

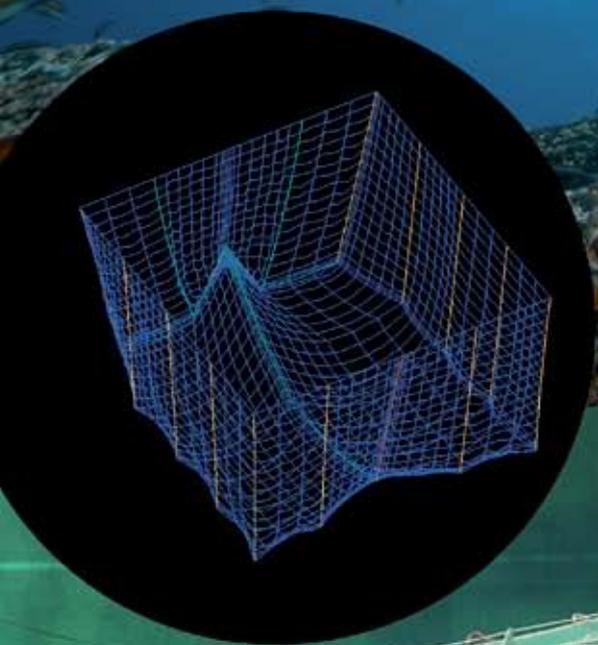


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Delphi study on future R&D
Aquaculture Europe 2009 full update



The shape of future aquaculture R&D

Results of a Delphi study

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INTRODUCTION

The future direction that research and development (R&D) will take in any one field is always shrouded by thick mist. The mist is, however, never impenetrable. In the summer 2008 we launched a worldwide online Delphi study to penetrate the mist that shrouds the future of aquaculture R&D. The purpose of the project was to contribute towards focussing better the nascent aquaculture research program of the Faculty of Agriculture and Nutritional Science of the University at Kiel, Germany.

The Delphi method is a widely-used and well-accepted method for casting light on future developments in a certain domain by systematically and repeatedly interrogating experts for this domain and by synthesizing experts' opinions. In some sense, the Delphi method can be characterized as a form of collaborative qualitative forecasting by geographically dispersed domain experts. We employ this method to ascertain the likely future directions of aquaculture R&D in developed, high-income countries. This study comprises three survey rounds. Goal of the initial round was to assess the current situation and anticipated future developments of research in aquaculture in the long run (until the year 2020), as seen by aquaculture experts. The second and third round focussed on finding consensus on specific fields as well as to discuss fields identified as promising for R&D investments in more detail. Our study focuses on aquaculture of finfish in advanced economies. Other species than fish, such as crustaceans, molluscs, aquatic plants, etc. and world regions, other than the high-income countries, such as China where aquaculture is particularly important, were outside the scope of our study.

Based on a bibliometric study of co-author networks in aquaculture and fisheries research (Seidel-Lass 2009) we developed a list of some 1,300 email addresses. The addresses were contacted by email and invited to participate in the Delphi survey which we conducted on the web. After two reminder emails 272 (21 percent of the addressees contacted) aquaculture researchers participated in the first round. This response rate is remarkably high compared to other online surveys, where response rates below one percent have been reported.

ISSUES AND DELPHI ROUNDS

The Delphi study was preceded by a survey of R&D issues in the aquaculture R&D literature (Guettler 2008). This set of issues was augmented and focused in consultations with a small number of aquaculture R&D experts. Based on this list of R&D issues we developed the questionnaire for the first Delphi round. This questionnaire comprised 45 questions which were organized into the following sections:

1. About the respondents
2. General questions
3. Fish breeding and reproduction
4. Fish husbandry and water management
5. Fish health
6. Fish nutrition
7. Marketing and quality management

The questionnaire of the second round was much shorter, comprising only 14 questions, while the third round questionnaire contained 10 questions.

The following sections present the key results of the Delphi study.

THE RESPONDENTS

The aquaculture experts participating in the survey were between 26 and 78 years old, their average age was 48 years. The vast majority of aquaculture experts hold a PhD degree (73 percent) and their professional experience in aquaculture spans a 19 year period, on average. While three fourths of the responding experts have between 11 and 25 years of experience in aquaculture R&D, half have 20 years or more of aquaculture research experience. Nearly half of the respondents are employed by Universities and nearly every fifth respondent works for a governmental agency. Most of the respondents are professors or senior researchers and focus on applied or basic research. The respondents currently live in all parts of the world, most in Europe, northern America, Norway, and the United Kingdom.

GENERAL ASPECTS OF AQUACULTURE R&D

Aquaculture experts agree on two points: (i) aquaculture research in general has achieved much and will continue to do so in the future, and (ii) aquaculture research achievements will have a very strong impact on the



productivity of aquaculture as well as on the quality of fish produced.

R&D rarely progresses in lock-step on all research fronts. For past and current research achievements fish nutrition was rated highest by the respondents, followed by breeding, reproduction, fish husbandry, fish health, water management, quality management, fish marketing and finally organic aquaculture (Tab. 1). The ranking was, however, significantly modified with regard to future expected research achievements. In the future, fish health will come first, followed by fish nutrition, quality management, and water management.

Will the hotspots of aquaculture R&D shift in the future? Norway was by far rated as the current and future leading aquaculture research nation. Spain and the USA are expected to become much stronger players in aquaculture research. Germany and Italy were rated very low and our experts expect these nations to continue to linger at the bottom of the aquaculture R&D charts. Interestingly, the mean ratings of the future development of the nations' strengths in aquaculture research lie very much closer together than the average ratings of current strengths (Tab. 2).

R&D on organic aquaculture was considered to have produced the least results so far. Moreover, most experts agreed that organic aquaculture is generally overrated; nevertheless, R&D spending on organic aquaculture is expected to increase considerably.

FISH BREEDING AND REPRODUCTION

There was consensus among almost all (98%) aquaculture experts that developing breeding programs comparable to livestock breeding programs would be useful or perhaps even very useful for fish species. Among the many fish species suitable for improvement through systematic

Research area	Average score		Rank past and current	Rank 2020
	Past and current*	Development until 2020**		
Fish nutrition	4.01	3.95	1	2
Breeding	3.91	3.74	2	7
Reproduction	3.91	3.61	3	8
Fish husbandry	3.75	3.59	4	9
Fish health	3.71	4.06	5	1
Water management	3.58	3.93	6	3
Quality management	3.22	3.93	7	3
Fish marketing	3.00	3.81	8	6
Organic aquaculture	2.51	3.87	9	5

* scale from 1 = poor to 5 = very substantial
** scale from 1 = much less to 5 = much more

Table 1: Average scores of expert rating of past and current achievements as well as future development of aquaculture research by areas (n=272)

breeding, European Seabass, Gilthead Seabream, and Turbot were, in this order, rated as particularly promising.

With regard to specific research areas concerned with fish breeding and reproduction, there was consensus that achievements were highest in conventional selective breeding, followed by chromosome set and sex manipulation, and crossbreeding. For the future our experts predict that marker based selective fish breeding will develop into a highly productive research area.

FISH HUSBANDRY AND WATER MANAGEMENT

How attractive for R&D are recirculating systems, cage systems, pond, and flow-through systems? Our experts agree that research expenditures on recirculating systems will increase most substantially, followed by R&D investments into cage systems. Very few, however, expect that more R&D money will be flowing into ponds or towards flow-through systems.

Because results of the first two Delphi rounds highlighted the high importance of R&D on recirculation systems, we decided to probe a bit deeper and ask our respondents to rate the importance of specific research issues related to recirculation systems. Energy efficiency, nutrient discharge, and biological clarification systems are considered to be the most promising research areas in

connection with recirculation systems. Research on the material and shape of the fish rearing unit were clearly rated lowest and the potential of this research was rated somewhere between "little" and "some" potential.

Research on fish husbandry and water management is not exhausted by research on specific water systems. Other areas which are expected by many to attract considerable attention and funding over the next decade are integrated multitrophic aquaculture (IMTA) as well as the environmental impact of aquaculture.

Country	Mean current strength*	Anticipated future strength**	Rank current	Rank future
Norway	4.64	3.75	1	1
Israel	3.68	3.55	2	5
United Kingdom	3.63	3.39	3	8
Canada	3.57	3.56	4	4
USA	3.50	3.58	5	2
France	3.45	3.40	6	7
Denmark	3.34	3.33	7	10
Spain	3.28	3.58	8	2
The Netherlands	3.26	3.35	9	9
Greece	2.92	3.46	10	6
Germany	2.76	3.31	11	11
Italy	2.74	3.27	12	12

* scale from 1 = very weak to 5 = very strong
** scale from 1 = much less to 5 = much more

Table 2: Advanced economies and their current strength in aquaculture R&D (n=272)

The environment is vast and aquaculture's impacts on the environment can be many. We therefore probed for research on specific impacts, distinguishing between carbon, carbon dioxide, nitrogen, and phosphorus. Our respondents believe that R&D on aquaculture's nitrogen and phosphorous related environmental impacts has, in the past, achieved more results than research on impacts related to carbon. This is, however, expected to change. In the future, research on all four impacts is expected to be on a similar level of achievement.

FISH HEALTH

Within the research fields concerning fish health, aquaculture experts expect a dynamic change in research fields with the greatest achievements. While research on bacteria and parasites were rated highest for their past and current research achievements, the future will be in developing therapeutics and vaccines, disease gene mapping, and early identification systems.

FISH NUTRITION

The contribution of aquaculture toward achieving sustainable food security for a growing world population will be questioned as long as aquaculture fish are fed with processed captured fish. There is hope that this blemish will soon be removed from aquaculture. Our experts think that R&D on vegetative resources and derivatives is very likely to yield until 2020 alternatives for fish meal and fish oil. Among the many potential plant resources that might provide the alternative feed compounds, legumes are considered to be the most promising source for alternative for fish meal whereas oleiferous fruits are considered to be the most important sources for fish oil substitutes. Few will be surprised to learn that our experts think that R&D on finding substitutes derived from potatoes is unpromising.

The hope to escape the dependence on fish caught in the wild is shared by many. Two thirds of the aquaculture experts participating in the survey think it will be possible to achieve feed conversion ratios below one when feeding carnivorous species. Three quarters of the respondents think feed conversion ratios smaller than one will be achieved by 2015. There is, however, considerable uncertainty as to the period when feed conversion ratios break through the barrier of 1: a standard deviation of 8.8 years suggests that breaking the barrier is as likely to happen tomorrow as in the year 2024.

MARKETING, QUALITY MANAGEMENT AND ECONOMICS OF AQUACULTURE

Most aquaculture experts think that current advances in research on fish and fish products is less or even much less advanced than research on meat and meat products. However, this is the one result on which our experts achieved no consensus.

Quality management was rated little better than marketing research, even though the average of all rating indicates that research on aquaculture fish quality management has not reached the same status as quality management research on meat and meat products

Even though there is dissent among the experts about current achievements, there is consensus that research on fish marketing and fish quality management will substantially increase until the year 2020.

Aquaculture experts think that past and current

achievements on aquaculture farm business management were highest, while they assume that the development of achievements will be highest in traceability and supply-chain-management.

CONCLUSIONS

Our Delphi study showed that aquaculture experts are commonly convinced by the high R&D achievements in the past and the future in order to increase productivity of aquaculture systems. Especially, improvements in the field of fish nutrition were identified as major strength in the past and fish health aspects will be focussed primarily in future R&D, followed by fish nutrition. Aquaculture experts are aware that efficient resource utilization in terms of e.g. feed conversion, energy utilization, nutrient discharge, water reuse technologies or pathogen treatment will be major challenges for upcoming research activities.

Highlighted priorities identified by our Delphi study among aquaculture experts should not only forecast R&D activities, but also should help funding agencies and decision maker to identify relevant areas of interests.

References

- Guettler, S. (2008). *Forschung und Entwicklung in der Aquakultur – ein Überblick über Arbeitsgebiete und offene Fragen*. I&I Working Paper, <http://www.agric-econ.uni-kiel.de/Abteilungen/II/veroeffentlichungen.shtml>.
- Linstone, H.A. and Turoff, M. (1975). *The Delphi Method – Techniques and Applications*. London: Addison-Wesley.
- Seidel-Lass, L. (2009). *Networks in International Aquaculture Research: a Bibliometric Analysis*. Göttingen: Cuvillier Verlag.

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It is also primordial to raise the profile of the aquaculture industry, by creating forums for dialogue between the European Aquaculture Technology and Innovation Platform, the Commission and Member States' research programme managers to facilitate the programming of research activities at Community and national level and by continuing the work started in CONSENSUS to provide balanced, science-based information to European consumers and their representative organisations on aquaculture.

With the green paper on the CFP, that "lays it back to its bare bones" and asks many fundamental questions. The ones addressing aquaculture "What role should aquaculture have in the future CFP: should it be integrated as a fundamental pillar of the CFP, with specific objectives and instruments, or should it be left for Member States to develop on a national basis? What instruments are necessary to integrate aquaculture into the CFP?" are important ones – with the two sectors being complimentary in providing European consumers with high quality, safe and responsibly-produced/fished seafood.

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