainable intensification in pond aquaculture, underlining that „freshwaters are also blue".

Mr. Peter Lengyel presented the activities of SCAR-Fish, with special regard to the work of the Sub-group on Research Prioritization and the outcomes of the prioritization exercise conducted in order to identify the research priorities of the participating countries. He explained that landlocked countries and freshwater aquaculture were strongly underrepresented in the final list of priorities, which led Hungary to initiate a separate collection of freshwater research initiatives. He presented the results of this data collection, noting that there were significant similarities between the freshwater priorities and the previously collected general aquaculture priorities, showing that many of the challenges are common, even if the focus is different. Still, there are several issues specific to freshwater systems, which may justify their separate treatment. Mr. Lengyel also distributed questionnaires containing the previously determined list of freshwater aquaculture topics, asking the participants to assign priorities to them.

Following the keynote presentations, each country presented their main directions and priorities of freshwater aquaculture research.

Ms. Ana Gavrilovic (University of Zagreb, Croatia) presented an overview of freshwater aquaculture development in Croatia and its trends over the last ten years. She viewed diversification, maintaining of the existing semi-extensive production and strengthening of intensive production, as well as technological development for sustainable aquaculture as the main ways of future development. The main research needs serving the principal objective of increasing the production were identified as follows:

- Technology improvement (in all phases);
- Optimization of RAS systems;
- Sustainable waste processing;
- Production and product diversification;
- Safety and quality issues (certification or standardisation);
- Improvement of health management (all kinds of prevention);
- Biosecurity;
- By-product processing (development of new products).

Mr. Petr Chalupa (Ministry of Agriculture of the Czech Republic) made a review of the Czech aquaculture research scene, as well as the status and main challenges of aquaculture in the country, including the effects of climate change and damage by fish-eating predators. The following main research needs were identified in the field of sustainable fish farming in ponds:

- Development of technologies and procedures for pond fish farming;
- Securing and spawning of broodstock, hatching of eggs and rearing of fry to produce fingerlings and stocking and grow-out of fingerlings for the market
- Actively influencing the health of farmed fish;
    - Optimizing the environmental conditions of early diagnosis and by preventive interventions in farming
    - Support for the immune system through suitable feeding strategies (appropriate additives to animal feed)
- Water quality and influence on the environment
    - Physical and chemical characteristics of water, including density, viscosity, temperature, pH, alkalinity, hydrostatic pressure, transparency of water, stratification,

oxygen cycle, cycle of basic elements (oxygen, nitrogen, carbon, phosphorus) and food chain (phytoplankton, zooplankton, phytobenthos, zoobenthos)

The following research needs were highlighted in intensive fish farming:

- Environmentally friendly intensive fish farming through deeper reflection on current trends in innovation and modernizaiton
    - Increasing the production volume and diversity of farmed fish species
    - Improvement and optimization of the environment of fish farming in flow-through systems (especially reproduction, farmed species and feeding methods)
- Development and use of combined breeding technologies of promising fish species using natural production conditions and breeding in special facilities
- Development and use of new technologies in the intensive farming of freshwater fish and methods for maintaining an optimum quality of the aquatic environment
- Optimization of fish feeding strategy and fish nutrition in different types of production systems using alternative and non-traditional feeds

Mr. Reinhold Hanel (Thünen Institute of Fisheries Ecology, Germany) reminded the participants about the 2014 report of the European Board of Auditors on the effectiveness of the European Fisheries Fund support for aquaculture, which showed that money spent on research had very limited effect. He then presented the situation in Germany, where aquaculture was within the responsibility of the Länder, resulting in a strongly fragmented character of both the funding (different research funding institutions ranging from ministries and national research funds to private foundations) and the aquaculture research scene (30 public-sector research organisations, many with very limited capacity). Mr. Hanel presented the views of the regions on the research fields to be strengthened, which included the following:

- Optimization of tank design, current regime and stocking densities to improve competitiveness, disease resistance and welfare;
- Use of surface waters and a general decrease of maintenance costs in recirculation aquaculture;
- Aquaponics and other multitrophic systems;
- Assessment of the potential of selective breeding (and epigenetic programming) to improve adaptation to changing environmental conditions (temperature, oxygen, water quality, feed etc.);
- Improving the availability of locally adapted and competitive fingerling supply to maintain national aquatic genetic resources;
- Better use of waste products.

However, it is still unclear to what extent these fields limit the development of aquaculture, i.e. whether a stronger investment in the above research topics would have an actual unlocking effect on aquaculture development. In view of this, Mr. Hanel proposed a further, multidisciplinary research topic aiming at the investigation of conflicting policy frameworks, such as the environmental, water and building restrictions and their effect on aquaculture production and ecosystem services.

Mr. Hanel also presented the recommendations of the German Agriculture Research alliance (DAFA). These include (i) studying the potential and prospects of German aquaculture in an international context to identify the most promising starting points for the eventual expansion of German aquaculture or for other strategic priorities (e.g. technology export); (ii) launching a collaborative project on “site-optimised expansion of aquaculture” and (iii) developing a (virtual) German Aquaculture Research Centre that would create the conditions for a better bundling of the existing research resources and fully exploiting the organizational innovation potential.

Mr. Riho Gross (Estonian University of Life Sciences, Estonia) outlined the history, current status and challenges of Estonian aquaculture, as well as the activities and ongoing research of the Chair of Aquaculture of the Estonian University of Life Sciences. He stressed that the current research priorities of the sector (except genetic research) are included in the „Innovation in aquaculture" measure of the European Maritime and Fisheries Fund (EMFF) operational programme 2014–2020 for Estonia, and include the following:

- Development of resource-efficient solutions;
- Development of breeding technologies for new species with great aquaculture potential;
- Development of new technologies and products to add value throughout the supply chain;
- Increasing the potential and synergy of aquaculture with other economic sectors.

Mr. Gross also drew the attention of the participants to the 2018 editorial „Aquaculture Research Priorities for the Next Decade: A Global Perspective", published in the Journal of the World Aquaculture Society. While that paper does not focus on freshwater issues, it identifies the following priority research directions:

- Markets and consumer demand;
- Diet ingredients and additives;
- Genetics;
- Health and survival;
- Economics and regulation;
- Technology and systems;
- Climate change and sustainability.

Mr. Jouni Vielma (Natural Resources Institute, Finland) highlighted the increasing vulnerability to climate change, which is why research into the development of recirculating aquaculture systems (RAS) is the main freshwater aquaculture research priority for Finland. From Finnish perspective, the main RAS-related research priorities are the following:

- Developing cost-efficiency in RAS (water treatment technologies, innovations for medium-size RAS);
- Quality control (avoiding off-flavour and off-odour problems);
- Decreasing nutrient discharges;
- Combination of RAS with marine farming;
- Performance of different genetic stocks in RAS;
- Species diversification (e.g. pikeperch, nelma).

From Hungary, Mr. Béla Halasi-Kovács stressed the importance of pond aquaculture in the conservation of natural and environmental values and its role in meeting te EU's environmental targets. He also pointed out the main challenges of the sector, such as climate change, economic changes and competition for land, water and human resources) and highlighted the possible research answers to these, including:

- Sustainable intensification (e.g. combined intensive-extensive systems);
- Research on common carp (gene banking, genetic research for development of KHV resistant strains);
- Technological innovation (new species in intensive systems, polyculture with new species);
- Innovation in feeding (sustanaible feed ingredients and additives);
- Modelling the impacts of climate change;

- Processing and marketing (including product diversification, by-products utilization);
- Standardization, labeling;
- Public acceptability.

However, Mr. Halasi-Kovács also raised the issue of the actual difference that aquaculture research makes. While significant amounts are spent on research, the impact on aquaculture technologies and practices seems to have been minimal in the last decades.

Mr. Arturs Skute (Daugavpils University, Latvia) presented an overview of the research scene of Latvia, including the EMFF innovation projects, as well as the activities of the Institute of Food Safety, Animal Health and Environment (BIOR) and Daugavpils University. The main freshwater aquaculture priorities of Latvia include:

- Genetics, epigenetics and improving of freshwater aquaculture species;
- Ecology of freshwater aquaculture species (pollution, plastics and nano-plastics, respiration, development under different conditions etc.)
- New freshwater aquaculture species and innovation in freshwater aquaculture;
- Freshwater aquaculture impact on ecosystems and rare species and its optimization;
- Strategic cross-border planning and modelling of the development of freshwater aquaculture under the impact of global climate change;
- Invasive hydrobionts and freshwater aquaculture: identification by environmental DNA; management, epigenetics and triggers of invasion;
- Development of freshwater aquaculture technologies for rare species for nature conservation and ecosystem services;
- Parasites and new parasite vectors in freshwater aquaculture and ecosystems;
- Innovative education on freshwater aquaculture: professional education and consulting;
- Management of freshwater aquaculture predators: birds, mammals, fishes.

Mr. Igor Wawrzyniak (Ministry of Maritime Economy and Inland Navigation, Poland) presented the Polish freshwater aquaculture priorities in the context of the 2014-2020 EMFF operational programme and the AQUACULTURE 2020 strategy. He highlighted the importance of the promotion of research on technological solutions targeted at:

- Intensification of production;
- Rational use of water resources;
- Ethical killing of fish (e.g. in points of sale);
- Implementing biotechnology for farming of a greater number of fish species;
- Development of new medicines and disinfectants for fish.

In the roundtable held with the representatives of producer associations, Mr. Jurgen Adriaen (University College Odisee, Belgium) presented the research and education activities of the College, as well as the research and innovation challenges and actions of the Flemish Aquaculture Platform, a mirror platform of the European Aquaculture Technology and Innovation Platform (EATIP). The identified challenges include integration on land (RAS and horticulture) and at sea (macro-algae and shellfish), prevention of off-flavours, localization of sites for aquaculture investments and technology development for new aquaculture species (freshwater crayfish, grey North sea shrimp). For the future, Mr. Adriaen envisaged investments into the integration of freshwater fish production with biogas production, trout production in Danish system and production of *L. vannamei*.

Peter Lengyel read an unofficial letter from Mr. Tacho Pashov, the president of the Bulgarian carp producers' organisation, in which he voiced criticism about the involvement of researchers in production, and thus, their competition with producers, as well as the poor cooperation between both science and practice and education and practice in Bulgaria. He also complained about the general lack of practical applicability of the research conducted. Mr. Pashov listed the following research topics as being of priority for the Bulgarian warmwater freshwater aquaculture:

- Control of some fish diseases (mostly viral and parasitic) in the production environment, as well as the development of modern drugs and treatment strategies;
- Development of products and technologies for reproduction on industrial scale, including genetic selection methods.

Mr. Laszlo Varadi, representing both NACEE and the Hungarian Aquaculture Technology and Innovation Platform expressed his conviction that practical aquaculture research is possible only at the intersection of an innovative industry, a focused research and an enabling governance. In this regard, there is a great need for strong and efficient producer associations, which are unfortunately still missing in many countries. Mr. Varadi also highlighted the importance of farmer exchanges and organization of common workshops and conferences, both thematic and regional.

In the following discussion, several thoughts and ideas were voiced about the problems and challenges of the research sector:

- Aquaculture is generally low on the political agenda of most governments because of its low contribution to the national economics. National strategic plans on aquaculture are not taken seriously by the politics, either.
- Several participants complained about relatively low support to aquaculture research and development. However, it was also noted that, globally, much funding was available for aquaculture, but money always finds the best place to work, e.g. research areas where higher profits are expected.
- It was pointed out that the industry, governance and research were often decoupled and lacked good communication, which was an obstacle to good aquaculture research. Success stories in the sector (e.g. in Denmark) confirm the importance of good cooperation between these sectors.
- From researchers' perspective, the low or missing demand of the industry for actual development was also an important obstacle. Many farmers are not interested in increasing their production (although the real production figures are not always known as farmers are often reluctant to communicate them). It would be important for the researchers to know the real needs of the industry in order to be able to address them.
- The inadequate duration of EU funding schemes was also pointed out as a problem. The three- or five-year lifespan of a research project is generally too short to successfully conclude a development (or, especially, a breeding) programme.
- The fragmented character of research was also pointed out as a problem. There are many research institutions in Europe competing with each other over the limited research funds. A better integration of research institutions and increased international cooperation could help improve the situation.
- From market perspective, the consumer demand was also seen as being of crucial importance. It was pointed out that many consumers did not perceive the consumed fish as a specific species, only as generic „fish". This makes fish species easily substitutable from the consumers' point of view and raises the issue whether there is a real consumer demand for new aquaculture species.

- Several participants noted that research did not have a real impact on practice. The same issues have been discussed by the sector for the last decades without much real progress. It was pointed out that, while the conclusions of the European Board of Auditors were really shocking, everything continued as before.

Summarizing the discussions, Mr. Lengyel thanked all participants for the important contributions and insights. He considered the workshop very useful in giving a good picture of the freshwater aquaculture research scene, its priorities and challenges over Europe. He admitted that the diversity of the sector and its research interests became quite obvious from the presentations and discussions, which made it very difficult to come to some consensus concerning the sector's research priorities. Therefore, he suggested that the organizers should prepare a discussion material based on the initial list of priorities, the views expressed during the workshop, as well as the answers to the questionnaires distributed to the participants during the day, and send it to all participants for consideration before submitting it to SCAR-Fish. Having received no objection, he thanked the participants for their work and the local hosts for the excellent organization, and closed the workshop.

The discussion material prepared by the Department of Fisheries Management, Ministry of Agriculture, Hungary, is attached as Annex 2.

International workshop on freshwater aquaculture research priorities in Europe

Tartu, Estonia, 8-9 May 2019

Struve II Hall in Dorpat Convention Centre

AGENDA

7 May 2019

Arrival to Tartu.
Accommodation at Dorpat Hotel.

8 May 2019

9.00-9.30 Registration - Struve II Hall in Dorpat Convention Centre

9.30-9.45 Opening addresses

Keynote presentations by invited experts

9.45-10.15 Aquaculture research within the context of bioeconomy (Béla Halasi-Kovács, NARIC Research Institute for Fisheries and Aquaculture, Hungary)

10.15-10.45 The BIOEAST Initiative (Helena Pärenson, Ministry of Rural Affairs, Estonia)

10.45-11.00 Coffee break

11.00-11.30 Freshwater aquaculture in the EU and its research agenda (Laszlo Varadi, NACEE, Hungary)

11.30-12.00 SCAR-Fish and the freshwater aquaculture research priorities (Peter Lengyel, Ministry of Agriculture, Hungary)

12.00-12.30 Discussion

12.30-13.30 Lunch

Session on freshwater aquaculture research needs

13.30-15.00 Short presentations and case studies on the main directions and priorities of freshwater aquaculture research in different countries

15.00-15.15 Coffee break

15.15-16.00 Roundtable discussion with representatives of producer associations on research gaps and needs in their respective countries

16.00-16.30 Work in groups – identifying common needs and priorities

16.30-17.00 Discussion of the results in plenary, proposing a prioritized list of the most important freshwater aquaculture topics

17.00-17.30 Follow-up, decision on further elaboration of the proposed topics recommended for inclusion into the Horizon Europe programme

17.30 Closing of the workshop

9 May 2019

9.00 – 15.00 Field trip to aquaculture farms.

1. Härjanurme Kalatalu; main species: rainbow trout, common carp, sturgeon, noble crayfish.
2. Simuna Ivax OÜ Äntu farm; main species: rainbow trout; arctic char, sturgeon.