Project Report
25 - 03

WEFTA

Icelandic Fisheries Laboratories

SEPTEMBER 2003

NETWORKING IN FISHERIES RESEARCH

A Report on the Networking Activities at the TAFT 2003 Conference, 11-14 June 2003, Reykjavik - Iceland

Guðrún Ólafsdóttir

Skýrsluágrip Rannsóknastofnunar fiskiðnaðarins
Icelandic Fisheries Laboratories Report Summary

Titill / Title	**Networking in Fisheries Research -TAFT 2003**		
Höfundar / Authors	*Guðrún Ólafsdóttir*		
Skýrsla Rf /IFL report	25 - 03	*Útgáfudagur / Date:*	September 2003
Verknr. / project no.	1544		
Styrktaraðilar / funding:	*Nordic Industry Fund project no.03004* *Icelandic Centre for Research*		

Ágrip á íslensku:

Netverki í fiskiðnaðarrannsóknum var komið á fót á TAFT 2003 ráðstefnunni í Reykjavik. Ráðstefnan var fyrsta sameiginlega ráðstefna aðila í fiskirannsóknum beggja megin Atlantsála. Það voru samtök rannsóknarstofnana í fiskiðnaði í vestur Evrópu (WEFTA) ásamt systursamtökum á austurströnd Norður Ameríku og Kanada (AFTC) sem stóðu að ráðstefnunni.
Á ráðstefnunni var skapaður vettvangur til að hrinda í framkvæmd netverki um gæði, öryggi og betri nýtingu fiskhráefnis. Tilgangurinn var einnig að skoða möguleika þess að stuðla að meiri samvinnu aðila í fiskiðnaðarrannsóknum í Norður Ameríku og Evrópu. Markmiðið er að móta verkefni milli aðila í fiskirannsóknum á Norðurlöndum, Evrópusambandinu, Kanada og Norður Ameríku. Í skýrslunni er gerð grein fyrir framkvæmd netverksátaksins á TAFT 2003, fjölda þátttakenda og helstu rannsóknaráherslum og niðurstöðum.

Lykilorð á íslensku: *Netverk, fiskirannsóknir, fiskur, aukaafurðir, gæði, öryggi, rekjanleiki*

Summary in English:

In connection with the TAFT 2003 conference, the first joint Trans Atlantic Fisheries Technologists conference of the Western European Fisheries Technologists´ Association (WEFTA) and the Atlantic Fisheries Technology Conference (AFTC), a networking initiative in fisheries research was organised.
A forum was arranged at the conference to launch a network in fisheries research with a focus on seafood quality, safety and further utilization of fish raw material. The aim was also to explore funding possibilities for joint projects in order to open up possibilities for cooperation in fisheries research in North America and Europe. The outcome of this event will become a basis for further networking and new cooperative research and development projects in fisheries research with the participation of scientists in Nordic, EU, Canadian and US institutions in fisheries research, as well as representatives from the industry on both sides of the Atlantic.
In this report the procedure of the Networking in Fisheries Research at the TAFT 2003 conference will be described, the participation and the outcome of the event.

English keywords: *Networking, fisheries research, fish, by-products, quality, safety traceability*

Nordic Industrial Fund
center for innovation and commercial development

RANNÍS

Networking in Fisheries Research

TAFT 2003

First Joint Trans-Atlantic Fisheries Technology Conference

33rd WEFTA and 48th AFTC Meetings,

11-14 June 2003, Reykjavik - Iceland

WEFTA

48th ATLANTIC FISHERIES TECHNOLOGY CONFERENCE

Titill / Title:	Networking in Fisheries Research -TAFT 2003		
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Á ráðstefnunni var skapaður vettvangur til að hrinda í framkvæmd netverki um gæði, öryggi og betri nýtingu fiskhráefnis. Tilgangurinn var einnig að skoða möguleika þess að stuðla að meiri samvinnu aðila í fiskiðnaðarrannsóknum í Norður Ameríku og Evrópu. Markmiðið er að móta verkefni milli aðila í fiskirannsóknum á Norðurlöndum, Evrópusambandinu, Kanada og Norður Ameríku.

Í skýrslunni er gerð grein fyrir framkvæmd netverksátaksins á TAFT 2003, fjölda þátttakenda og helstu rannsóknaráherslur og niðurstöður.

Lykilorð á íslensku: *Netverk, fiskirannsóknir, fiskur, aukaafurðir, gæði, öryggi, rekjanleiki*

Summary in English:

A networking initiative in fisheries research was organised in connection with the TAFT 2003 conference, the first joint Trans Atlantic Fisheries Technologists conference of the Western European Fisheries Technologists´ Association (WEFTA) and the Atlantic Fisheries Technology Conference (AFTC). A forum was arranged at the conference to launch a network in fisheries research with a focus on seafood quality, safety and further utilization of fish raw material. The aim was also to explore funding possibilities for joint projects to open up possibilities for cooperation in fisheries research in North America and Europe. The outcome of this event will become a basis for further networking and new cooperative research and development projects in fisheries research with the participation of scientists in Nordic, EU, Canadian and US institutions in fisheries research, as well as representatives from the industry on both sides of the Atlantic.

In this report the procedure of the Networking in Fisheries Research at the TAFT 2003 conference will be described, the participation and the outcome of the event.

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1. INTRODUCTION

The First Joint Trans Atlantic Conference (TAFT) held in Reykjavik, Iceland in June 2003, was a concerted effort of two independent organisations, the Atlantic Fisheries Technology Conference (AFTC), based in North America, and the West European Fish Technologists' Association (WEFTA). Both WEFTA and AFTC organise annual meetings on their respective continents, focusing on similar topics of relevance for the fish processing industry. Invitations for participating in each other's meetings have been communicated from both sides and the idea to have a joint meeting has been discussed for some years. The TAFT 2003 was thus a timely event as a response to globalization of trade and the common goal of sustainable fisheries to ensure a high quality of life.

The topics of the TAFT 2003 conference reflect the current emphasis in the area of fish technology research. It focuses on increasing awareness and international networking in fisheries research to ensure the development of good quality, health promoting, safe fish products for consumers. The total number of participants at the conference was 215 from 22 countries worldwide. The forum was thus an excellent opportunity to launch the Networking in Fisheries Research.

Box 1. Aims of the Networking in Fisheries Research

- to establish a network to promote international cooperation in fisheries research
- to explore possibilities for cooperative projects
- to stimulate the development of international fisheries research projects

2. PROCEDURE AND OUTCOME OF THE NETWORKING

The key to the success of the Networking initiative at the TAFT conference was the early registration of participants via the website of the TAFT 2003 conference, which gave the organisers time for planning the procedure at the conference and also stimulated the

interest of the participants. The procedure of the Networking initiative at the TAFT 2003 conference was the following:

2.1 Networking Questionnaire

Participants filled out a questionnaire via the website of the TAFT 2003 conference (http://www.rf.is/TAFT 2003) prior to the conference and additional entries were made at the conference. The questionnaire was aimed at collecting data on networking participants relating to their affiliation, company activity, new project ideas and their expertise. The website contains a database with contact details for people who are interested in the respective research topics. The complete data is now available on the IFL website: http://www.rf.is/TAFT 2003/Networkresults.htm.

Box 2. Data collected in the Networking questionnaire via the Internet

Name:	Company activity:
Company:	Other activity:
Position:	Expertise:
Email:	Experience in R&D:

Stage of project idea:
Project idea /Networking topics no:
Other Networking topics no:
Brief description of project idea:

2.2 Networking in oral sessions at TAFT 2003 - Session Reports from Moderators

The conference itself was a forum for presenting ongoing projects in fisheries research. Discussion in both the oral and the poster sessions stimulated new ideas for networking topics. All the moderators in the scientific sessions were asked to prepare a session summary report which is now available on the website and is also included in this report

(Appendix I). This document is valuable for further networking, in particular the discussion on the future trends in research in each session. Powerpoint presentations from most of the speakers are also available at the website.

Box 3. Questions included in the summary report prepared by the session moderators (Appendix I)

- Give a brief outline of the contents of the lectures in the session and evaluate the possibility for exploitation of the scientific results in the industry and what are the main obstacles for their implementation
- From the point of view of science, industry and consumers, is the session covering the current and future trends in the respective research area covered by the session related to ensuring quality and safety of fish product?
- Give ideas on other important research areas that are not covered in the session, but may have potential for future research and networking.

2.3 Networking in the poster session at TAFT 2003

The Poster session at the TAFT 2003 conference was dedicated to the networking and time was allocated at the beginning of the conference for a plenary poster session. The poster session was open throughout the conference to give the participants the opportunity to introduce their research and to stimulate discussions and further networking. Abstracts from all the posters are on the website and also included in the TAFT proceedings.

2.4 Networking topics

Networking topics were the same as those covered by the sessions at the TAFT 2003 conference. Other topics were also included in the networking to cover environmental aspects of fisheries research and risk related issues.

Box 4. Networking Topics

- 01 - Development of new, functional fish products to promote human health and well-being
- 02 - Novel components derived from marine origin with health benefits
- 03 - Better utilization of by-products, fish waste and effluents from fish processing
- 04 - Functional properties and stability of fish proteins and lipids
- 05 - Molecular biology techniques for use in fish and fishery products
- 11 - Traceability in the fishery chain to increase consumer confidence in fish products
- 06 - Innovative fish and shellfish handling, processing, packaging and distribution
- 07 - Scientific bases for international standards on quality and safety of fish products
- 09 - Consumer perceptions to fish consumption
- 08 - Influence of feed and feeding processes on quality factors such as nutrient composition and eating quality of aquacultural species
- 10 - Aquaculture's contribution to new seafood products and future supply
- 19 - Other

Other topics of interest:

2.5 Networking meetings

Networking meetings were arranged at the TAFT conference and project ideas discussed. Reports from networking meetings have been compiled with information about participants, contact persons and action plans for further networking activities. The reports are available on the website www.rf.is/TAFT 2003 and also in this report and give immediate information on the results from the networking event (Appendix II).

Box 5. Topis at the networking meetings

Networking topics 1, 2 and 3
- Better utilization of by products / raw material

Networking topics 1, 2 and 4
- Functional fish products - Novel components
  - Fractionation of edible parts of fish into new functional food ingredients

Networking topis 5 and 11
- Traceability
  - Central reference bank for fish species identification

Networking topic 6
- Total quality management
  - Harvesting: Post-harvesting treatments, handling, innovative techniques, quality assesment tools/methods
  - Logistics: Handling/storage/shipping treatment, traceability, documentation, database, innovative techniques
  - Processing: Innovative techniques, minimal processing, quality assesment tools/methods
  - Marketing: Stimulate export, regulation, documentation
  - Consumer and health: preferences, needs, acceptancy of products

Networking topic 7
- Safety and quality exchange programme
  - Risk – whole food chain approach

Networking topics 8 and 10
- Aquaculture - Replacements in fish feed
  - shrimp, flatfish, cod, salmon, sea bass - stress, disease resistance, fish welfare, consumer aspects, social aspects

Networking topic 9
- Consumer driven fish production

2.6 TAFT 2003 Proceedings

The TAFT 2003 proceedings includes scientific papers from the nine keynote speakers, extended abstracts from all the other speakers, abstracts from posters and information about the networking. The proceedings was published prior to the conference and the networking event and is also available on the TAFT website. It gives a good overview on the research activities covering the topics of the conference and is an important document for further research and networking.

2.7 Workshop in Fisheries Research at TAFT 2003.

The networking was further stimulated in connection with the workshop organised for the fish industry at the TAFT 2003 conference. A dicussion panel was organised entitled: FUTURE TRENDS FOR UTILISATION OF BY-PRODUCTS AND APPLICATION OF NOVEL COMPONENTS FROM MARINE SOURCES. Nigel Allen (Canada) chaired the panel and representatives from the industry, Jóhannes Gíslason (Primex, Iceland), Agnes Joly (SIF, France) and Ronan Gormley, (Ireland) representing research – industry collaboration, were selected in the panel in addition to the keynote speakers from the workshop: Fareidoon Shahidi (Canada), Asbjörn Gildberg (Norway) and Michael Morrisay (USA).

Nigel Allen commented that "the session adequately addressed the state of the science in terms of current and future possibilities regarding functional ingredients. There is some uncertainty with respect to future exploitation. The R&D is primarily a **science and technology push rather than directed by market pull**, and there is little in the way of pre-market assessment in terms of technical and economic feasibility and market demand. The primary obstacles to industrial applications is a lack of industry involvement in requesting that much of the research be conducted, and no structured approach to evaluating the 'need' for these products and/or the size of market".

3. FUNDING OF FUTURE PROJECTS

The first session of the conference was dedicated to funding of scientific research and dissemination. Representatives from the European Commission, the funding agencies in USA and Canada, the Nordic Industry Fund and the Icelandic Centre for Research gave an overview of funding possibilities for joint projects and encouraged the launching of the Networking initiative. The following presentations are all available on the website and in the TAFT 2003 proceedings:

Sigurður Bogason, EU Commission: Review of European Union research funding for fisheries technology during the FAIR (FP4) and QUALITY OF LIFE (FP5) framework research programmes

Ronald G. Hodson and James D. Murray, USA: Ensuring global competitiveness of the U.S. seafood industry - A national sea grant initiative

Nigel Allen, Canada: Fisheries Science and Technology Research and Development Collaborations - A Canadian Perspective

Oddur Gunnarsson, Nordic Industry Fund and Snæbjörn Kristjánsson, The Icelandic Centre for Research: Funding possibilities for networking RTD projects.

The overview of funding possibilities gained at the conference will stimulate and make common projects a reality in the near future.

4. PARTICIPATION STATISTICS OF THE NETWORKING

A total of 113 entries into the networking database were made and these were processed and grouped according to networking topics. Not all participants of the Networking were present at the TAFT conference, but the lists of participants interested in different networking topics are available the on the website and in this report.

Because of an overlap in the interests of participants in networking topics it was decided to combine several topics and as a result, seven parallel networking meetings were held. The majority of the participants were interested in topics 1-4 (Figure 1). Networking meetings on the additional topics 12-18 were not held since the participants were more interested in the initial topics of the TAFT.

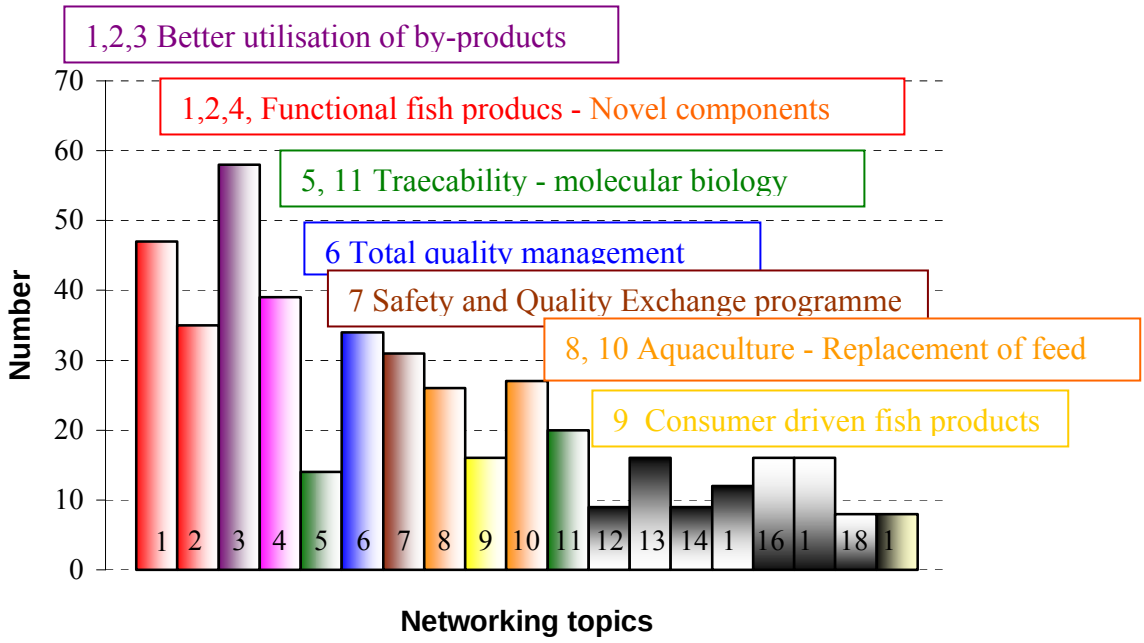

Figure 1. Total number of entries on interest in networking topics registered via the internet. Many participants marked more than one topic.

Total number of participants present in seven networking meetings at TAFT were 106.

Networking topics 1, 2 and 3 (28 particpants at the meeting)

- Better utilization of by products / raw material

Networking topics 1, 2 and 4 (26 particpants at the meeting)

- Functional fish products - Novel components

Networking topis 5 and 11 (6 particpants at the meeting)

- Traceability - Central reference bank for fish species identification

Networking topic 6 (13 particpants at the meeting)

- Total quality management

Networking topic 7 (20 particpants at the meeting)

- Safety and quality exchange programme

Networking topics 8 and 10 (9 particpants at the meeting)

- Aquaculture - Replacements in fish feed

Networking topic 9 (4 particpants at the meeting)

- Consumer driven fish production

The majority of the participants come from research institutes and universities which could be expected since the forum was a scientific conference (see Figure 2). A complete list of participantsis is enclosed in this report. In all, 113 participants from 22 countries participated in the networking event.

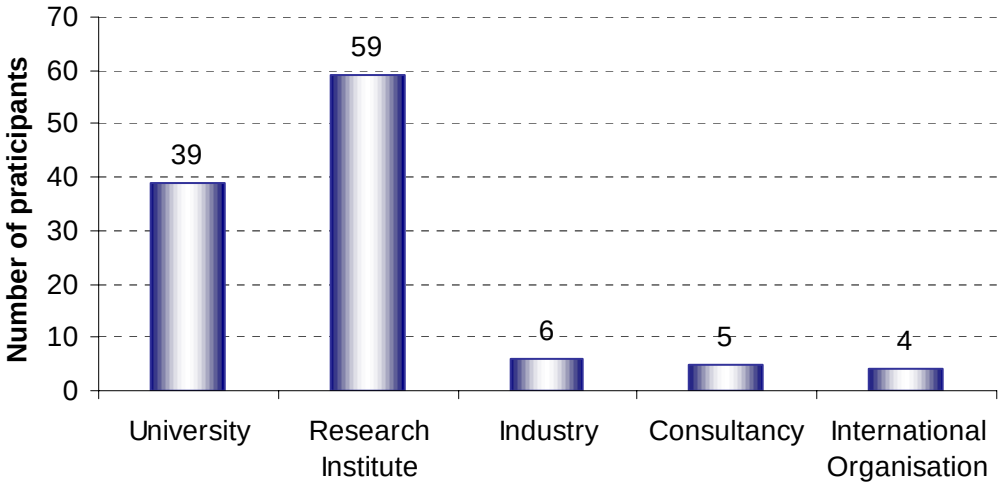

Figure 2. Company activity of participants of the Networking in Fisheries Research

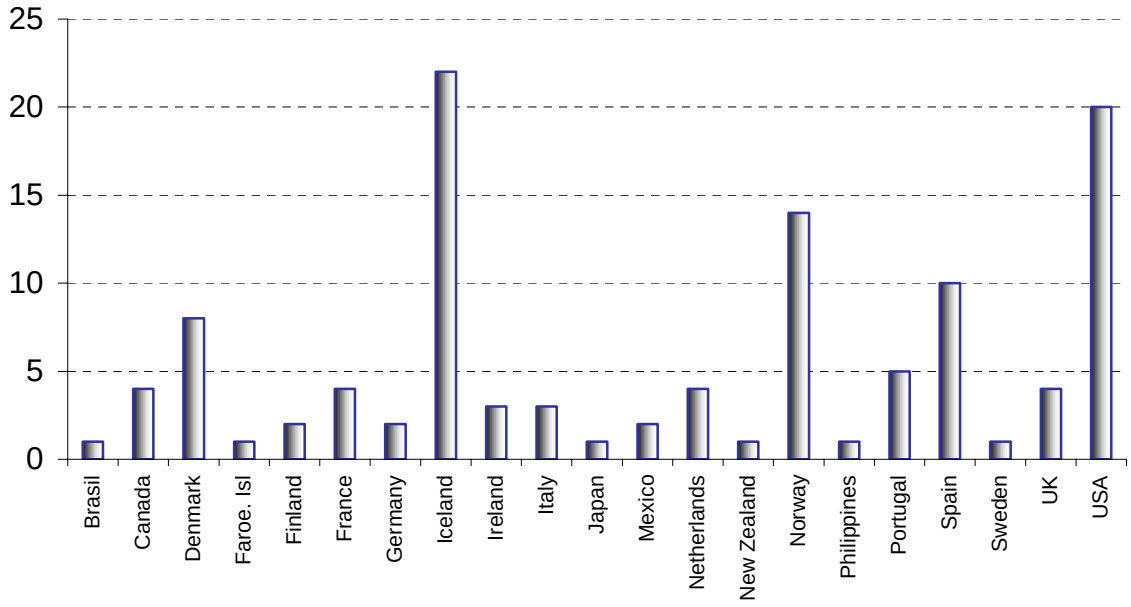

Figure 3. Number of participants from different countries

5. DISSEMINATION

Advertisments to promote the participation at the conference and the networking:

- The TAFT 2003 conference was advertised prior to the conference via the Internet using address lists of the AFTC and WEFTA.
- Each organisation advertised the event in their home country
- The event was listed in calenders of various scientific journals and at the IFT website / Seafood Davis.
- Invitation letters were sent to a target group of people of relevance to seafood research.
- Advertisment in an Icelandic newspaper
- An article was written in an Icelandic trade journal: Björn Audunson, Alþjóðleg ráðstefna í júní um nýtingu sjávarfangs. Ægir , May 2003.
- Two interviews with organisers of the TAFT 2003 conference in the largest Icelandic newspaper (Morgunbladid) before and after the event
- Networking in Fisheries Research - Two posters presented at the TAFT 2003 Conference

Publications and activities to promote further networking

- Information on the networking is updated regularly on the TAFT 2003 website hosted by IFL: http://www.rf.is/TAFT 2003
- Proceedings of the TAFT conference was published and is available on the website
- Networking in Fisheries Research, IFL report (this report, also available on the website)
- Introduction of the Networking in Fisheries Research at the 2003 North Atlantic Conference, Shetland Islands:

Roland Cormier, Coordinator Food Product Initiative, Fishery Industries Division, FAO will participate in the 2003 North Atlantic Conference, 30 September - 2 October, hosted by the Shetland Islands Council in Lerwick, Shetland. The event will be held in cooperation with the Nordic Council of Ministers. Mr Cormier will speak on the topic of

"Trans-Atlantic Cooperation in Fisheries Research and Development" and introduce the Networking initiative at TAFT.

6. CONCLUSIONS

The Networking in Fisheries Research was successfully launched at the TAFT 2003 conference. Hopefully, it was only the beginning of several trans-Atlantic inititatives in fisheries research in the coming years.

The main deliverables are:

- Summary report from moderators (Appendix I)
- Reports from the Networking Meetings (Appendix II)
- List of participants (Appendix III)

About half of the participants in the networking (54) selected networking groups focusing on**: Better utilisation of by products - novel components and functional properties of fish components**. This great interest reinforces the importance of fishery utilization to the North Atlantic rim countries. Ongoing work in this area on the utilization of by-products were presented at the TAFT 2003 conference from e.g. Iceland and Newfoundland. By-Products Utilization Center was cited as an example of trans-Atlantic cooperation. The area of neutraceuticals comes under this secondary product category as well and may well become the trans-Atlantic cooperation that will develop from the networking at TAFT conference.

There was also a considerable interest in the topic **safety and quality exchange programme** (20 participants) which is consistent with the Aquatic Fish Product Initiative (AFPI) of FAO (www.FishPort.org). The networking will focus on common global safety and quality problems and communication on methodology, with the aim to establish convenient, recognized methods and scientifically based programs for verifications/certifications of product quality and safety in international commerce..

Thirteen participants in the networking group on innovative handling identified **"total quality management"** as a networking research and development area with the whole chain approach in mind. While this in not well defined yet, one sub-area that appears to be developing quite well is the implementation of the "Quality Index Method" for assessing fish quality.

The importance of **"traceability"** in light of impending EU regulations is very high. Furthermore, authenticity is becoming increasing important with regard to the economic substitution of species. Six participants joined the networking meeting on traceability and identified a common interest in establishing a central reference bank for fish species identification.

The need for replacement of fish oil/fish meal in feed for fish is indisputable and there seems to be a lot of interest in cooperation in finding alternative replacements in feed for the most common species in farming. Therefore, the networking group on "aquaculture" with 9 participants identified the networking topic **"Aquaculture - replacements in fish feed"**

The networking group on consumers issues consisted of four participants. From the lectures presented in the oral session it was clear that the fish industry is not very much involved in consumer studies, at least not so far. However, the outcome of the research presented is important for the fish industry in order to optimise and improve the quality of fish products. The networking idea **"Consumer driven fish products"** was identified**.**

A futuristic approach was introduced by Guðrún Marteinsdóttir, Iceland. This is a project idea called MARESCO - Integrated management of MArine REsources for sustainable Socio-ECOnomic development. The overall objective of this research framework is to develop a holistic approach to sustainable management of marine resources in the context of climate change. This will be achieved by developing a generic model that explores the sustainable utilisation of natural resources through different harvest regimes, integrating the effects of community dynamics, biodiversity, climate changes, product utilisation, consumer behaviour, as well as anthropologic and socio-

economic effects. With proper modification the model will be applicable to the management of other natural resources, such as agriculture and forestry.

ACKNOWLEDGMENTS

Financial assistance from the Nordic Industrial Fund and the Icelandic Centre for Research is greatfully acknowledged. Snæbjörn Kristinsson at the Icelandic Centre for Research is thanked for helpful guidance in organising the networking forum. All the hard work of the IFL staff is appreciated who skilfully organised and managed The Networking in Fisheries Research at the TAFT 2003 conference. Also, the session moderators are sincerely thanked for taking time and efforts to compile the session reports and the networking groups and their leaders to put together the reports from the networking meetings.

APPENDIX 1

SESSION REPORTS FROM MODERATORS

Innovative fish and shellfish handling, processing and distribution
Moderators: David Green, USA and Helene Lauzon, Iceland

Development of new, functional fish products to promote human health and well-being
Moderators: Heidi Nilsen, Norway and Joop Luten, Norway

Consumer perceptions to fish consumption
Moderators: Heidi Nilsen, Norway and Joop Luten, Norway

Scientific bases for international standards on quality of fish products impact of processing and handling
Moderators: Maria Bianca Poli, Italy and Jörg Oehlenschläger, Germany

Traceability in the fishery chain to increase consumer confidence in fish products - application of molecular biology techniques
Moderators: Maria Leonor Nunes, Portugal and Mike Morrisey,USA

Scientific bases for international standards on safety of fish products
Moderators: Lucay Han Ching, France and Brian Himelbloom,USA

Quality characteristics and functional properties of lipids, proteins and enzymes from fish Including applications for surimi and protein hydrolysate processes
Moderators: Charlotte Jacobsen, Denmark and Hördur Kristinsson,USA

Aquaculture - Influence of feed and harvesting processes on quality factors
Moderators: Jón Árnason, Iceland and Luc Leclerc, Canada

Workshop for the fish industry:

Novel components derived from marine origin including better utilization of by-products, fish waste and effluents from fish processing
Moderators: Tyre Lanier, USA and Gudjon Torkelsson, Iceland
Moderators: Margarita Tejada, Spain and Chong Lee, USA
Moderators: Nigel Allen,USA and Irene Stoknes, Norway

Innovative fish and shellfish handling, processing and distribution

Moderators: David Green, USA and Helene Lauzon, Iceland

Q: Give a brief outline of the contents of the lectures in the session and evaluate the possibility for exploitation of the new innovative techniques in the industry and what are the main obstacles for their implementation

In this session, an excellent overview of minimal processing, as it affects quality and safety and enhances shelf-life of foods, was presented. Many of these innovative techniques can possibly be exploited in the fish/shellfish industry.

Ultra high pressure can be used as a cold pasteurisation process, decreasing microbial load and affecting many enzymes. However textural problems have been reported at very high pressure. Commercial sterility can even be achieved by using 900 MPa and 90°C treatment. High pressure treated oysters are available on US market. High pressure assisted thawing of frozen fish fillets can be more rapid than traditional thawing in water and decrease microbial load. However various sensory attributes and protein denaturation can be problematic. High electric field pulses will puncture cell walls and inactivate microorganisms and could therefore be used for the extraction of proteins and enzymes of interest. Radio-frequency heating allows for a very rapid heating (over 70°C for 2 minutes) of fishery products, hence leading to improved quality as well as some bacterial inactivation.

Colour and appearance are important factors in aquatic foods. Oxidation of the heme proteins will cause browning during frozen storage, but can be avoided by low temperature storage (-50 to -60°C) or chemical treatment of the muscle to stabilize the heme proteins. The use of carbon monoxide for colour retention in frozen fish products is an innovative technique that prevents discolouration, but its effect on the microbiological quality and regulator acceptance, especially in Europe, has yet to be evaluated.

The use of modified atmosphere packaging is an interesting processing step that may be considered when shelf-life extension of chilled products is required. Also, oxygen absorbers can be useful, especially where oxygen reduction is necessary to reduce lipid oxidation. Moreover, a better understanding of the dissolution of carbon dioxide into the fish muscle must be achieved in order to establish optimum levels in different applications, without affecting sensory parameters. The use of Carnobacterium strains as a means to reduce risk by inhibiting pathogen growth (Listeria monocytogenes) found in ready-to-eat fishery products is very promising.

Relaying of shellfish is a valid approach to improve rapidly the bacteriological quality of clams. Ideal conditions for relaying to effect depuration of potential harmful bacteria remains to be determined; such as choice of container size and depth in water which affects duration time required. Finally, pre-rigor processing of salmon was shown to have advantages for the industry by reducing costs in shipping and adding value to raw materials.

Q: From the point of view of science, industry and consumers, is the session covering the current and future trends regarding innovative techniques to ensure quality and safety of fish product?

The topics generally represented current and future trends. Greatest interest was shown in market development as it relates to better utilization of raw material, such as sea-frozen cod or fresh seabream, pre-rigor processing of fillets to reduce costs and add value as well as in the area of safety to reduce risk by increasing hurdles for growth of potential pathogens such as *Listeria monocytogenes* in RTE seafood.

Q: If appropriate please give ideas on other important innovative fish and shellfish handling, processing and distribution techniques that are not covered in the session, but may have potential for future research and networking.

More information in the mechanisms and use of high intensity light was identified as a new technology area that was not discussed at the TAFT 2003 conference. Also, there were concerns expressed for the latest developments, particularly in the US, for the use of carbon monoxide, filtered smoke or tasteless smoke. The safety and regulatory policies regarding this new process has not been determined and the policy varies by countries. This issue will need further attention in both the scientific and regulatory communities.

Development of new, functional fish products to promote human health and well-being

Moderators: Heidi Nilsen, Norway and Joop Luten, The Netherlands

Q: Give a brief outline of the contents of the lectures in the session and evaluate the overall positive and negative influences of the development of new, functional fish products for the different parties of interest (scientists, fish industry and consumers).

In the keynote lecture (K2) by Gert Jan Schaafsma, the development of food and human health in the period 1900 - until 2003 was presented. It showed a development from classical nutrition, via optimal nutrition to functional foods and dietery supplements. It also demonstrated that functional food is not a hype but a trend that will remain. The major food trends are health, convenience and pleasure. For functional food it is essential to have scientific evidence of the effects (enhanced effect or reduction risk).

For the development of functional food, the strategic consumer oriented triangle is important (efficacy, emotinal fit, rational fit and taste). One problem area identified is the lack of good biomarkers in order to document the health effects. Much emphasis should be laid upon seafood proteins in relation to gut health.

Although a lot of nutrition research is going on with respect to n-3 fatty acids and cardiovascular diseases, it is recommended that attention should be paid to n-3 fatty acids in connection with to sudden death and inflammatory diseases .

Seafood (by-products) contain a large number of components with potential bioactivity but the evidence is still only preliminary.

Q: From the point of view of science, industry and consumers, is the session covering the current and future trends regarding development of new, functional fish products?

The cost of developing functional or novel foods is very high due to the needed evidence for the health effect (human volunteers nutrition studies are a must). This means that for the seafood industry with its great number of SMEs this will hardly be feasible.

Q: If appropriate, please give ideas on other important research areas related to the topic that are not covered in the session, but may have potential for future research and networking.

To tailormade seafood products by farming it is recommended that fishfeed experts, farmers and human nutritionists should create a platform to discuss the optimal composition of the feed for the farmed fish and the final product for the consumer.

Consumer perceptions to fish consumption

Moderators: Heidi Nilsen, Norway and Joop Luten, The Netherlands

Q: Give a brief outline of the contents of the lectures in the session and evaluate the current trend of seafood consumption behaviour and the influence of packaging and handling techniques on consumer perception.

A general model for explaining food consumption behaviour was presented in the keynote lecture (K3) by Svein Ottar Olsen . This model focuses on attitudes and preferences, social and moral norms and perceived controls and barriers. Applying this model to seafood consumption in Norway showed for example that seafood is very much associated by consumers with health, in contrast to meat. Older people eat more seafood than younger ones and quality is associated with freshness, the preference being for fresh, rather than frozen seafood

Several examples of consumer oriented product testing and development were shown in short presentations:

1. Effect of brining frozen cod showed an upgrading effect in consumer appreciation
2. Preliminary results of an in house consumer trial with farmed and wild cod showed a main effect on consumer preference due to production type (wild or farmed) and information about farming
3. Consumers found difference between 2 and 10 days old cod packed in air or in MAP
4. No country specific preference for smoked salmon but different consumers preferences in each country.
5. Consumers are able to differentiate between high quality fish and fish they normally buy at retailer site

Q: What is the importance of this type of research for the different parties of interest (scientists, fish industry and consumers) and how will they use the results.

From the lectures that were presented it is clear that the fish industry is not very much involved in consumer studies, at least not so far. However, the outcome of the presented research is important for the fish industry in order to optimise and improve the quality of fish products. It was also

observed by an industrial representative that there is a market for seafood of different qualities (high, medium and lower quality).

Q: If appropriate, please give ideas on other important research areas related to the topic that are not covered in the session, but may have potential for future research and networking.

In order to transfer the scientific outcome of seafood consumer studies, as presented at the TAFT 2003 conference to the industry, it was announced that RIVO-Fiskeriforskning has taken the inititiave to organise an international workshop in early 2004 about conusmer oriented seafood product development and consumer behaviour to seafood.

Scientific bases for international standards on quality of fish products impact of processing and handling

Moderators: Maria Bianca Poli, Italy and Jörg Oehlenschläger, Germany

Q: Give a brief outline of the contents of the lectures in the session and evaluate the need for international standards on quality of fish products.

The lectures presented in the session discussed traditional and new approaches to fish quality and, in particular, to freshness/spoilage measurements. Measurements of electrical properties, rigor phases evolution, colour by CieLab method, carotenoids concentration, texture, muscle gaping, water or liquid holding capacity in fresh fish and dried salted fish, phenol and salt content in cold smoked salmon, near infrared spectroscopy and the measurements of dielectric properties of individual fish using an open ended coaxial sensor and automatic network analyser, appear among the most promising technique for measuring freshness/quality. Such information on emerging technologies is quite useful and represents a challenge for the future.

Since a general agreement on the need for international standards on quality of fish products, the choice of parameters to be applied as quality standards will probably end up favouring those techniques that succeed in being both reliable, rapid and inexpensive.

Q: Evaluate the overall need for quality measurements for the different parties of interest (scientists, fish industry and consumers) and the possibility for exploitation of the new innovative techniques in the industry. What are the obstacles for their implementation?

The session covered some trends, however, in this kind of decision the involvement of policy-makers and/or governmental bodies responsible for standards would be helpful. A dialogue between scientists and those making the decisions, e.g. politicians, is thus very important to ensure an early incorporation and adoption of science-based methodologies into standards or papers of advisory nature. Methods lacking in this session were: Sensor techniques, determination of basic parameters like net weight, drained weight, washed drained weight, fish content determination which are actually discussed and usually needed for the existing Codex standards.

Traceability in the fishery chain to increase consumer confidence in fish products - application of molecular biology techniques

Moderators: Maria Leonor Nunes, Portugal and Mike Morrisey, USA

Q: Give a brief outline of the contents of the lectures in the session and evaluate the need for tools to ensure traceability in the fishery sector and the possibility for exploitation of the new tools to ensure traceability of fish products

In 2005, a new regulation in the European Union will require traceability in the food system. Traceability must be fully implemented in the EU by 2006. This will have a great impact in the fisheries sector, which will then be required to trace the origin of the raw material, the proccesing history, and the distribution and location of the products after delivery.

Q: Evaluate the overall need for traceability for the different parties of interest (scientists, fish industry and consumers).

Traceability is considered essential for improving confidence in the safety of seafood products. Previously, retail chain traceability has been widely implemented and what is different in this link is the tie between the fishing-processing sector with the retail/consumer links. The results of the Tracefish project were reviewed in the session, also as well as a joint project between Danish and Australian seafood chains. Furthermore, an independent project in Japan was discussed.

Q: If appropriate, please give ideas on other important research areas related to traceabilty that are not covered in the session, but may have potential for future research and networking.

Several of the presentations in this session focused on molecular biology methods, such as realtime PCR including a TAQMAN assay medhod, as well as looking at fatty acid profiles from fish captured from different locations. Different software systems and data handling systems, such as RFID tags, EAN, GLN and other systems were briefly described. Because the traceability regulation will be mandatory, research efforts should be continued to be made to facilitate its implementation. One added benefit for implementation of traceability is better reporting of actual fishing activities, which could lead to more responsible fishing practices and increased confidence in the fishing industry by the puplic.

Overall the session went very well and demonstrated e.g. the application of molecular biology techniques that will help in the traceability effort. It would, however, have been helpful if one lecture had covered in more detail some of the software applications that are currently being employed for traceability and where these efforts will be headed over the next few years.

Scientific bases for international standards on safety of fish products

Moderators: Lucay Han Ching, France and Brian Himelbloom, USA

Q: Give a brief outline of the contents of the lectures in the session and evaluate the need for international standards on safety for fish products. Consider also products produced using innovative preservation techniques or handling.

For international trade, the standards for food safety set up by the Codex Alimentarius are scientifically-based. The need for international standards on safety of prepacked fish is obvious to facilitate commercialization. This session contained a keynote address followed by ten presentations (six of which dealt with safety issues and four focusing on quality issues).

The keynote address by John W. Austin (K5), provided an overview of the most important microbiological topics for seafood. The speaker covered selected bacteria (*Clostridium botulinum, Salmonella, Listeria monocytogenes, Vibrio parahaemolyticus* and *V. vulnificus*), parasites and viruses. Dr. Austin gave an in-depth presentation on *C. botulinum* situations with particular reference to the prevalence in indigenous peoples' foods (i.e., "fermented" fish and marine mammals), an ethnic food (salted, uneviscerated, dried whitefish) and vacuum-packed, lower water-phase salt, smoked seafood that may be susceptible to temperature abuse during distribution and storage. Research has been carried out recently to determine botulinal toxicity of products in packaging having various oxygen transmission rates and stored at refrigerated to

abuse temperatures. The recommendation to avoid botulism in ready-to-eat, minimally-preserved seafoods remains: keep <4°C for <28 days. Other products such as sous-vide seafood and caviar in jars were questioned for possible risk from *C. botulinum*.

The next speaker was Fletcher M. Arritt (L41) who provided additional *C. botulinum* results of modified atmosphere packaging (MAP) of fish fillets in various packaging at 4°C and 10°C. The product spoils when air-packed before botulism toxin could be produced. However, toxin may occur in MAP fish at or before spoilage is noticeable when stored at abuse temperature. It is assumed that the consumer cooks the product to inactivate the heat-labile toxin that may be present. Suggestions were made to experiment using naturally low spore population levels but were rejected as these experiments would be difficult to conduct due to the sporadic nature of *C. botulinum*.

The third speaker (L42) was Helena Lourenço who described the levels of mercury (Hg), cadmium (Cd) and lead (Pb) in a variety of canned seafoods in Portugal. Only a few samples exceeded the European Union regulatory limits (<1 ppm) but it is expected that the low consumption of these foods eliminates any risk to the human.

Aslý Cadun (L43) investigated the quality of the invertebrate, sea cucumber, during processing (raw, boiled, sun-dried) in Turkey. Microbial and chemical tests showed these products to meet quality standards. A suggestion was to determine other quality parameters such as texture testing and sensory evaluation.

The fifth speaker (L44), Sónia Pedro, discussed concerns for pathogenic bacteria being present in desalted cod used in the home or for restaurants in Portugal. Although dried, salt cod presents no safety hazard, desalting at ambient temperature (20°C) for 24 hr provides a potential consumer hazard from Staphylococcus aureus enterotoxin. The recommendation was to maintain temperature control (4°C) during desalting.

Birna Guðbjörnsdóttir, (L45), described the difficulty of removing biofilms in seafood processing plants and on nonhygienically-designed equipment. Biofilms made up of spoilage bacteria (i.e., *Pseudomonas sp*. and *Enterobacteriaceae*) can contain the pathogen *L. monocytogenes*. Recommendations were made to use appropriate sanitizers against the spoilage bacteria and to use equipment designed with plant sanitation in mind. Suggestions were made to test rougher

surface materials (although not common in Iceland fish processing plants), determine when biofilms are formed and try enzymes to remove the adhering biofilm.
The seventh speaker, Pierre Colin (L46), discussed the prevalence of *L. monocytogenes* in two French freshwater fish farms and one processing plant located in the vicinity of the farms. The epidemiological method of pulsed field gel electrophoresis (PFGE) was used to show similar strains were found in the two farms but a different resident strain isolated from the processing plant. A recommendation was made to use good hygienic practices and efficient cleaning and disinfection to reduce the incidence of the pathogen.

June Frisby, (L47), displayed plans for using wireless and satellite communications in "real time" to monitor fish temperatures in boxes at sea. The information will be useful for traceability of raw fish quality and aid in electronic fish auctions. Concerns were expressed for validation of fish quality and potential loss of data during wireless and satellite transmissions. However, fish quality measurements will be done for confirmation and the on-board temperature loggers can maintain the raw data for receipt upon return of the fishing boats to shore.
The ninth speaker (L48), P. J. Bykowski, described a thermal process (70°C) and centrifugation to handle Polish fish waste to recover fish oil, coagulated protein and reduce harmful materials such as toxic metals, pesticides and polychlorinated biphenyls. The method would relieve the municipal water treatment facilities from handling fish waste streams.

J.D. Fagan (L49), the tenth speaker, discussed the quality attributes of MAP (three different atmosphere treatments vs. air) of Irish fish portions that are then frozen then displayed in the chill case for up to seven days. Total volatile nitrogen increased during 4°C storage although there were no differences in sensory tests by the 25-person panel tasting cooked samples. The 100% CO_2 packs were the best for quality although the packages were not as appealing due to a concave appearance. Recommended "use-by dates" will assure fish product quality.

Finally, T.R. Gormley, (L50), talked about celiac disease (autoimmune, malabsorption in the intestine) in Ireland and its alleviation by providing wheat gluten-free products. Fish surimi at 10% of the rice flour and potato starch content was a substitute for wheat flour and wheat starch in baking breads. Quality attributes (colour, firmness and loaf volume) were dependent on the fish species used to make surimi. Taste panels composed of coeliac disease patients determined all breads, except ones made with gurnard, to be acceptable with no detection of fish flavor.

Recommendation was made that these products be produced commercially although these will be more expensive.

Q: Evaluate the overall need for methods to monitor safety of fish products for the different parties of interest (scientists, fish industry and consumers) and the possibility for exploitation of the new techniques to monitor safety in the industry. What are the obstacles for their implementation?

Safety standard are in place by regulatory agencies. New research may allow revision of the regulations to meet consumer demand for riskier products. However, less control by the manufacturer may force reliance on consumers to prevent seafood-borne illnesses. Hazard controls are simple such as mandatory temperature control (4°C) of MAP and vacuum-packed seafoods and "use-by date" labelling. Many new molecular biology techniques are now available to monitor safety of seafood products. The fish industry needs rapid and cheap methods for incorporating traceability and management of safety. Better sanitation and equipment design can prevent potential, unwanted microbiological problems. There are no obstacles to implementation. It may require better, understandable and honest labelling to assist consumers in making wise choices in the seafood market.

Q: From the point of view of science, industry and consumers, is the session covering the current and future trends regarding innovative techniques for monitoring safety? If appropriate, please give ideas on other important research areas related to the topic that are not covered in the session, but may have potential for future research and networking.

These topics covered current issues of on-going concerns regarding seafood quality and safety. The *C. botulinum* and MAP, toxic metals, and *L. monocytogenes* studies were not innovative but merely confirmatory of previous research by others in the field. The biofilm, desalting and fish waste projects were routine standard analyses. The temperature-monitoring project is only one piece of the fish quality picture but it does take advantage of the Internet and the use of miniature autonomous temperature data loggers. The fish surimi in bread study is a novel extension for a limited population of affected consumers.

The need to conduct studies to specifically address geographical origins of species harvested around the world for potential safety problems was expressed. Another comment was about the

lack of any presentation involving risk analysis, a necessity to model potential food safety problems. Both aspects have the potential for future research and networking.

Quality characteristics and functional properties of lipids, proteins and enzymes from fish Including applications for surimi and protein hydrolysate processes

Moderators: Charlotte Jacobsen, Denmark and Hördur Kristinsson, USA

Q: Give a brief outline of the contents of the lectures in the session. Evaluate in particular the overall need for research on quality characteristics and functional properties of lipids, proteins and enzymes from fish for the different parties of interest (scientists, fish industry and consumers).

- Factors affecting the role of hemoglobin in lipid oxidation of fish muscle, including 1) species related differences which may be attributed to differences in living conditions such as temperature, 2) the structure of hemoglobin as related to species differences. Further research is needed in this area to obtain a full understanding of the mechanisms.
- Effect of natural antioxidants (tocopherol, rosemary and tea catechins) in cod liver oil. Research on complex emulsion systems was recommended.
- Possibility of manipulating the location/distribution of antioxidants in fish thereby optimising the antioxidant effects. Only few results are available and data on the relation between antioxidant location and antioxidant efficacy in fish are lacking
- Oxidation data in surimi indicated that proteins and lipids are interacting during oxidation
- Protein solubility as affected by frozen storage of herring before solubilization.
- Role of water structuring in protein cryoprotection as affected by e.g. long chain carbohydrates that decrease water mobility and thereby increase glass transition temperature. This area deserves further research
- Protein recovery from blue whiting by alkali/acid extraction described and transglutaminase was shown to increase gel strength of the protein.
- Protein concentrate from squid with gelling properties. The process is patented.
- Processes for protein hydrolysis of cod by-products, salmon heads, viscera were developed, but application potential is not clear and needs to be investigated.
- Existence of matrix metalloproteins documented, but its exact role in muscle tissue needs to be clarified.

- Trypsin/chymotrypsin activities in different cod species investigated. This appears to be important in relation to utilisation of viscera.

Q: Evaluate the possibility for exploitation of the innovative techniques in the industry. What are the obstacles for their implementation

- Identifying the underlying parameters that influence the role of hemoglobin in lipid oxidation of fish muscle is an important area of research that can aid in strategies to minimize rancidity problems on harvest, processing and storage. However much work is needed to understand the species to species differences in hemoglobin pro-oxidative activity before species specific antioxidative strategies can be implemented.
- The possibility of directing the antioxidant to different locations in the fish, e.g. to membranes is very interesting and has good commercial potential, but the effect of the antioxidant location on the oxidative stability of the fish needs to be evaluated in more detail along with accurate analysis on the fate of the antioxidants.
- Natural antioxidants may have good antioxidant effects, but some of them e.g. rosemary and tea catechins are not yet permitted in foods and this may prevent their use in the food industry. Furthermore the effect on flavour and consumer acceptance needs to be assessed.
- The physics and chemistry of how water structure play a role in quality and quality preservation of fish muscle and products derived from fish muscle is an important area of investigation. More research is needed to explain how experiments with theoretical/model systems apply to more complex systems and how manipulation of water structure can be increasingly more incorporated into aquatic food processing applications.
- Techniques are now readily available for preparing protein hydrolysates using enzymatic methods, but their functionality, quality and stability deserves more research. Furthermore, market potential needs to be evaluated.
- Squid was presented as a novel and abundant source of surimi. This material is an interesting alternative to finfish derived surimi and deserves more research to optimise its functionality.
- Blue whiting and sardines can be utilized to a fuller and different extent using a newly developed patented process. Transglutaminase was shown to possess interesting gel strength enhancing properties for the isolated proteins from these species that can be exploited in surimi production.
- Identifying whether metalloproteinases play a significant role in fish muscle post-mortem can give important insight into processes responsible for texture modification of fish muscle

tissue. Whether knowledge on these proteinases can be applied to controlling texture of fish muscle remains unknown.

- Documenting the seasonality of trypsin and chymotrypsin in cod viscera can give important information on how to handle these species on harvest and also for those interested in extracting these enzymes for commercial or research use.

Q: From the point of view of science, industry and consumers, is the session covering the current and future trends regarding research in this area?

The session covered several topics, but the following topics were not discussed:

- The session did not cover the possible applications of protein hydrolysates. Neither did it include discussion on the consumer acceptance and legal issues in relation to exploiting by-products such as viscera
- Application of fish oil in foods. Strategies to protect fish oil enriched foods (e.g. fish protein hydrolysates) by e.g. antioxidants, careful processing and intelligent design of the oil-water interface to reduce lipid oxidation.
- Protein-lipid interactions in connection with oxidation of fish muscle.
- Preventing the pro-oxidant effect of hemoglobin
- Optimisation of cryoprotection.

Aquaculture - Influence of feed and harvesting processes on quality factors

Moderators: Jón Árnason, Iceland and Luc Leclerc, Canada

Q: Give a brief outline of the contents of the lectures in the session. Evaluate in particular the need for research on the influence of feed and harvesting processes on quality factors?

The session consisted of a keynote presentation from Francoise Medale, who gave an overview on the relationship between feed and feeding and product quality, as well as twelve other presentations.

Three presentations were on alternative or new raw-materials that can be used in feed formulation on short- or long term, five presentations discussed the effects of farming and slaughtering practices on product quality and, finally, three presentations which dealt with the effects of farming practices on the environment and ethics.

Q: From the point of view of science, industry and consumers, is the session covering the current and future trends regarding the importance of farmed fish as a future source of raw material for fish products (for example environmental, ethical and ethnic concerns).

As can be seen from the presentations, the quality of the farmed fish can be influenced in many ways by the practice used in the aquaculture.
This is of particular importance today when there is an increased demand for food safety and traceability of the food by the consumer.
In the future it can be very important for the aquaculture industry, not only to use sustainable and healthy feed, but also to use acceptable practices in the farming in general, in order to be able to gain and maintain the confidence of the consumer.

Q: Please give ideas on other important research areas related to the topic that were not covered in the session, but may have potential for future research and networking.

The presentations showed that there is still a lot to be learned regarding quality characteristics like gaping and what factors are influencing it. The session clearly demonstrated the effect of pre-processing operations on the general quality of fish and fish products. As pointed out by Dr. Medale, the industry needs to conduct more studies to understand the influence of individual parameters and the combination with the final objective of developing a model to optimize the production. The question of the availability of raw material and new material in particular has been discussed but the cost of feed production has not been extensively covered. It has to be kept in mind that it is still a factor to consider in a model of production. The efficiency improvement of feed by utilization of preparative method, like enzyme hydrolysates from squid (Lee, C.) or incorporation of soybean meal seems to be a good trend for the future.
It is also evident that there is still a lot to research in order to understand the influence of farming practices on the liver size and textural quality in farmed cod.

Other important questions to be addressed in the future are related to sustainability and ethics, in the light of traceability and consumer comfort, when farmed fish will play an ever increasing role in delivery of raw-material to the fish processing and marketing.
The food industry also needs to adapt quality indicators to evaluate the products and adjust the processes, in particular concerning texture and texture changes during storage. The feeds and feeding strategies should be investigated with regards to the consumer's health and can also

become useful tools for marketing advantages like the extension of shelf-life of fresh products, unsaturated fatty acid balance and antioxidants implementation. The feeding parameter and pre-process operation will influence further processing like smoking and cooking and could be another point of interest.

WORKSHOP FOR THE FISH INDUSTRY

Novel components from marine origin -better utilization of by-products I

Moderators: Tyre Lanier, USA and Gudjon Torkelsson, Iceland

Q: Give a brief outline of the contents of the lectures in the session. Evaluate the need for research on novel components derived from marine origin including better utilization of by-products, fish waste and effluents from fish processing

The keynote lecture was given by Dr. Shahidi from St. Johns Newfoundland. It was on the current status and future trends in marine oils and bioactive compounds as nutraceuticals and functional food ingredients.

Health benefits of marine lipids

Most of the lecture was on the marine oils. He stressed that the effects of consumption of marine foods and of marine oils, in particular, in reducing the incidences of coronary heart disease were well known and recognized. Omega-3 fatty acids are considered to be responsible for the effects. N-3 fatty acids are also known to relieve arthritic swelling, type II diabetes and to enhance body immunity. N-3 fatty acid, especially DHA are known to dominate the fatty acid spectrum of the brain and retina lipids and play an essential role the development of fetus, infants and the health status and body requirements of pregnant and lactating women.

Both algal and marine species may be employed for the production of n-3 fatty acids. The marine species sources being the liver of lean white fish, the body of oily fish and the subcutaneous (blubber) fat of marine mammals. The can be processed into refined, bleached, deodorised and stabilised oils and used like that in different applications.

The structural features of the triacylglycerols and the location of the fatty acids in the glycerol may have an determining effect on the availability of the fatty acids involved and their potential health benefits. Presence of HUFA in the sn-2 position generally leads to their better assimilation into the body and offer better stability to the products. DHA is primarily located in the sn-2 position in menhaden oil bet mainly in sn-1 and sn-3 in seal blubber oil.
Addition of an antioxidant into refined oils is essentials in order to allow their use in food formulations. Most applications involve foods that can be used within a short period of time where off flavour does not develops during their useful shelf-life.

Omega 3 concentrates may be produced in the free fatty acid forms, simple alkyl ester and acyl glycerol forms. The available methods suitable for large scale production include low-temperature crystallization, supercritical extraction, molecular distillation, chromatography, urea complexation and enzymatic splitting. Other fatty acids of importance may also be concentrated or used in combination with long-chain fatty acids. The other fatty acids of nutritional and/or therapeutic importance include medium chain fatty acids(MCFA), conjugated linolenic acid (CLA) and gamma linolenic acid (GLA).

Enzyme hydrolysis may be employed to selective decrease the amount of monoacylglycerols and increase the amount of triacylglycerols and thereby increasing the amount of HUFA in the concentrates.

Structured lipids (SL) are developed to fully optimize the health benefits of their fatty acid varieties in order to affect immune function, nitrogen balance and lipid clearance from bloodstream. Structured lipids have been produced from seal blubber oil by acidalysis with capric acid. A SL containing both long-chain PUFA and GLA has also been prepared.

Oxidative stability. The type of process employed and product obtained affect oxidative stability. Stability of structured lipids is dictated by fatty acid composition and the content and distribution of minor components with antioxidant activity. Modified oils, in general, contain a lesser amount of endogenous antioxidants than natural oils due to their removal during processing.

Other speakers of the session.

Jannicke Fugledahl Remme from Möre-Research Ålesund, Norway spoke deep water sharks and the protein and fatty acid composition of their heads, muscle, liver and eggs as well as antimicrobial activity in subcellular extracts and fatty fractions of liver. There was high content of oleic acid and DHA in the lipid extracts of the sharks. Squalene content of liver varied between individuals from 11 – 84% and between species from 17 to 66%. Antimicrobial activity seems to correlated with squalamine content in the liver. There was a variation between species in their antimicrobial activity.

Eva Falch from SINTEF, Trondheim, Norway, spoke about variation in lipid composition in different rest biomass from species of the Gadidae family. The lipid composition and α-tocopherol levels in the liver, total viscera and cut off from cod, haddock, saithe, ling and tusk caught at three different fishing grounds in Europe were evaluated at three different intervals over a one-year perod. The composition of the liver and viscera of the haddock was most different from the other species evaluated. α-tocopherol was higher in liver than viscera or cut off and varied more between fishing grounds than season. But this difference was not statistically significant.

Scott Smiley from Fishery Industry Technology Center, Kodiak, Alaska spoke the utilisation of Pacific salmon by-products, heads and viscera and the production of dried hydrolysates. The objective was to characterise the lipid fraction from both pink salmon heads and viscera in raw samples and in wet and dried hydrolysates. There were significant differences between pink salmon heads and viscera in saturated/polyunsaturated and the n-3 and n-6 fatty acid ratios.

Q: From the point of view of science, industry and consumers, is the session covering the current and future possibilities to develop functional ingredients from marine sources. Is the research today on novel components likely to be exploited in the industry for health benefits of the consumers? What are the main obstacles for the implementation of the scientific results in this area in the industry?

There are still many exciting fields within the exploitation of marine lipids as functional ingredients. One of the challenges is to improve stability by the application of antioxidants and the development and production of structured lipids. Structured lipids can also be produced by

incorporating beneficial fatty acids from other sources. But the challenge is not only the oil itself but also to increase the access of native lipids from marine resources by upgrading by-products, pelagic fish and studying the possibilities in under-utilised fish like the deep sea species. Bio-prospecting is important in order to explore and understand better the vast possibilities that there may be in health promoting compounds from the sea. Marine lipids have been exploited in the fish industry for centuries but there are new changes, some easily implemented like the better utilization of by-products and cut off in products for human consumption, other that take more effort like improved n-3 concentrates for food formulations and then there are the most futuristic and most uncertain and most exciting ones that are based of basic research in bio-prospecting.

Novel components from marine sources – Better utilization of by-products II

Moderators: Margarita Tejada, Spain and Chong Lee, USA

Q: Give a brief outline of the contents of the lectures in the session. Evaluate the need for research on novel components derived from marine origin including better utilization of by-products, fish waste and effluents from fish processing

This session focused on byproduct utilization employing enzyme technology including potential bioactive products, marketable commercial products, and process design and development.

Gildberg at Norwegian Inst. of Fish and Aquac. Res. gave a keynote talk on Production of Enzymes, Bioactive Peptides, Feed Supplement and Fish Sauce from Cod and Shrimp Byproducts. From hydrolysate of cod byproducts (viscera), specialty enzymes (primarily low temperature activating pepsin group) and peptone can be fractionated by ultrafiltration and showed unique characteristics for industrial usage such as deskinning and descaling. The cod-peptone appears to have a better performing micro-medium compared to the commercial Bacto-peptone. The hydrolysate can also be used as feed supplement due to its high levels of essential amino acids. In addition, in vitro leucocyte test and cod fry feeding show that low molecular weight peptides displayed immunoenhancing properties. Those peptides are not previously identified and are believed to be protein breakdown products. Shrimp byproducts can be enzymatically treated to produce chitin and chitosan as well as potential bioactive peptides.

Other potential products such as flavor and fish feed supplement are being considered in the future work. An enzymatic conversion process for low-temperature production of cold-water fish sauce containing bioactive peptides is also being in development in which protease was highly

active at pH 8. The interesting elements of this presentation are process development of bioactive peptide-containing hydrolysate for potential marine nutraceuticals and immunoenhancing feed supplements. Also noted was fish sauce production from cold water fish at low temperature unlike the conventional process at temperature higher than room temperature, possibly making fish sauce unique in terms of flavor and taste.

The Cod/Shrimp Byproduct Utilization was followed by Anaerobic Digestion of Fish Waste presented by Reddington at Environmental Microbiology Research Unit of National Univ. of Ireland, Galway. Upflow anaerobic reactors were designed and tested under psychrophilic, mesophilic and thermophilic environments to compare their operating performance and determine optimum conditions for digestion to reduce the mass by 80% and biogas production.

The next presentation (L 68) dealt with Enhancement of Fat Extraction by Pre-enzymatic Digestion of Byproducts by Dumay et al. at the IFREMER Center de Nantes, France. After screening various commercial enzymes, Flavourzyme and Alcalase (Novo Nodisk, Denmark) were compared for their digestion performance on gadidae species byproducts. Alacalase was more effective and the pre-enzymatic digestion greatly increased the yield while reducing the amount of solvent required for extraction.

Novel components derived from marine origin - Better utilization of by-products III

Session moderators: Nigel Allen, Canada and Irene Stoknes, Norway

Q: Give a brief outline of the contents of the lectures in the session. Evaluate the need for research on novel components derived from marine origin including better utilization of by-products, fish waste and effluents from fish processing

Keynote speaker Michael Morrissey (K 8) gave an overview of marine biotechnology from the perspective of the extensive biodiversity of marine organisms, and unique metabolic pathways that have evolved to adapt to extreme and harsh environments. These give rise to human applications in the areas of molecular genetics, bio processing and tissue culturenatural products, pathogens and toxins, and marine by-products. Specific areas that are raised are the perceptions of GMO's, labelling, intellectual property protection for biologics, human health and environmental concerns. Bio-Tec was noted as a commercially successful company based upon marine enzymes taken from fisheries sources.Commercial concerns that have to be taken into consideration include the levels of complexity and costs associated with transformation, separation and concentration, the High costs of clinical trials, and the market considerations for using alternate

products from other sources. For future R&D in the area of novel components from marine sources the economics, the consideration that processing by-products can produce new waste streams, the fact that many developments have been tried but few have succeeded, and that gene transfers can work both ways, i.e. the cloning of specific genes from marine sources into micro organisms have to beg the question, “Does the promise meet the reality?”

Sigurjon Arason (L 69) detailed the scope of the available by-products from the Icelandic fishing industry in both volume and value terms. Iceland has a natural competitive advantage for producing dried products due to cheap geothermal energy. The best potential for commercial success in by-product utilization is to focus on edible consumer products, and wherever possible reduce the volumes of by-products by maximizing processing yields.

Although chitin and its derivatives have many potential applications, the commercial uptake of these to date has been limited, according to Kristberg Kristbergsson (L70). The main market today is its use in ‘diet pills’ which accounts for ~ 50% of the global market. However, despite these volumes of sales very little research has been conducted on the effects on human health. This natural biopolymer has many applications in food processing but has had little commercial success due to the insolubility and pH dependent effects on functionality of chitin, the bitter after taste of chitosan, and the regulatory status of this family of compounds. Recent proprietary developments in creating water soluble chitin may resolve some of these limitations.

Egidijus Dauksas (L71): The use of fish by-product based hydrolysates into food and animal feed applications has been restricted by the presence of bitter after tastes. Research has shown that these can be reduced and or eliminated. However the economic and practical commercial applications would need to be clearly demonstrated in order for industry to view these materials as ‘near market’ for application in the food and animal feed industries.

Rosa Jonsdottir (L 72): Marine sources have a high potential as commercial sources of flavourants. However, to achieve good commercial success a producer must be able to develop consistent flavour profiles form highly biologically variable raw materials. Therefore it is essential to develop characterization profiles, specifically of the volatile compounds that give these flavourants their organoleptic attributes, and the precursors of these compounds in order that their presence and concentrations in the raw materials can be evaluated. This information can then be applied to product formulation and recipe development. The work conducted has

produced positive results in establishing odour profiles and identifying the responsible components and pre cursors. This work has direct industrial application and is proprietary to Primex for commercial development.

Hans van de Vis & Niam Shaw (L73): The extraction and characterization of collagen from cod filleting discards, (skin and bones) was studied. There is a consistent and expanding market for collagen. It is demonstrated that collagen can be recovered from the sources although recoverable yields still need to be elucidated. These collagens have very good film making properties in low concentration aqueous solutions. This suggests that natural fish collagen derived from filleting operations has wide commercial applications particularly in the food industry.

Posters

The session did also contain 10 posters. Subjects discussed were a.o:-novel applications of cod milt cationic proteins-lipid content, composition and nutrional properties of byproducts-naturally occurring antioxidants in fish oil-utilization and stabilisation of byproducts-novel functions of marine byproducts (minimal processing)-protein isolate from shrimp-volatile compounds in artificial bait. The oral session and poster display clearly indicated that there are political, social and environmental drivers to significantly enhance the levels of utilization of harvested and farmed marine products. The most feasible and effective approach is to develop technologies for elevating the yields that are directed towards human consumption.Marine organisms have evolved to be able to survive in harsh and extreme environments. Consequently their metabolic systems are a unique source of 'biologics' that havea potential for 'human need' applications. However, the real 'need' and applications for such biologics need to have preliminary or early stage market and economic evaluations conducted prior to investing significant economic and human resources in R&D initiatives. Future sources of marine biological materials not only include secondary and tertiary products from marine organisms produced for human and/or animal feeds, but also unexploited macro and micro organisms.

Q: From the point of view of science, industry and consumers, is the session covering the current and future possibilities to develop functional ingredients from marine sources. Is the research today on novel components likely to be exploited in the industry for health benefits of the consumers? What are the main obstacles for the implementation of the scientific results in this area in the industry?

The session adequately addressed the state of the science in terms of current and future possibilities re: functional ingredients. There is some uncertainty with respect to future exploitation. The R&D is primarily a science and technology push rather than directed by market pull, and there is little in the way of pre-market assessment in terms of technical and economic feasibility and market demand. The primary obstacles to industrial applications is a lack of industry involvement in requesting that much of the research be conducted, and no structured approach to evaluating the 'need' for these products and/or the size of market.

Q: Give ideas on other important research areas related to the topic that are not covered in the session, but may have potential for future research and networking.

The keynote address covered the many potential aspects of marine biotechnology and food related applications of marine bioactive molecules. The emphasis on current research and development is the identification, functionality and extraction of bioactives from exploited resources. It may be appropriate to look at unexploited bio resources, (macro and micro) that have adapted to specific extreme environments or that have known specialized biological properties, e.g. disease resistance.

Discussion panel: FUTURE TRENDS FOR UTILISATION OF BY-PRODUCTS AND APPLICATION OF NOVEL COMPONENTS FROM MARINE SOURCES.

The networking was further stimulated in connection with the workshop for the fish industry at the TAFT 2003 conference. A dicussion panel was organised entitled: FUTURE TRENDS FOR UTILISATION OF BY-PRODUCTS AND APPLICATION OF NOVEL COMPONENTS FROM MARINE SOURCES. Nigel Allen (Canada) chaired the panel and representatives from the industry Jóhannes Gíslason (Primex, Iceland) and Agnes Joly (SIF, France) and Ronan Gormley (Ireland) representing research – industry collaboration were selected in the panel, in addition to the keynote speakers from the workshop: Fareidoon Shahidi (Canada), Asbjörn Gildberg (Norway) and Michael Morrisay (USA).

A few comments from the panel discussion:

Economy - Market - Value of product:

- are important parameters in the selection of which product should be considered for further research
- by-product value vs. transformation costs
- R&D support of companies
- logistics of raw material, collection, preservation
- feasibility analysis of research subjects

Factors hindering the use/uptake of technical information according to companies

- time, lack of suitable information, cost, language, personnel, equipment

Market trends

- clean and healthy products, functional foods, less additives, more natural additives, use of marine ingredients in fish products
- value added products - need to justify increasing prices; to document value and nature of products; functional foods
- functional aspects of ready meals, including fish/fish components (bone, calcium, etc...)

Barriers for research and industry collaboration:

- industry is passive: not innovate, conservative
- confidentiality, limiting flow of information/communication
- legal issues
- cost / time balance

Where is the strongest market pull?

- Convert by-products to main products, like in aquaculture. Aquaculture is growing, because the world population is increasing.
- Immigrants in western countries motivate new food habits and the demand will grow.
- Ready meals market is growing. Nutrition emphasis, not only convenience.
- Aging population. Nutrition and health emphasis.

APPENDIX II

REPORTS FROM NETWORKING MEETINGS

Seven networking groups were formed at the conference:

Networking report - topics 1, 2 and 3

Better utilization of by products / raw material

Networking report - topics 1, 2 and 4
Functional fish products - Novel components

Networking report - topis 5 and 11
Traceability - species identification

Networking report - topic 6
Total quality management

Networking report - topic 7
Safety and quality exchange programme

Networking report - topics 8 and 10
Aquaculture - Replacements in fish feed

Networking report - topic 9
Consumer driven fish production

Better utilization of by products / raw material

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: "Better utilization of by products / raw material"

Session chairman: Chong Lee, e-mail: uricml@uriacc.uri.edu / Irene Stoknes e-mail: ist@mfaa.no

Identify research area (key words)

Type of collaboration

research projects

x networking
__ internet databases

Results of discussion

Project idea identified

__ Agreement reached
Further contact planned
__ No further contact

Assistance needed from funding agencies

x Canada
x EU
x NI
x USA
x National

Specify other activity needed

x Partner search
x Info. on funding programme
__ Application forms
__ Pre-project assistance
x Legal consultancy

PARTNERS

CONTACT PERSON Gudrun Olafsdóttir e-mail: gudrun@rf.is

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
Group e-address comp	C. Lee	To have a single group address for network communication	June 30	
Experties profile	?	To compile group members expertise including analytical capabilities	July 30	
Individuals areas, that	?	To reveal individuals areas of problems to be solved through network	July 30	
Shrimp waste utilizatio	Nigel Allen	Reduce environmental impacts from waste disposal	3 years project	funding secure,
				looking for European partners
Chitin, chitosan from s	Sükran Çakli	Using chitin and chitosan in different industries	3 years	fundings
Finishing of proposal				

Better utilization of by products / raw material

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Functional fish products - Novel components

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: Functional Fish products - Novel components

Session chairman: Gudjon Torkelsson e-mail:gudjont@rf.is

Identify research are (key words): Fractionation of edible parts of fish into new functional food ingredients

Type of collaboration

- x research projects
- x networking
- __ internet databases

Results of discussion

- x Project idea identified
- __ Agreement reached
- x Further contact planned
- __ No further contact

Assistance needed from funding agencies

- x Canada
- x EU
- x NI
- x USA
- x National

Specify other activity needed

- x Partner search
- x Info. on funding programme
- __ Application forms
- __ Pre-project assistance
- x Legal consultancy

PARTNERS see below

CONTACT PERSON Gudjon Torkelsson e-mail: gudjon @rf.is - Margret Geirsdóttir e-mail: mg@rf.is

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
		Fractionation of edible parts of fish into new functional		
		food ingredients		
		a) Nutritional aspects		
		b) Physical properties		
		c) Bioactive properties		
		d) Pharmaceutical properties		
		This is an "umbrella idea" covering marine proteins, lipids		
Finishing of proposal		and other fractions		

Comments ____ Networking Groups 1-4

Partners: Functional Fish products - Novel components

Name	Country	Company	E-mail	Phone
Reza Kamarei	USA	Oceanic Institute	rkamarei@oceanicinstitute.org	18082593112
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Traceability - species identification

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: **Traceability**

Session chairman: Sigrún Guðmundsdóttir, e-mail: sigrun@rf.is

Identify research area (key words): Central reference bank for fish species identification

Type of collaboration

__ research projects
x __ networking
__ internet databases

Results of discussion

x __ Project idea identified
__ Agreement reached
__ Further contact planned
__ No further contact

Assistance needed from funding agencies

__ Canada
__ EU
__ NI
__ USA
__ National

Specify other activity needed

x __ Partner search
__ Info. on funding programme
__ Application forms
__ Pre-project assistance
__ Legal consultancy

PARTNERS

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CONTACT PERSON: Hartmut Rehbein, Federal Research Centre for Fisheries, Germany, e-mail: hartmut.rehbein@ibt.bfa-fisch.de

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
1. Collect partners for the network	Hartmut Rehbein	Collect partnesr globally, find out about transport of samples	after the summer	
2. Collection of official methods	Iciar Martinez	Collect methods that are used in different countries	autumn	
3. Contact the EU	Hartmut Rehbein			
Finishing of proposal				

Comments _____

Total quality management

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: Total quality management

Session chairma Helga Gunnlaugsdóttir e-mail: helgag@rf.is, Hélène Lauzon e-mail:helene@rf.is

Identify research area
(key words) **Environmental research, Raw material, Quality, Safety, Harmonisation of methods, Value added products, Regulation, Information database**

Sub-topic 1 Harvesting: Post-harvesting treatments, handling, innovative techniques, quality assesment tools/methods
Sub-topic 2 Logistics: Handling/storage/shipping treatment, traceability, documentation, database, innovative techniques
Sub-topic 3 Processing: Innovative techniques, minimal processing, quality assesment tools/methods
Sub-topic 4 Marketing: Stimulate export, regulation, documentation
Sub-topic 5 Consumer and health: preferences, needs, acceptancy of products

Type of collaboration

__ research projects
X networking
X internet databases

Results of discussion

X Project idea identified
__ Agreement reached
X Further contact planned
__ No further contact

Assistance needed from funding agencies

X Canada
X EU
X NI
X USA
X National

Specify other activity needed

__ Partner search
X Info. on funding programme
__ Application forms
X Pre-project assistance
__ Legal consultancy

PARTNERS (participants)

Institute/Company	Country	**Representative**	email	Sub-topics of interest
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Research and Training Center for Fishe	Canada	Marie-Lyne Larrivee	ml_larrivee@globetrotter.net	
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CONTACT PERSON Helga Gunnlaugsdottir, Hélène Lauzon, David Green, Bianca Maria Poli

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
Confirm discussed ideas	Hélène Lauzon, Helga Gunnlaugsdottir	Define the Network in more details, list participants	June	
Feedback from participants	All participants	Refine the ideas, define sub-topics, add participants, funding	September	
Finishing of proposal				

Comments: The network is an umbrella for a wide research area and participants are interested in different sub-topics

Safety and quality exchange programme

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic:	(Group 7) Safety and quality **exchange** program
Session chairman:	Steve Otwell

Identify research area (key words): **Risk** - The whole food chain approch from the environment - through process - through distribution - to consumer.

Type of collaboration	Results of discussion
x research projects	x Project idea identified
x networking/**exchange program**	x_ Agreement reached
x internet databases	x Further contact planned
	__ No further contact

Assistance needed from funding agencies	Specify other activity needed
x Canada	x Partner search*
x EU	x Info. on funding programme
x NI	__ Application forms
x USA	_x_ Pre-project assistance
x National	Legal consultancy
	* Industry advisory group, consumers association

PARTNERS: See worksheet partners

CONTACT PERSON: Birna Guðbjörnsdóttir, Eva Yngvadóttir, Steve Otwell

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
Obtain a list of existing list of international quality and safety problem. Information collected from FAO, CODEX, WTO, WT-banks	Steve Otwell	Obtain the state of art of international quality and safety problems	1.sep.03	Grímur Valdimarsson (FAO), Roland Cormier (FAO), Steve Otwell (USA), Nils K. Sorensen (Norway) and Lu Leclerc (Canada). We need to involve Jörg Oehlenschlager (Germany) into this work
All participants identify 3 most common problems from their area related to quality or safety. Send the idea to birna@rf.is	Birna Guðbjörnsdóttir	Obtain the state of art of international quality and safety problems to define global topics to focus on in the network/exchange program	1.sep.03	All participants
Submit following methods to database: water, salt content,TMA,coliforms	Roland Cormier	How to share methodology and how to communicate through the web?	1.sep.03	Each participant institute will submit information about several methods to FAO and Roland and Grímur will transfer the information into an database (FISH PORT) that will be tested by the participants.
Finishing of proposal		2004		

Comments	At the meeting a scientific group was formed: Francoise Leroi (France), Graham Fletcher (New Zealand), Grímur Valdimarsson (FAO-Itlay), Lu Leclerc (Cananda), Paul Nesvadba (UK), Roland Cormier (FAO-Canada) and Steve Otwell (USA), Eva Yngvadóttir (Iceland), Birna Guðbjörnsdóttir (Iceland). The role of this group is to define global topics to focus on in the network based on information from the participant group. The aim is to meet again in February 2004 in U.S.A and form an application

Safety and quality exchange programme cont.

Participants at the meeting

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Aquaculture - Replacements in fish feed

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: **Aquaculture - replacements in fish feed**

Session chairman: Rannveig Björnsdóttir e-mail: rannveig@rf.is

Identify research area (key words) ***shrimp, flatfish, cod, salmon, sea bass -*** stress, disease resistance, fish welfare, consumer aspects, social aspects

Type of collaboration

_X_ research projects
_X_ networking
__ internet databases

Results of discussion

_X_ Project idea identified
_X_ Agreement reached
_X_ Further contact planned
__ No further contact

Assistance needed from funding agencies

_X_ Canada
_X_ EU
_X_ NI
_X_ USA
_X_ National

Specify other activity needed

_X_ Partner search (the first step in the reached agreement)
__ Info. on funding programme
__ Application forms
__ Pre-project assistance
__ Legal consultancy

PARTNERS

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CONTACT PERSON: Rannveig Björnsdottir

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
Each of the participants will do a short "state of the art" overview in corresponding countries, as well as contact relevant/promising partners in respective countries.				
The contact person is responsible for contacting all partners - scheduled for late July/early August 2003 - as a short reminder of the task and with scheduled outlines of what should be included in "the state of the art" review.				
The next step will be to form a definite project idea and apply for fundings needed to carry through an extensive project like this - scheduled for Sept-Des 2003.				
Finishing of proposal: scheduled for 2003/2004				

Comments; The need for replacement of fish oil/fish meal in feed for fish is undisputable and there seems to be a lot of interest in cooperation in finding alternative replacements in feed for the most common species in farming (salmon, flatfish, shrimp, sea bass, cod etc.)

Consumer driven fish production

Report on networking meetings

Networking in Fisheries Research - TAFT 2003 June 12 Reykjavik, ICELAND

Report to be filled in jointly by all participants in each meeting and returned to session chairman of each session or to information desk if completed outside session.

Networking topic: Consumer driven fish production

Session chairman: Adriaan Kole e-mail:adriaan.kole@wur.nl

Identify research area (key words): Consumer research, sensory science, product deveopment

Type of collaboration

__ research projects
__ networking
__ internet databases

Results of discussion

X __ Project idea identified
__ Agreement reached
X __ Further contact planned
__ No further contact

Assistance needed from funding agencies

x __ Canada
x __ EU
__ NI
x __ USA
__ National

Specify other activity needed

x __ Partner search
__ Info. on funding programme
__ Application forms
x __ Pre-project assistance
__ Legal consultancy

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CONTACT PERSON Adriaan Kole

ACTION PLAN

Activity	Responsible	Objective	When	Remarks
Pre-project on the idea	Adriaan Kole	Motivate people in more countries to join the project		
Finishing of proposal				

Comments _____

APPENDIX III

LIST OF PARTICIPANTS REGISTERED IN THE NETWORKING FOR FISHERIES RESEARCH AT TAFT 2003

LIST OF PARTICIPANTS REGISTERED IN THE NETWORKING FOR FISHERIES RESEARCH AT TAFT 2003

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