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Global Trade Conference on Aquaculture

29–31 May 2007
Qingdao, China

Cover photo:
Women harvest oysters from cultivation beds in the Oualidia lagoon in Morocco. Aquaculture provides an increasing proportion of fish protein to diets. FAO/21706/Giuseppe Bizzarri.

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Global Trade Conference on Aquaculture

29–31 May 2007
Qingdao, China

Edited by
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FAO Fisheries and Aquaculture Department

and

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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Preparation of this document

These proceedings contain the full papers and abstracts of presentations from the first Global Trade Conference on Aquaculture, held in Qingdao, China from 29 to 31 May 2007.

The conference was organized by the FAO Fisheries and Aquaculture Department in cooperation with the FISHINFONetwork. The national preparation and the identification of speakers from the host country were the responsibility of INFOYU. International promotion was initiated by GLOBEFISH and INFOFISH, which was also in charge of the registration of international participants.

The Conference was hosted by the Chinese Ministry of Agriculture with the support of its Bureau of Fisheries and the Society of Fisheries. The technical editing, publishing and distribution of this document were undertaken by FAO, Rome.

Abstract

These proceedings contain the manuscripts and summaries from the first Global Trade Conference on Aquaculture, held in Qingdao, China from 29 to 31 May 2007. A total of 23 papers (2 keynote presentations and 21 session presentations) and six abstracts are published, together with the programme and the opening and closing remarks.

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The conference was developed in five sessions. In the first session, "Aquaculture Growing Strength", an overview on production and trade was followed by five commodity presentations showing the success in shrimp, salmon, tilapia, catfish and bivalve aquaculture.

The second session on "Challenges" highlighted the current and future challenges facing the sector. These included challenges related to assuring food safety in aquaculture products, maintaining and improving consumers' perceptions of the quality and environmental acceptability of aquaculture, improving aquatic animal health management, addressing issues related to feed quality and availability, and improving the view investors take to assure economic and financial sustainability.

During the third session, the "Advantages and Opportunities" of aquaculture were covered by taking into account the globalization process and the requirements of processors and the food service and retail sectors, which all seem to have a preference for aquaculture products under special conditions. Seafood and health benefits, and the potential offered new species were seen as driving factors in the aquaculture sector. The opportunities and challenges for the small-scale fish farmers in Southeast Asia were also considered.

The fourth session was fully dedicated to the aquaculture sector in China, with presentations on the domestic market, the export potential, safety and quality inspection and China's role in reprocessing seafood for re-export to the global market.

In the last session on "Progress – The Future", the future developments expected for aquaculture were covered. Here the interaction between capture fisheries and aquaculture was analyzed and also presented in a case study on wild and aquacultured salmon. Aquaculture was viewed within the context of other intensive animal production systems. The enormous potential of the technical innovations in aquaculture compared to capture fisheries was highlighted under the term of "Blue revolution". The last session was closed with a description of the political framework required to allow for the sustainable development of aquaculture.

Arthur, R.; Nierentz, J. (eds).
Global Trade Conference on Aquaculture. Qingdao, China, 29-31 May 2007.
FAO Fisheries Proceedings. No. 9. Rome, FAO. 2007. 271p.

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COURTESY OF INFOYU

Opening of the Global Trade Conference on Aquaculture with participation of the Chinese Government, FAO and the FISHINFONetwork (represented by INFOYU, INFOFISH and GLOBEFISH).

COURTESY OF INFOYU

FISHINFONetwork stand visited by Jochen Nierentz, FAO Senior Fishery Officer, GLOBEFISH; Ichiro Nomuro, Assistant Director-General of the FAO Fisheries and Aquaculture Department; and Chen Shuping, Deputy of INFOYU.

Abbreviations and acronyms

ACC	Aquaculture Certification Council
APEC	Asia Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
AQSIQ	General Administration of Quality Supervision/Inspection and Quarantine of the People's Republic of China
BRC	British Retail Consortium
BSE	bovine spongiform encephalopathy
CAC	Codex Alimentarius Commission
CCPs	critical control points
CITES	Convention on International Trade in Endangered Species
COFI	Committee on Fisheries (of FAO)
CSR	corporate social responsibility
DFID	Department for International Development (United Kingdom)
DDA	Doha Development Agenda (of WTO)
DFO	Department of Fisheries and Oceans (Canada)
DG	Directorate General (of the EC)
DSP	diarrhetic shellfish poisoning
ENGOs	environmental nongovernmental organizations
EC	European Commission
EIA	environmental impact assessment
EU	European Union
EUS	epizootic ulcerative syndrome
FADS	fish aggregation devices
FAO	Food and Agriculture Organization of the United Nations
FOS	Friends of the Sea
FCR	food conversion ratio
GAA	Global Aquaculture Alliance
GAP	good aquaculture practices
GATT	General Agreement on Tariffs and Trade
GHP	good hygienic practices
GFSI	Global Food Safety Initiative
GM	genetically modified
GMOs	genetically modified organisms
GTCA	Global Trade Conference on Aquaculture
HACCP	hazard analysis critical control point system
H/G	high-grade
HPLC	high performance liquid chromatography
HUFAs	highly unsaturated fatty acids
IUU	illegal, unreported and unregulated (fishing)
KHVD	koi herpes virus disease
LC/MS	liquid chromatography/mass spectrometry
LWG	liveweight gain
MBA	mouse bioassay
MRLs	maximum residual limits
MSC	Marine Stewardship Council
NACA	Network of Aquaculture Centres in Asia-Pacific
NGOs	non-governmental organizations

NMFS	National Marine Fisheries Service (United States)
OECD	Organisation for Economic Co-operation and Development
OECD-COFI	Committee on Fisheries (of OECD)
PCB	polychlorinated biphenyl
PSP	paralytic shellfish poisoning
PUFAs	poly-unsaturated fatty acids
QS	quality safety
RFID	radio frequency identification
RSPCA	Royal Society for the Prevention of Cruelty to Animals
RST	Regal Springs Tilapia group
SBM	soybean meal
SOFIA	FAO's State of World Fisheries and Aquaculture
SPS Agreement	Agreement on Sanitary and Phytosanitary Measures
TBT Agreement	Agreement on Technical Barriers to Trade
TS	Taura syndrome
UNEP	United Nations Environment Programme
US FDA	United States Food and Drug Administration
WHO	World Health Organization
WSS	white spot syndrome
WTO	World Trade Organization
WWF	World Wide Fund for Nature

Summary of the Global Trade Conference on Aquaculture

Aquaculture has seen a robust and sustained growth during the last decades. This is foreseen to continue in order to meet the ever-increasing demand for fish, both for domestic food security and for supplying international markets. The role of Asia in general and China in particular as the main producer and supplier is highly impressive, and the trend is likely to continue. This requires particular attention to promote responsible and sustainable aquaculture with strong emphasis on the role of small-scale farmers, who contribute a large share of aquaculture supply.

The forecast growth in aquaculture offers vast opportunities to producers and producing nations, as well as to foreign investors, consumers, retailers, processors and food services. Taking advantage of these opportunities presents several challenges to international organizations, governments, producers, traders and retailers. The key issues are how to make all these stakeholders work together in a coherent manner and how to develop the necessary synergies between the public and private initiatives, policy and governance, industry market forces and nongovernmental organizations (NGOs).

Assuring the safety of aquaculture products remains a fundamental issue for all stakeholders. Other issues such as environmental protection, social protection and animal welfare are gaining more importance for market access. The influence of environmental and social NGO and consumer advocacy groups in shaping consumer perceptions and choices and consequently the sourcing policy of importers, traders, retailers and food services was again and again highlighted during this conference.

Aquaculture has diversified and new species have been domesticated over the last decade. Pilot trials indicate that several more species of finfish, shellfish and bivalve will enter commercial production in the future. Technological development will contribute significantly to improve productivity, yield, quality and consumer acceptability, but consumer acceptability will have a bearing on this future.

Upstream value-addition offers significant opportunities to extract more wealth from aquaculture and create employment opportunities. This will require further care to assure safety, quality and consistency. Retailers and food services are interested in taking advantage of the proximity of production and low labour to outsource value-addition operations to producing nations. It is a win-win situation.

All types of labels, whether quality labels, ecolabels or social labels, are instruments that can convey information and assurance to retailers and consumers. However, they need to "fit the purpose" for which they have seen development, and the certification schemes need to be simple, robust and transparent, so as not to confuse the consumers. Harmonization of standards and equivalence of standards are fundamental.

Better consumer education and communication will improve and balance consumer perception of the benefits/risks. Aquaculture has a great advantage to farm products that will meet nutritional and health aspects and mitigate the risks.

Feed availability and competition for feed from livestock will impact the future of aquaculture. Likewise competition for trash fish and its impact on food security of the rural poor needs careful consideration. Livestock and agriculture by-products may fill the gap for high demand for feeds, but again safety and consumer acceptance need careful consideration. Competition of biodiesel for agriculture by-products can be another development further impacting aquaculture development.

Global warming will no doubt have an impact on aquaculture. The rise in sea level, access to waters and mangrove deforestation are consequences to be considered. Likewise, issues such as food miles/carbon miles/carbon offsets will increase in importance.

Aquaculture and wild fisheries interact in many ways that impact ecosystems, innovations and technology, markets and prices. The challenge is to find the best ways to optimize the positive interactions and mitigate the negative ones.

Development in livestock and poultry farming has interesting lessons for the future of sustainable aquaculture that need to be studied. Aquaculture certainly has advantages that need to be amplified and communicated.

ANNEX 1

Programme

GLOBAL TRADE CONFERENCE ON AQUACULTURE

Qingdao, China, 29 – 31 May 2007

Registration: Monday 28 May, 1700 – 2000 hrs/ Tuesday 29 May, 0800 – 0900 hrs

Tuesday 29 May

09:00 **Opening of Conference**
Mr Ichiro Nomura, Assistant Director-General, Fisheries and Aquaculture Department, FAO
Mr Xue Liang, Chief Economist, Ministry of Agriculture, China

09:30 **Keynote: Driving Forces for Aquaculture – Different Scenarios towards 2030**
Ms Kjersti Gravningen, Director, Pharmaq Asia, Norway
Keynote: Developing Sustainable Aquaculture Industry and Building a Harmonious International Trade Order
Mr Li Jianhua, Director General, Bureau of Fisheries, MOA, China

10:15 Coffee Break

10:30 **Session 1: Aquaculture Growing Strength**
Chair: Mr Ichiro Nomura, FAO

Overview of Production and Trade – the Role of Aquaculture Fish Supply
Mr Jochen Nierentz, Senior Officer, FAO GLOBEFISH
Five Success Stories in Aquaculture
1. Shrimp: The most Valuable Seafood Commodity from Aquaculture
Mr Wally Stevens, Vice President, Global Aquaculture Alliance (GAA), United States
2. Salmon: Production Growth and New Markets
Mr Frank Asche, University of Stavanger, Norway
3. Tilapia: Sustainability by Social and Environmental Commitment
Mr Israel Snir, Vice President for Technology – Regal Springs Tilapia, General Manager - Aquafinca Honduras
Panel Discussion

12:30 Lunch Break

13:30 **4. *Pangasius*: Viet Nam - Fairy Tale of an Unknown Species**
Mr Nguyen Huu Dzung, President, VASEP, Viet Nam
5. Bivalves: Success in a Shell
Mr Douglas McLeod, Chairman of the Association of Scottish Shellfish Growers, United Kingdom
Panel Discussion

14:30 **Session 2: Challenges**
Chair: Mr Lahsen Ababouch, FAO

Safety of Aquaculture Products: Consumer Protection, International Regulatory Requirements and Traceability
Mr Lahsen Ababouch, Chief, Fish Utilization and Marketing Service, FAO

Consumer Assurance: Market-based Quality Schemes, Certification, Organic Labels, Ecolabelling, Retailer Specifications
Ms Melanie Siggs, United Kingdom Director, Seafood Choices Alliance

15:20 Coffee Break

15:45 **Aquatic Animal Health Management in Aquaculture**
Ms Supranee Chinabut, Senior Advisor Fish Diseases, Department of Fisheries, Thailand
Environmental Capacity – Where are the Limits?
Mr Rohana Subasinghe, Senior Fisheries Resource Officer (Aquaculture), FAO
Meeting the Feed Supply Challenges
Mr Albert Tacon, Aquatic Farms Ltd, United States
An Investor's View on Investments and Financing
Mr Björn Myrseth, Marine Farms ASA, Norway
Panel Discussion

17:45 Session expected to end

Dinner reception hosted by the Chinese Ministry of Agriculture

Wednesday 30 May

09:00 **Session 3: Advantages and Opportunities**
Chair: Mr Audun Lem, FAO

Globalization and the Impact on Aquaculture
Ms Lori Ridgeway, Director General, DFO, Canada
Value-added Seafood: Opportunities and Challenges – a United States Restaurant Chain Perspective
Mr George Williams, Vice President, Government & Environmental Affairs, Darden Restaurants, United States
Aquaculture – What Retailers Expect from Producers
Mr Andrew Mallison, Marks & Spencer, United Kingdom
The New Consumer: Seafood and Health Benefits
Ms Linda Chaves, Senior Advisor, Seafood Industry Issues, NMFS, United States

10:30 Coffee Break

10:45 **Aquaculture Production, Certification and Trade: Challenges and Opportunities for the Small-scale Farmer in Asia**
Mr Rohana Subasinghe, Senior Fisheries Resource Officer (Aquaculture), FAO with NACA
Role of New Species - Panel Presentation
Mr Manfred Klinkhardt, Fischmagazin/EUROFISH and Mr Björn Myrseth, Marine Farms ASA
Panel Discussion

12:30 Lunch Break

13:30 **Session 4: China**
Chair: Mr Chen Yide, Deputy Director-General, Bureau of Fisheries, MOA

Domestic Aquaculture Product Market
Mr Chen Lansun, Professor, Shanghai Fisheries University, China
China as an International Supplier
Ms Xiao Fang, Director, Bureau of Fisheries, China
Ecological Aquaculture and Safety Control on Shellfish
Mr Wu Hougang, President, Dalian ZhangZiDao Fishery Group Co., Ltd.

15:15 Coffee Break
15:30 **Aquaculture Seafood Safety and Quality Inspection**
Mr Deqing Zhou, Safety Quality Inspection Control, China
Development of China as the World's Largest Re-processing Centre of Frozen Fish Products and Future Challenges for the Industry
Mr Joo Siang Ng, Managing Director, Pacific Andes Group, Hong Kong, China
Panel Discussion
Chinese Fisheries Information System - presentation by INFOYU
17:15 Session expected to end

Thursday 31 May
09:15 **Session 5: Progress – The Future**
Chair: Mr Jochen Nierentz, FAO
Aquaculture and Fisheries: Complementary or Competition
Mr James L. Anderson, Professor and Chair, University of Rhode Island, United States
Implications of Aquaculture for Wild Fisheries: The Case of Alaska Wild Salmon
Mr Gunnar Knapp, Professor, University of Alaska, United States
Experience in other Food Sectors, Future Lessons for Aquaculture?
Mr Jonathan Shepherd, IFFO, United Kingdom
10:30 Coffee Break
10:45 **Aquaculture – The Blue Revolution**
Mr Manfred Klinkhardt, Editor Fischmagazin/ EUROFISH, Germany
Policy Development for Sustainable Benefit
Ms Linda Chaves ,Senior Advisor, Seafood Industry Issues, NMFS, United States, and Mr Jonathan Shepherd, IFFO, United Kingdom
Panel Discussion

12:00 CONCLUSIONS & FAO VISION
Chair: Mr Lahsen Ababouch, FAO
12:30 Closing Ceremony and End of Conference

ANNEX 2

Opening statements

Ichiro Nomura

Assistant Director-General
Fisheries and Aquaculture Department
Food and Agriculture Organization of the United Nations

Since April 2000, Mr Ichiro Nomura has held the position of Assistant Director-General, Fisheries and Aquaculture Department of the FAO in Rome. Mr Nomura, a national of Japan, holds a B.Sc. in Marine Biology from the University of Tokyo, a Master of Law and Diplomacy from the Fletcher School of Law and Diplomacy, Tufts University, and a Master of Public Administration from the John F. Kennedy School of Government, Harvard University. Mr Nomura's professional career spans a period of 26 years, starting in 1974 at the Fisheries Agency of the Ministry of Agriculture, Forestry and Fisheries in Tokyo in the International Affairs Division, then to the Offshore Fisheries Division, where he was in charge of purse seine fisheries. At the Japanese Embassy in Washington DC, Mr Nomura served as First Secretary in charge of fisheries. Returning to the Fisheries Agency in Tokyo, he was appointed Deputy Director, Fisheries Marketing Division, in charge of fish trade, and Deputy Director of the International Economic Division, in charge of the GATT Uruguay Round agricultural negotiations. Mr Nomura's later positions in the Japanese Fisheries Agency ranged from Deputy Director of the International Affairs Division; Director for International Negotiations; Director, Resource and Environment Research Division; to Director, Far Seas Fisheries Division, where his main responsibilities included administering Japan's long-distance fishing fleet. Mr Nomura was well known in various international fisheries fora, including the FAO Committee on Fisheries, the FAO Compliance Agreement Negotiation, the UN Fish Stock Agreement Negotiation, the Commission for Conservation of Antarctic Marine Living Resources and the International Whaling Commission. He also served as Chairman of the Organisation for Economic Co-operation and Development (OECD) Committee on Fisheries and Chairman of the International Commission for Conservation of Atlantic Tuna.

Opening statement

Ichiro Nomura
Assistant Director-General
Fisheries and Aquaculture Department
Food and Agriculture Organization of the United Nations

Your Excellency, Mr Xue Liang, Chief Economist, Ministry of Agriculture,
Distinguished Representatives and Participants,
Ladies and Gentlemen, Colleagues,

For the first time the FAO Fisheries and Aquaculture Department together with the FISH INFONetwork has taken the initiative to cover the topic of aquaculture trade in an international conference foreseen to bring the perspectives of industry, governments, science, consumers, retailers and nongovernmental organizations (NGOs) together. It is a pleasure for me, as the Assistant Director-General of the Fisheries and Aquaculture Department, to extend to you all a warm welcome to this Global Conference on Trade in Aquaculture, on behalf of the Director-General of FAO, Dr Jacques Diouf.

Preparation for this important event was a collaborative effort between the Ministry of Agriculture of the People's Republic of China, The Department of Fisheries and Aquaculture in FAO and the FISH INFONetwork, in particular INFOFISH and INFOYU. I greatly appreciate the very valuable support of the Chinese Ministry of Agriculture, and particularly from the Bureau of Fisheries and its Society of Fisheries. The Chinese Conference Steering Committee and Secretariat, under the leadership of Mr Fan Xiaojian, Vice Minister of Agriculture, have invested valuable time and efforts to promote the event in China and prepare for it, and I am very grateful for this.

In 1996, FAO assisted China to set up the special Information Unit INFOYU as part of the Fisheries Society through a Technical Cooperation Project in the Ministry of Agriculture, Bureau of Fisheries. I am happy to see that this office has developed to a very useful link in the FISH INFONetwork, and as we will see on Wednesday, has started with an international news service, covering the most important fisheries and aquaculture nation for the world.

I should also mention the other FISH INFONetwork members, in particular INFOFISH, which handled the administration and promotion of the conference and GLOBEFISH, our in-house Marketing Information Service in the Fish Utilization and Marketing Service. I have been asked by the members of the FISH INFONetwork, which are all former FAO regional projects, to welcome you also in their name to this conference.

As you already may be aware, the title of the Department was changed from the Fisheries Department to the Fisheries and Aquaculture Department as of 1 January 2007. This can be interpreted that we intend to put more priority on responsible aquaculture, whose contribution to global supplies of fish and fisheries products continues to grow. This conference is part of these efforts and as a next step, the results of our discussions will be used in November when all 190 member countries of FAO come together in Rome at the FAO Conference, where the role of aquaculture in sustainable development has been proposed as one topic.

I shall also highlight the importance FAO has accorded to trade and aquaculture – importance that is reflected in the creation of two fora – the Committee on Fisheries (COFI) Sub-Committee on Fish Trade and the Sub-Committee on Aquaculture. These two

fora enable FAO Members to gather every two years to discuss the major global issues for the promotion of responsible aquaculture and trade.

Distinguished Representatives and Colleagues, facts and figures show a clear picture – as we will see in detail later today – of the important role aquaculture is playing in seafood production, as well as the challenges it puts on the environment, consumer safety and last but not least, on capture fisheries. Aquaculture growth is distributed unequally over the globe, a fact to be analyzed carefully to be able to give technical and policy guidance to ensure that the growth is sustainable with due recognition of both ecosystem issues as well as the urgent needs of poverty eradication and food security. We are all aware that capture fisheries and aquaculture provide a major contribution to global food security, both directly, as a source of food, income and employment and indirectly, as a source of meal and oil for animal feed.

As fish trade gets further globalized and out-processing develops further, the issue of certification of production and processing methods and products is becoming crucial to ensure, on one hand, consumer and environmental protection and transparent processes, and fair trade practices on the other. In this respect, FAO has been tasked to develop international guidelines for certification in aquaculture, and you will be informed of the course of actions undertaken to achieve this.

Ladies and Gentlemen, FAO's mandate is to raise levels of nutrition, improve agricultural productivity, better the lives of rural populations and contribute to the growth of the world economy. Four main areas of activities are identified:

- putting information into reach,
- sharing policy expertise,
- providing a meeting place for nations, and
- bringing knowledge to the field.

To fulfil its mandate, FAO strives to be proactive and will have to work with all stakeholders. The Fisheries and Aquaculture Department has been quite innovative and open-minded by trying to listen closely to the opinions, knowledge and expectations of the seafood industry and to the NGOs, in addition to its member countries. This year we already had organized the FAO/OECD Workshop on Globalization and met with the NGOs during the Committee of Fisheries. We actively support the FISH INFONetwork in their commodity conferences on organic aquaculture, tuna, shrimp, bivalves, tilapia and catfish later this year, which are important meeting points for the industry and decision-makers.

We recognize that fisheries and aquaculture, due to the internationalization of a sector where nearly 38 percent of its catches are traded, is not any more only the domain of biologists, fishing experts and processors, but is strongly influenced by clear economic factors along the value chain through retailers, the food-service sector, the regulatory framework, technological innovations, consumers' perceptions and expectations, and NGOs' advocacy agendas, and in all those areas aquaculture has advantages compared to capture fisheries.

With this short provocative statement I want to hand over the opening to the distinguished Vice Minister Fan Xiaojian, whose Ministry secured this conference here in the "romantic" city of Qingdao where we will also have the chance to get a glimpse of the fantastic variety of seafood in the Chinese cuisine.

I wish you a very fruitful conference that should help us and other stakeholders to have a positive impact in the aquaculture sector. I wish you well in your deliberations and thank you very much for your attention.

Opening statement

Xue Liang
Chief Economist
Ministry of Agriculture
China

Respectable Mr. Ichiro Nomura, Assistant Director-General for Fisheries, Food and Agriculture Organization of the United Nations;
Distinguished Guests, Ladies and Gentlemen:

Good morning! The First Global Trade Conference on Aquaculture (GTCA), jointly sponsored by the Food and Agriculture Organization of the United Nations (FAO) and Chinese Ministry of Agriculture, is officially opened in Qingdao, a beautiful coastal city of China. On behalf of Mr. Fan Xiaojian, Chairman of China's Organizing Committee of the GTCA, I would like to express my warm congratulations on the convocation of this conference and to extend my warm welcome to all the participants present here today.

The rapid development of global aquaculture and trade prompted the convening of this conference. With the theme of "Sustainable Development of Aquaculture and Trade Globalization", many world-famous scientists and elites of the business circle have been invited to deliver speeches in such areas as aquaculture, value-added processing, quality safety, market prospects, trade cooperation etc. This conference is of great importance to China's fishery, and it provides us a precious opportunity to learn more from each other, so that it is bound to accelerate the restructuring of China's fishery and promote the transformation of the growth mode, as well as upgrade the industrial quality. Hereby, on behalf of the Chinese Ministry of Agriculture, I'd like to express once more our warm welcome and sincere appreciation to all speakers present at the conference.

Ladies and Gentlemen, the major problems we face in the twenty-first century are population, food, energy and environment, which are of vital importance to human existence and development. Solving the problems facing agriculture, rural areas and farmers and ensuring food safety remains the common task of all developing countries. Over the past 20 years of China's reform and opening-up to the world, we have achieved the basic goal of keeping a balance between supply and demand. However, ensuring food security will continue to be an arduous job for a big country with a population of 1.3 billion. The Chinese Government has attached great importance to fishery development, which is a very important element of agriculture and the main source of animal protein. In order to maintain the sustainable development of the coastal fishery, people are encouraged to be engaged in ocean and inland waters exploration in the light of the breeding-dominant policy established in mid-1980s. In the past 20 years, China has made remarkable achievements in aquaculture. By 2006, the area for aquaculture has expanded to 7.79 million ha and the output is 35.94 million tonnes, which contributes to the market supply, ensuring food security, readjusting the industrial structure in rural areas, and increasing job opportunities and the income of farmers and fishermen, as well as expanding the international trade of aquatic products. Last year, China's trade in aquatic products reached a total volume of US$ 13.66 billion. China's fishery has grown by leaps and bounds thanks to China's reform and opening-up policy, the breeding-dominant principle and the entry into the World Trade Organization (WTO) for global trade cooperation.

Aquatic products for international trade, and aquaculture products in particular, are now mainly produced by developing countries, which is a positive contribution made to global trade of aquatic products and food security. Meanwhile, trade of aquatic products also promotes the economic growth and industrial improvement of developing countries. However, the current trade development is still facing quite a number of major problems that need to be resolved, such as market access, food safety, technology standards etc. Therefore, it's an important task for governments and enterprises across the world to establish an international order for trade in aquatic products, which is beneficial to exporting and importing countries of aquatic products, meeting the diverse consumption demand and protecting resources and the environment, as well as ensuring the world's food security and sustainable development. In light of seeking common ground while resolving differences, we should retain our common interests in fisheries and handle the divergences and our common concerns in an appropriate way. We should keep an eye on the future development of mankind and jointly promote the sustainable development of global aquaculture and trade on the basis of equality, mutual benefit and win-win cooperation.

Ladies and Gentlemen, as China's economy is continuing to grow at a great speed and there is a big potential in production and market, we have seen a broader prospect for our future cooperation with foreign countries in terms of fishery economy, technology and trade. With the scientific view of development as our guiding principle, we are striving to transform our mode of growth in fisheries and pursue a harmonious and sustainable development between man and nature. I sincerely welcome all friends to visit China and put forward more valuable suggestions and advice for the advancement of China's fishery.

I'd like to express my gratitude to FAO for choosing China as host for the first Global Trade Conference on Aquaculture, as well as to all fishery organizations at home and abroad, institutions and individuals for their help. My special thanks go to INFOFISH and the Secretariat of China's Organizing Committee for their efforts that have made this conference possible.

In closing, I wish for a successful conference and wish you all a pleasant stay here in Qingdao.

Thank you all.

Keynote presentations

Kjersti Gravningen

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Kjersti Gravningen, a microbiologist from the University of Oslo, holds a Master of Management from the International School of Business Administration in Oslo. She started her aquaculture career by working with the larval rearing of marine fish and then transferred to fish health management in 1991. Ms Gravningen has extensive experience in global fish health management and disease prevention. Her key areas of expertise include the development, testing and implementation of vaccines and vaccination regimes in fish. Since 1991, she has held several positions within Alpharma Aquatic Animal Health, Research and Development and Business Development, until the aquatic business unit was established as PHARMAQ in 2004. Ms Gravningen has developed different scenarios for future commercial aquaculture as a part of the scenario programme at the International School of Business Administration in Oslo.

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Driving forces in aquaculture – different scenarios towards 2030

Kjersti Gravningen
PHARMAQ AS
Oslo, Norway

ABSTRACT

During the past decades, the aquaculture industry has expanded, diversified, intensified, integrated and made technological advancements. According to FAO's statistics, aquaculture's contribution to the global supply of fish continues to grow, increasing from 9.3 percent of total production (excluding aquatic plants) in 1985 to 34.1 percent of total production in 2005. The production from aquaculture has almost doubled during the past ten years, increasing from 24.4 million tonnes in 1995 to 48.1 million tonnes in 2005. At the same time, the production from capture fisheries has stabilized at approximately 93 million tonnes. The world's population is projected to grow from six billion in 1999 to nine billion by 2042, an average annual increase of 69 million people. Given this population growth, stable consumption per capita and a stable production from capture fisheries of 95 million tonnes, the aquaculture sector will need to supply 89 million tonnes in 2030. Aquaculture production would thus be greater than capture fisheries in 2035. Important factors with assumed future impact on the aquaculture industry towards 2030 include climatic changes, environmental issues, access to sites and water, raw material supply for feed, pandemics and fish health management, integration and ownership structures, food safety and traceability. The forces with high impact and a high level of uncertainty are presented as a basis for some future scenarios for aquaculture.

INTRODUCTION

During the past decades, aquaculture has expanded, diversified, intensified, integrated and made technological advancements. Although production from aquaculture doubled from 24 million tonnes in 1995 to 48 million tonnes in 2005, the percentage annual growth rate has since slowed down. The production from capture fisheries has stabilized at approximately 93 million tonnes (FAO fishstat +[1]). The world population increases by around 77 million annually and is projected to reach 9 billion by 2042 (United States Census Bureau 2007). The production of fish per capita in 2005 was 22 kg. Assuming stable production per capita and stable capture fisheries, the future projections indicate that aquaculture production will need to supply 89 million tonnes in 2030.

This study uses scenario planning, a technique that attempts to capture a whole range of possibilities by using joint impact of various uncertainties to create future scenarios. Scenarios are mental pictures of future worlds, formulated into focused stories that can be used to make us aware of the possible changes, challenges and opportunities that the future may hold. Scenario planning differs from other methods, such as contingency planning and sensitivity analysis, in that it explores the impact of several uncertainties

[1] All numbers used represent total production excluding aquatic plants.

that change simultaneously and often includes elements such as the impact of new regulations and value shifts that cannot be formally modeled (Schoemaker 1995).

MATERIALS AND METHODS

The scenario focus of this study was "what commercially interesting species will be produced in 2030 and in which countries will they be produced?". A deductive scenario structuring method was used (Van der Heijden 1996). The driving forces were identified and ranked based on the uncertainty and the impact on the scenario focus. The two top independent driving forces with high impact and high uncertainty were selected as the basis to establish the scenario cross, resulting in four different scenarios. The data were collected through interviews with experts in the different areas and a literature search.

The study includes finfish only. The fish groups used as the basis for the scenario development were "High-value fish species"[2] and Tilapia[3]. The 2005 numbers are FAO fish stat+ numbers for the respective groups.

RESULTS

Driving forces with high impact on the aquaculture industry

The important driving forces in this study relate to technology, politics, society, environment, globalization and financial aspects. The driving forces selected were climatic changes, endemics and fish health, management, raw materials for fish feed, food safety, access to sites and water, integration, global ownership, environmental impact, implementation of transgenic fish and nanotechnology.

Climatic changes

Over the past four decades, sea temperatures of the North Sea have risen by about 1 °C and by 2100, are predicted to further rise by 1.1° to 4.6 °C (relative to 1990). The consequences of this include rising sea level, with impacts on marine ecosystems, fisheries and aquaculture, as well as epidemic diseases and harmful algal blooms (Epaedia 2007). The warming will impact on the diversity and quantity of species. The effects will probably be most dramatic around the equator, where aquaculture may become difficult.

Increasing and less predictable extreme weather conditions such as drought, floods, storms and typhoons will affect both freshwater and marine aquaculture. These climatic changes may affect the world fisheries and aquaculture even more than overfishing.

Epidemics and fish health management

Fish products are transferred frequently around the world. Transfer of eggs, fry and brood fish increases the risk of disease transfer. The most striking example of spread of disease and major loss in aquaculture is white spot disease in farmed shrimp. The disease emerged in 1991/92 in Taiwan Province of China and by 2000 had spread to all shrimp-producing countries in the world. The global estimate of economic loss due to this disease is US$ 3 billion per year (Hill 2001). The introduction of new farmed species, farming of multiple species, intensification of rearing and environmental changes will increase the probability of new diseases. Epidemics with broad host range may be a threat for the future.

Vaccination is common practice in salmonid-farming countries. In Norway, vaccination has dramatically reduced the use of antibacterials from almost 1 kg per tonne in 1987 to almost nothing (FAO 2006). The development of effective vaccines has

[2] ISSCAP groups: Cod, hakes and haddocks; Flounders halibuts and soles; Sturgeons and paddlefishes; Tunas, bonitos and billfishes; Misc. coastal fishes; Misc. pelagic fishes; Salmons, trout and smelts (numbers from FAO Fishstat + 2005).

[3] ISSCAP group: Tilapias and other cichlids.

made a great contribution to the sustainability of salmon farming by reducing mortality, improving the food conversion ratio (FCR), and reducing the use of antibiotics and the possibility of developing antibiotic resistance. Further development of vaccination strategies, prophylactic treatments, probiotics and immunostimulants is expected. Implementation of improved fish health management is driven by technological advancement, regulations and consumer demand for safe and healthy food.

Raw materials for fish feed

The International Fishmeal and Fish Oil Organisation (IFFO) anticipates that the production of fish oil and fish meal will stabilize over the next 10 years. The proportion of fish oil used in aquaculture has increased from 18 percent in 1995 to 80 percent in 2005. The proportion of world fishmeal used by aquaculture was 15 percent in 1995 and 50 percent in 2005 (Kilpatric 2003, E. Wathne personal communication 2007). In addition, 7.3 million tonnes of by-catch is discharged every year (FAO 2004). Technologies are being developed to reduce by-catch, but it is also a political task to harmonize and properly manage the regulations on quotas for fishing.

The supply of raw marine materials for fish feed relative to the predicted future increase in production is critical. If the production of carnivorous fish species increases, alternative technologies must be developed. Captured zoo- and phytoplankton may be an alternative source of high-quality oils and proteins. Vegetable proteins and oils can partly replace the marine sources; however, the quality and fatty acid profile of farmed fish fed such products may be altered. There may also be potential to use bioproteins produced by methanothropic bacteria from natural gas (Mydland, Frøyland and Skrede 2007).

Food safety

The consumer and retail industries' focus is on healthy food, free of residuals and accumulated heavy metals. Requirements in regard to quality and traceability of all food ingredients apply throughout the value chain. Several cases of unauthorized residues were reported in the months previous to the writing of this article: the chemical compound melamin was detected in fish feed, Japanese inspectors found several kinds of banned antibiotics in imported seafood, and Alabama banned imported catfish due to flouroquinolones. Such incidents are bad for the reputation of the entire industry and further strengthen the focus of consumers on food safety and traceability. Food safety will be even more important for the future, and functional food will also play a key role.

Access to sites and water

Water is essential for all processes. State and private bodies are increasingly aware of water as a finite resource that needs to be used efficiently to satisfy the global demands. Freshwater aquaculture is not a large consumptive user of water, as the water is ultimately returned into the system. However, the water quality may be modified, particularly in areas with intensive production. Conflicts may arise where there is a strong local competition for water supply.

Two-thirds of the earth's surface is seawater. The use of marine waters faces competition from fisheries, tourism, urban development and the conservation of biodiversity. There are almost unlimited exposed marine areas available for aquaculture. The technology for exposed off-shore production capable of withstanding typhoons and storms is being developed.

Integration, global ownership

The past 20 years have seen extensive consolidation of the aquaculture industry. In 1985, small family companies produced 26 000 tonnes of salmon. In 2007, Marine Harvest controls 30 percent of the world's production of 1.6 million tonnes (Cherry

2007). In Viet Nam, the top four processing plants controlled 35 percent of the 286 000 tonnes of catfish fillets that were exported in 2006 (Viet Nam General Department of Customs 2007). Currently, the salmon-producing companies are entering the tilapia industry. One of Chile's largest suppliers of salmon controls 45 percent of the tilapia farming in Costa Rica (Baklien personal communication 2007). The horizontal and vertical integration of the aquaculture industry is likely to continue towards 2030 and is expected to impact on industrialization as well as technology development.

Environmental issues

Aquaculture production can cause environmental problems by pollution of waters, antibiotic resistance, genetic pollution and utilization of energy. Last year an estimated 790 000 salmon (0.35 percent) escaped from Norwegian fish farms. The escaped farmed fish might interbreed with wild stocks (Vulliaume 2007). Farm escapees are a growing concern among fish farmers, environmentalists and authorities alike. The extensive use of legal and illegal antibacterials in many areas can lead to the development of strains of resistant bacteria. This resistance could ultimately be transferred to bacteria that pose a threat to humans. There is also a risk of accumulation of chemicals in sediments surrounding aquaculture operations.

Some positive developments have also occurred: the feed conversion rate has more than halved since the salmon industry emerged, and the industry's discharge of nitrogen has decreased by about 80 percent (E. Wathne personal communication 2007).

The environmental impact of aquaculture is strongly related to other factors such as climate change, management, fish welfare, traceability and food safety. As with all other industries, the aquaculture industry should focus on the environment, and the impact of aquaculture on the environment will be subject to even closer scrutiny in the future.

Implementation of transgenic fish

Transgenic fish are fish that have foreign DNA that has been artificially inserted into their genome. More than 20 species of finfish have been genetically modified to produce selected traits: increased growth, improved feed conversion, cold tolerance and disease resistance. Transgenic tilapia have been reported to grow four times faster than non-transgenic siblings. A number of antimicrobial peptides have potential to improve disease resistance. A key enzyme (n-6 desaturase) that may help fish in converting plant proteins to omega 3 fatty acids (EPA and DAH) has been identified (Rasmussen and Morrissey 2007).

The technology has already been developed; however, it is highly questionable if, how and when it will be fully implemented. Concerns include human safety issues – that transferred genes may maintain allergenic or toxic properties, that transgenic proteins may continue to possess bioactivity following consumption or that disease-resistant fish may become hosts for new and more serious pathogens. The main environmental concerns include the potential impact that escaped transgenic fish may have on natural biodiversity, with transgenics out-competing or cross-breeding with natural populations. The economic concerns are that surveys indicate that buyers (particularly outside the United States) have a negative perception of genetically modified (GM) foods (McLeold *et al.* 2006).

Transgenic fish must be approved by the regulatory authorities. No product has until now been approved, and several regions around the world have banned GM products (McLeold *et al.* 2006). Thus, the implementation of transgenic fish is highly uncertain.

Nanotechnology

Nanotechnology is an interdisciplinary science covering biosciences and material sciences, among others. As with all other industries, aquaculture will be affected by

this development. Carbon nanotubes are currently used in several other industries. The material is 300 times stronger than steel. There are also nano materials with anti-algal and anti-bacterial effects. Such materials could be highly beneficial for the aquaculture industry.

Tracking nano sensors are being developed. "Smart fish" may be fitted with sensors and locators that relay data about their health and geographical location to a central computer. Such technology may be used to control cognitive cage systems or individual fish (ETC Group Report 2004). Nanotechnology may provide solutions for targeted delivery of medicines to fish. Nanotechnology may also increase the absorption of nutrients. Scientists from the Russian Academy of Sciences have reported that young carp and sturgeon exhibited a faster growth rate (30 and 24 percent, respectively) when they were fed nanoparticles of iron (ETC Group Report 2004). Nanotechnology will thus be a strong driver for development of cognitive cage systems, pharmaceuticals, materials and communication.

Scenario cross

All of the above mentioned driving forces have high-impact potential on the future. The most uncertain forces are:

- raw materials for fish feed,
- implementation of transgenic fish, and
- nanotechnology.

Nanotechnology interacts with both transgenic fish and with fishfeed raw materials. Implementation of transgenic fish and the fishfeed raw materials are selected for the scenario cross.

Raw materials for fish feed: the vertical axis depends on capture fishery and technology development. At one end of the scale fisheries resources are heavily exploited and there will consequently be no fish products used for fishfeed production, either due to political or biological reasons (Figure 1). If high-value fish species are

FIGURE 1

Four scenario pictures generated from the high-impact uncertain driving forces. Availability of fish feed raw materials, and implementation of transgenic fish. The four scenario pictures are called "Banning policies, Green revolution, Diversification and the Big five".

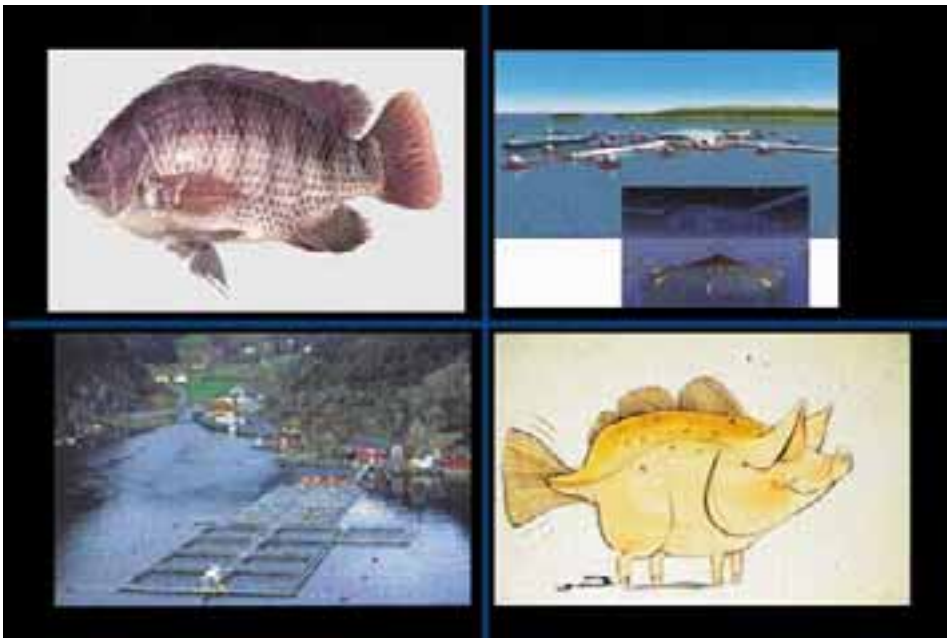
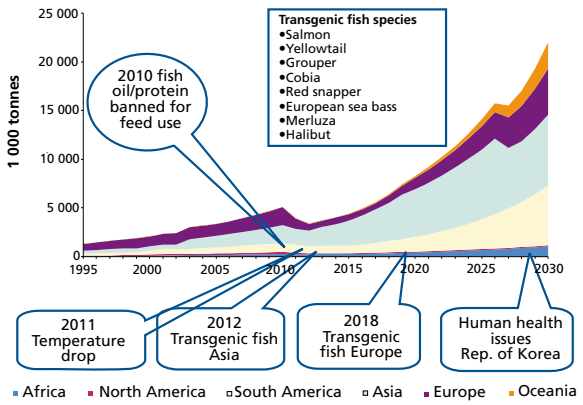


FIGURE 2
Development of high value fish species in different regions of the world, in the Green revolution scenario



to be produced, cost effective alternative sources for fish feed must be developed. At the other extreme, capture fisheries stabilize at current levels.

Implementation of transgenic fish: the horizontal axis will be influenced by the perceived environmental and consumer safety and regulations. At one extreme of the scale, transgenic fish will not be accepted. In the other extreme, transgenic fish are well perceived (Figure 1).

This cross generates four different future scenarios, which I have named; Banning policies, Green revolution, Diversification and the Big five (Figure 1). Only the Green revolution and the Diversification are presented below.

The scenario story "Green revolution"

In 2006, the industry was in very good condition. The market acceptance was generally good. However, cadmium was detected in fishmeal used for fish feed in Norway. This was three years after the polychlorinated biphenyls (PCBs) and dioxin discussion in farmed fish. The World Health Organization (WHO) banned the use of fish-based raw materials in fish feed in 2010 (Figure 2).

The captured production was stable until 2009; however, wild species contained levels of contaminants above recommendations from WHO. In 2011, global temperatures increased, resulting in the ice on Greenland melting and the slowing and eventual change in direction of the Gulf Stream. The diversity and quantity of captured fish dropped by 30 percent. Aquaculture production declined by 40 percent in the North Atlantic. Due to great need of healthy food rich in omega-3 fatty acids, the first transgenic fish were introduced in Asia in 2012. The drivers for transgenic traits were consumer and environmental acceptance. The fish were sterile, resistant to diseases, utilized vegetable proteins and oils, and were rich in omega-3 fatty acids. This, together with the presence of contaminants in wild stocks, meant that the discussions on interbreeding and human health concerns never took off.

High-value fish species are produced in cognitive submerging cages. The self-automated free-floating systems continuously report the feed conversion, fish welfare status and environmental conditions to databases that are assessed by producers, retailers, authorities and consumers. When typhoons or toxic algal blooms are predicted, the system automatically relocates itself to a safe location. The eight different high-value transgenic fish species (Figure 2) represent 95 percent of all high-value fish produced. Three vertically integrated companies own and control the production globally. The production in the European Union (EU) has declined, as the EU was the last to implement transgenic fish in 2018.

In 2026, the young generation in the Republic of Korea, which eats much fish, develops symptoms of reduced fertility rate. The cause has not been clarified, however people are concerned. The production of high-value transgenic species drops. The production of high-value fish species in 2030 is 22 million tonnes, lead by Asia and South America.

The concern about transgenic food in 2026 boosted the production of non-transgenic tilapia, whose production reached 33 million tonnes and was lead by Asia and Africa (Figure 3).

The scenario story "Diversification"

The escape of illegally used transgenic salmon from Canada into Alaskan rivers in 2010 was the driver behind the implementation of strict regulations on transgenic fish and an eventual global ban of the use of transgenic fish in aquaculture. Capture fisheries maintains a stable level, and the growth rate for marine aquaculture is highest in Latin America and Oceania due to control of the majority of the wild catch.

New fish-farming clusters are established in the Middle East and the Russian Federation, where gas is used for production of proteins. Some "carnivorous" species were adapted to vegetable-based diets and although these fish lack the high-value fatty acids, the marketing of a low fat product was successful. Global warming led to extreme temperatures around the equator, species were eradicated and the fish farming moved towards the poles. In Europe, species such as sea bass and snappers are produced on rebuilt oil-platforms in the Barents Sea. Tuna broodstock were fed on fish diet only: consequently a prion disease occurred in 2028. Fortunately, the brood fish were kept in a closed system and the entire population was eradicated without further spread. The diversity of different high-value species and technologies is great, with 200 high-value species produced commercially to a total volume of 17 million tonnes in 2030 (Figure 4). The retailers complain about the logistics.

Tilapia was adapted to thrive in seawater and out-competed the native fish, resulting in dramatic changes in the diversity of wild fish in the affected areas. In 2017, Asia suffered from drought and freshwater became heavily polluted, which caused a 70 percent mortality in all freshwater production. Tilapia production suffered from global warming; however, in 2030 the industry is recovering and the total production of tilapia is 15 million tonnes (Figure 5).

Diseases cause losses in all operations. New advanced technologies for vaccines are available; however, the high diversity of species and lack of harmonization of

FIGURE 3
Development of tilapia in different regions of the world, in the Green revolution scenario

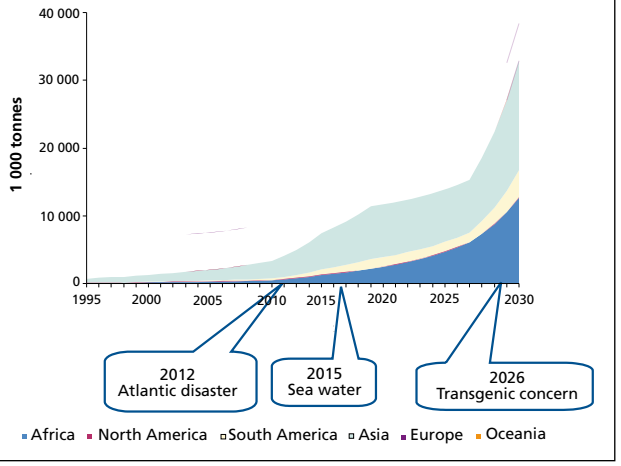


FIGURE 4
Development of high value species in the different regions of the world, in the Diversification scenario

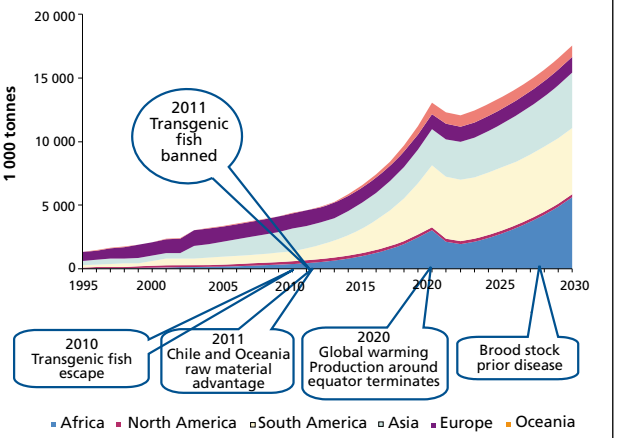
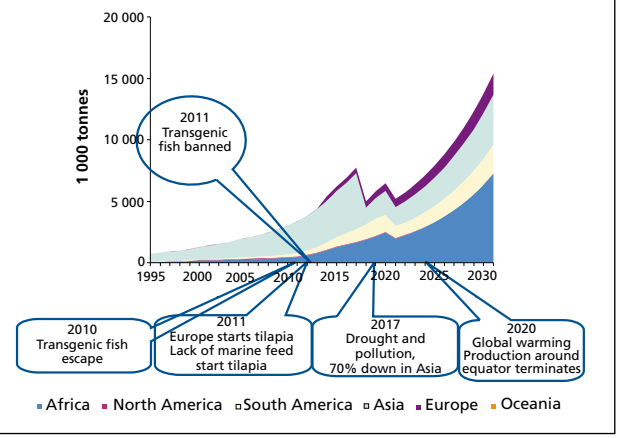


FIGURE 5
Development of tilapia in the different regions of the world, in the Diversification scenario



regulatory requirements make it difficult to bring efficacious products into all market segments. Antibacterials are heavily used.

DISCLAIMER

The above scenarios are prepared based on creative sessions that attempt to take account of a whole range of possibilities and the joint impact of various uncertainties. These scenarios are not facts, but rather some thoughts on what might happen in the future. Scenarios can be used to make us aware of the possible changes, challenges and opportunities that the future may hold, thus helping to prepare us for the future.

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Developing sustainable aquaculture industry and building a harmonious international trade order

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ABSTRACT

In the past 20 years, a China-characterized path for fishery development has been set up by the Chinese Government, based on the fish farming-focused principle. Driven by the development of aquaculture, Chinese traditional fishery has been greatly improved. This contributes not only to the income of fishers and relieves pressure on marine resources, but also assists global food security and world fish trade. Facing both challenges and opportunities, the aquaculture and fisheries sectors need strategically to strengthen international cooperation, which is supposed to drive global aquaculture development in a more sustainable way and ensure the fish supply. In China, fair, orderly and harmonious trading policies and regulations have been proposed and emphasized by the government to provide more effective direction and ensure better resource management and an environmentally friendly, high-quality and trade-harmonious aquaculture development system.

INTRODUCTION

Distinguished Chairman, Distinguished Guests, Ladies and Gentlemen,
It is my honor to deliver a keynote speech at the conference. My topic is "Developing Sustainable Aquaculture Industry and Building a Harmonious International Trade Order". I would like to explain it from the following three aspects:

SUSTAINABLE DEVELOPMENT OF THE AQUACULTURE INDUSTRY IN CHINA AND ITS CONTRIBUTION TO INTERNATIONAL TRADE

China has a long history of aquaculture. During the Tang Dynasty (618–907 AD) some 1 200 years ago, the culture of four major fish commonly consumed in China (i.e., grass carp, silver carp, black carp and bighead carp) had reached a certain scale. Twenty-two years ago, China issued the Fisheries Law, in which it laid down the guidelines for fisheries development as aquaculture-based fisheries. The enactment of the Fisheries Law was an important turning point for fisheries development in China, as it clearly indicated that China had shifted its focus for fisheries development from the fishing industry to aquaculture. In 1988, the output of China's aquaculture surpassed that of its capture fisheries for the first time. Over the past 20 years of development, China's aquaculture industry has made brilliant achievements. By 2006, the output of aquaculture accounted for 68 percent of the total output of aquatic products in China,

and the fisheries population engaged in aquaculture was 13.06 million. A great number of farmers have shaken off poverty and become rich through taking up aquaculture.

The sustainable development of China's aquaculture industry lays a solid foundation for expanding trade in aquatic products. During the 20 years from 1985 to 2006, the export volume of China's aquatic products increased from 120 000 tonnes to 3.01 million tonnes, and their export value increased from US$ 270 million to US$ 9 360 million. At present, there are more than ten aquaculture species that have achieved a certain export scale in China. Among them, the annual export value of prawns and eels has reached more than US$ 800 million and $700 million, respectively. The contribution of aquaculture to China's aquatic products approximates 50 percent.

We can summarize the experience in developing international trade in China's aquaculture products over the past 20 years as follows:

Developing aquaculture by making progress in science and technology

To develop international trade in aquaculture products, we must select advantageous aquaculture species and areas for intensive development according to the demands of the international market. In addition, we should surmount the key technological difficulties in the breeding and culture of fry, strengthen selection and breeding, and introduce and promote improved species, as well as improve our ability to control aquatic animal diseases through progress in science and technology. In the 1980s, Chinese scientists and researchers overcame the difficulties in artificial breeding and developed high-yield aquaculture techniques for Chinese prawns and solved the difficulties in high-yield aquaculture techniques for European eels. These two species, Chinese prawns and European eel, have become the important species for the export of aquatic products. At the end of the 1990s, China focused on large-scale aquaculture technology for tilapias to meet the demand of fillet processing. In doing so, China can partially supply the tilapias for the international market.

Promoting the layout of advantageous regions and improving their development potential

In recent years, the Ministry of Agriculture has taken an integrated approach in terms of resources, environment, market demand, production scale, location advantage, industry foundation etc. according to the natural conditions and local production features in China. In addition, it also actively improves the establishment of regional layout for advantageous aquatic products, optimizes the allocation of resources, gathers talents, strengthens the improvement of infrastructure, attracts social investment and improves production conditions. Furthermore, it strives to advance standardized production and management, as well as promote healthy aquaculture. All the above measures that the Ministry of Agriculture has taken promote the development of an effective and high-quality aquaculture industry, as well as its foreign trade.

Enhancing the quality and safety of aquaculture products and providing safe raw materials

In recent years, the Chinese Government has attached great importance to the quality and safety management of aquatic products and is constantly improving relevant laws and standards. It is also taking the following measures:

- strengthening the quality and safety management system for aquaculture by intensifying drug residue monitoring and management and taking stern actions against violators of laws and regulations concerning drug use;
- promoting origin identification and product certification, introducing export inspection and a traceability system, and supervising the record of exporting raw materials base;

- strengthening aquatic environmental monitoring, developing methods for safety evaluation and the risk assessment of veterinary drugs, and accelerating research and development for new veterinary drugs and vaccines; and
- reinforcing training for popular science education, promoting healthy aquaculture techniques and training new-type fishermen in aquaculture.

Through concerted efforts, China's ability to control drug residues in aquatic products has been strengthened and aquaculture enterprises have gradually established good specifications and quality management systems that have greatly improved the quality and safety of aquatic products.

Developing a modern processing industry and enhancing industrial quality

In order to comply with the high standards of the international market, China's aquatic products processing enterprises have constantly strengthened their self-improvement and elevated their abilities. In doing this, they have formed a number of modern export-oriented enterprises for aquatic products processing, mainly private enterprises that are characterized by the use of advanced technology, standardized specifications and honesty in business operations. These enterprises actively compete in the international market and have become leading enterprises in the aquaculture industry in China, thus promoting the aquaculture industry and modern fisheries with the characteristics of mass production and integrated management.

Actively open up the market and strengthen international exchanges

Although China is a developing country, we actively participate in the process of globalization and promote establishment of a fairer and freer global trade system. As China's aquatic products approach the world, we open our aquatic market with a positive attitude through substantially lowering our import tariffs and developing the free trade zone. Meanwhile, China has also introduced advanced production technology, management experiences and food safety concepts to promote sound development of its aquaculture industry.

CHALLENGES IN THE DEVELOPMENT OF INTERNATIONAL TRADE IN AQUACULTURE PRODUCTS

The aquaculture industry and the international trade of aquaculture products have not only provided high-quality animal protein for us and ensured food security, but also played an important role in such aspects as promoting economic growth in developing countries, shaking off poverty, and increasing job opportunities and fishermen's incomes, as well as protecting marine resources and the environment. However, we should be aware that there are many factors, including trade environment and aquaculture production, that constrain the development of international trade in aquaculture products.

Problems in the criteria for food safety

It is the government's obligation to protect consumers' health and safeguard their rights and interests. It has become a common understanding in the world's fisheries to control drugs used in aquatic products and guarantee the quality and safety of products. However, it is a complicated process to develop hazard risk assessment and to set up scientific quality and safety standards. In recent years, a succession of standards has been established in some importing countries, and the standards have become increasingly strict. Therefore, making use of "green measures" to control importations has become a trend. There were 54 World Trade Organization (WTO) members submitting 853 bulletins of *Agreement on the Application of Sanitary and Phytosanitary Measures* in 2005. Among them, there were 357 bulletins concerning food safety, which was

the largest number compared to other fields. Different quality and safety standards often cause unnecessary consumer panic and market levity between export and import countries, which brings about big losses for aquaculture producers.

Problems in implementation and application of anti-dumping measures

In recent years, anti-dumping measures have become an important method to constrain the trade of aquatic products. WTO's *Agreement on Dumping and Anti-Dumping Measures* aims at constraining countries that disrupt normal trade relations through dumping. But unfortunately, more and more people believe that this agreement has become a method for WTO members to protect their markets and production. Regardless of the discrepancy among different countries in terms of economic development mode, management system and labor costs, they determine margins of dumping subjectively and levy punitive tariffs at will. These phenomena cause trade disputes and increased friction. Although the trade surplus on aquatic products for export obtained by the cheap labor force in developing countries is over $US 20 billion each year, the profits are less because of the increasing trade friction. In today's international trade, people engaged in aquaculture are often in a disadvantaged position.

Problems in the opportunities of market access

The overall level of import tariffs in the developed countries is low, but tariff peaks and escalation still exist, which restricts developing countries from further developing their processing industries, promoting their industrial quality and improving their modernization in varying degrees. Meanwhile, some countries still set up market access quotas or tariff quotas, which constrain normal trade in aquatic products. In addition, with the high starting point, strict requirements and complicated procedures, as well as traceable standards, the requirement for product certification and accreditation systems has appeared in recent years, which has increased costs and created difficulties for the aquatic products produced by developing countries to obtain access to the market.

Problems facing the development of aquaculture

This includes the following three aspects:

- the unscientific use of water resources for aquaculture, the expansion of scale and improvement of per unit area yield resulting in increased outbreaks of disease that threaten the quality and safety of products;
- the traditional way of scattered aquaculture constrains the promotion of production scale and standardized aquaculture; and
- as developing countries achieve economic growth and as the process of urbanization accelerates, some water areas become seriously polluted and the quality of the environment is reduced, which exerts a negative influence on the healthy development of aquaculture.

PROMOTING THE SUSTAINABLE DEVELOPMENT OF AQUACULTURE AND ESTABLISHING A NEW ORDER FOR HARMONIOUS INTERNATIONAL TRADE OF AQUATIC PRODUCTS

The declining trend of the world's fisheries resources has not been reversed and in the future, the increased need for international aquatic products will depend mainly on the development of aquaculture. Looking to the future, we can see that aquaculture can become an important and rapidly developing industry. If we want to develop sustainable aquaculture, we must promote industrial quality and at the same time create a favorable external environment and strengthen international cooperation.

Promoting industrial quality refers to establishing the scientific development concept, constantly exploring healthy aquaculture methods and solving the problems

concerning feed and the environment. In addition, we should also build a resource-saving and environmentally friendly aquaculture, produce products according to international standards, transform the growth mode in a comprehensive way and improve the quality of development. To protect the healthy development of aquaculture, we must strengthen its planning and infrastructure, promote the improved species system, improve disease prevention and control, and adopt a standardized system for quality and safety supervision for aquatic products.

Creating a favorable external environment means establishing a fair and impartial international trade order for aquatic products and creating a harmonious and open international trade environment with orderly competition for aquatic products. We believe that we should adopt the following three principles so that we can establish a reasonable trade order for the aquatic products. Firstly, it should be beneficial to the establishment of normal trade relations between developing countries and developed countries, so as to achieve equality and mutual benefit as well as opening up and creating a win-win situation. Secondly, it should be instrumental in satisfying the increased consumer demands and protecting food safety in the world. Thirdly, it should be conducive to maintaining an ecological environment of resources, promoting harmony between human beings and nature, and trading in a responsible and sustainable way.

Therefore, we would like to put forward the following four proposals:

- Firstly, we should set up scientific, reasonable, appropriate and workable technical regulations or standards. We should also emphasize the role of risk assessment, establish scientific risk assessment mechanisms and formulate standards for aquatic product safety on the basis of scientific analysis and objective evaluation. To establish technical regulations and standards requires us to consider developing countries' capability to adapt to them and to give developing countries enough time to implement them.
- Secondly, we should be in strict accordance with WTO trade regulations. Imposing punishments and sanctions cannot, by itself, solve trade problems. We should prevent the abuse of anti-dumping measures and technical safety standards, increase transparency in introducing and implementing regulations, and resolve trade disputes through dialogue and consultation.
- Thirdly, we should orderly promote various certifications. That is to say, we should intensify guidance towards meeting the standards of these certifications in order to prevent them from becoming barriers to market access and at the same time consider most developing countries' production level and their capacity to implement certification programmes.
- Fourthly, we should promote trade liberalization and facilitation. We must eliminate quotas; reduce tariff peaks and escalation; provide a favorable environment for transparent, effective and fast clearance and further simplify entry and exit procedures so as to increase the efficiency in clearance.

Strengthening international cooperation means extensively developing the all-round cooperation in terms of economy, technology, management, service and information on aquaculture and its trade development. Starting from the practical needs of the developing countries, we should increase our support for their capacity building, and improve the target-direction and effectiveness of economic and technological support. In addition, we should strengthen exchanges and communication among different countries, seek common interests, eliminate misunderstandings, and promote mutual understanding and trust according to the principle of seeking common ground while resolving differences. The role of international organizations and networks such as the Food and Agriculture Organization's (FAO) Sub-Committee on Aquaculture (COFI) and the Network of Aquaculture Centres in Asia-Pacific (NACA) in different regions should be highlighted.

Distinguished guests, ladies and gentlemen,
In the 21st century, aquaculture will take on historically great responsibilities of revitalizing fisheries. Therefore, developing and maintaining trade of aquatic products will have great significance to the sustainable development of aquaculture so that our increased need for aquatic products will be met. Let's join hands together to make concerted efforts to establish a new order for the harmonious trade of aquatic products and promote the development and prosperity of the world's fisheries.
Thank you all.

Session 1: Aquaculture growing strength

Jochen Nierentz

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Jochen Nierentz has more than 25 years experience in marketing and international trade of fishery products. Working for the FAO Fisheries and Aquaculture Department since 1978, he has covered particularly Latin America and Asia where he was stationed in regional projects. He created the GLOBEFISH services based in FAO headquarters (HQ) in Rome, Italy and cooperated closely with the fisheries administrations in Europe and North America, many of which joined GLOBEFISH as member institutions. In 1996, he set up the EASTFISH project in Copenhagen covering 19 Central and Eastern European Countries that became the EUROFISH International Organisation in 2001. He holds a Master in Agriculture and a Master in Economics from the universities of Munich and Goettingen. Presently he is Senior Officer, Marketing, in charge of the GLOBEFISH unit in the Fisheries Utilization and Marketing Service (FIIU) in FAO HQ. In this function he is also responsible for backstopping the activities of the FISH INFONetwork (FIN), formed by the independent intergovernmental organizations INFOPESCA (Latin America), INFOFISH (Asia Pacific), INFOPECHE (Africa), INFOSAMAK (Arab Countries), INFOYU (China) and EUROFISH.

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Overview of production and trade – the role of aquaculture fish supply

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ABSTRACT

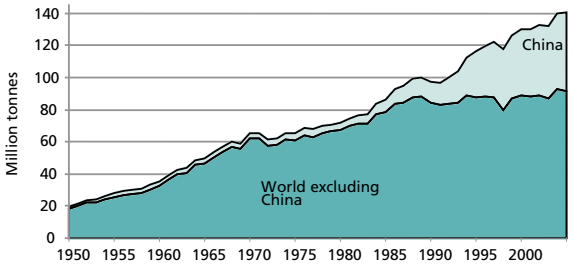
Capture fisheries and aquaculture supplied the world with about 108 million tonnes of foodfish in 2005, with aquaculture accounting for 45 percent of the total. Apparent per capita supply reached 16.7 kg (live weight equivalent), the highest on record. Growth in supply from aquaculture more than offset the effects of stable capture fishery production levels and a growing population. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.8 percent per year since 1970, compared with only 1.2 percent for capture fisheries and 2.8 percent for terrestrial farmed meat production systems over the same period. In terms of foodfish supply (excluding 13.4 million tonnes of aquatic plants) the world's aquaculture sector produced about 15 million tonnes of farmed aquatic products in 2004 (excluding China). Corresponding figures reported for China are about 31 million tonnes from aquaculture and 6 million tonnes from capture fisheries, a powerful indication of the dominance of aquaculture in China. The growth in production of the different major species groups continues, although the increases seen so far this decade are less than those realized during the extraordinary growth in the 1980s and 1990s. Over 240 different farmed aquatic animal and plant species were reported in 2004.

INTRODUCTION

Capture fisheries and aquaculture supplied the world with about 108 million tonnes of foodfish in 2005, providing an apparent per capita supply of 16.7 kg (live weight equivalent), which is the highest on record (Figures 1 and 2, Table 1).[1] Of this total, aquaculture accounted for nearly 45 percent.

Estimates for 2005 indicate that total world fishery production for human consumption represented an increase of over 2 million tonnes compared with 2004 and a record

FIGURE 1
World capture and aquaculture production



[1] Fishery production data given in the tables and figures presented in this paper exclude the production for marine mammals, crocodiles, corals, sponges, shells and aquatic plants.

FIGURE 2
World fish utilization and supply, excluding China

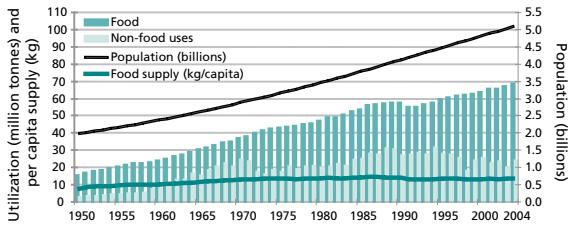
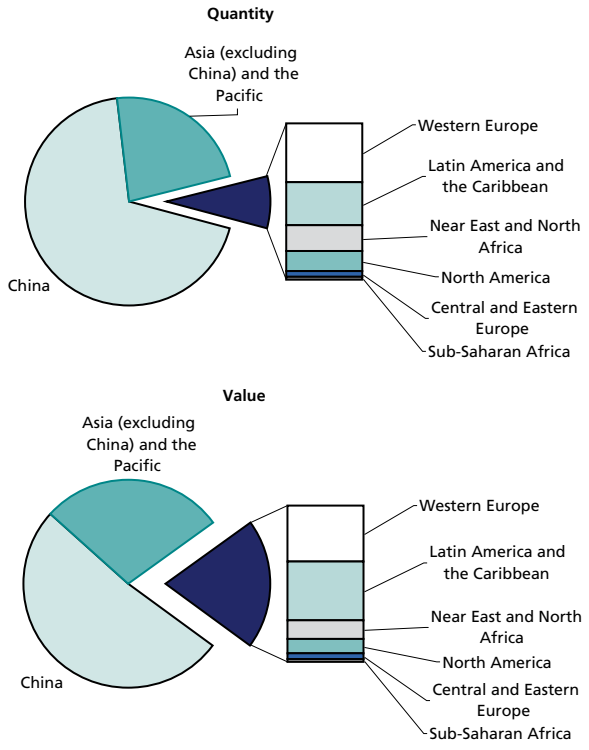


FIGURE 3
Aquaculture production by regional groupings in 2005



high production. There was a decrease in the contribution of capture fisheries, but this was offset by an increase in the aquaculture contribution.

China remains by far the largest producer, with reported production of fish, crustaceans and molluscs of 48.7 million tonnes in 2005 (16.7 and 32.0 million tonnes from capture fisheries and aquaculture, respectively), providing an estimated domestic food supply of 29.1 kg per capita (2005 data), as well as production for export and non-food purposes (Figure 3). Because of the importance of China and the uncertainty about its production statistics, the country is analyzed separately from the rest of the world under the framework of FAO's State of World Fisheries and Aquaculture (SOFIA).[2]

Aquaculture continues to grow more rapidly than all other animal food-producing sectors, with an average annual growth rate for the world of 8.7 percent per year between 1970 and 2005, compared with only 1.1 percent for capture fisheries and 2.9 percent for terrestrial farmed meat production systems. However, there are signs that the rate of growth for global aquaculture may have peaked, although high growth rates may continue for some regions and species. Aquaculture production of fish, crustaceans, molluscs and other aquatic animals in 2005 was reported to be 48.1 million tonnes (Table 1) with a value of US$ 70.9 billion or, if aquatic plants are included, 62.9 million tonnes with a value of US$ 78.0 billion. Of the world total, China is reported to account for nearly 70 percent of the volume and over half of global value of aquaculture production. All regions showed increases in production from 2002 to 2005, led by the Near East and North Africa region and Latin America.

AQUACULTURE PRODUCTION

The contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals[3] continues to grow, increasing from 3.9 percent of total production by weight in 1970 to 27.1 percent in 2000 and to 34.0 percent in 2005. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.7 percent per year since 1970, compared with only 1.1 percent for capture fisheries and 2.9 percent for terrestrial farmed meat production systems over the same period (1970–2005). Production from aquaculture has greatly outpaced population growth[4], with per capita

[2] Available at http://www.fao.org/docrep/009/A0699e/A0699e00.htm.
[3] Also includes amphibians (frogs and turtles).
[4] Population has increased with an average annual growth rate of 1.6 percent during the same period.

TABLE 1
World fisheries and aquaculture production and utilization (million tonnes)

	2000	2001	2002	2003	2004	2005
Inland:						
Capture	8.8	8.8	8.7	8.9	8.9	9.5
Aquaculture	21.3	22.6	24.0	25.5	27.8	29.3
Total inland	*30.1*	*31.4*	*32.7*	*34.4*	*36.7*	*38.8*
Marine:						
Capture	86.8	84.2	84.5	81.4	85.5	83.7
Aquaculture	14.2	15.4	16.4	17.2	18.2	18.8
Total marine	*101.0*	*99.6*	*100.9*	*98.6*	*103.6*	*102.6*
Total capture	*95.6*	*93.0*	*93.2*	*90.4*	*94.4*	*93.3*
Total aquaculture	*35.5*	*38.0*	*40.4*	*42.7*	*45.9*	*48.1*
Total fishery production	**131.1**	**131.0**	**133.6**	**133.0**	**140.3**	**141.4**
UTILIZATION						
Human consumption	97.0	100.2	100.5	103.3	105.6	108.0
Non-food uses	34.0	30.8	33.1	29.7	34.7	33.4
Population (billions)	6.1	6.1	6.2	6.3	6.4	6.5
Per capita food fish supply (kg)	16.0	16.3	16.1	16.4	16.6	16.7

TABLE 2
World fisheries and aquaculture production and utilization, excluding China (million tonnes)

	2000	2001	2002	2003	2004	2005
Inland:						
Capture	6.6	6.7	6.4	6.5	6.5	7.0
Aquaculture	6.1	6.6	7.1	7.8	8.9	9.2
Total inland	*12.7*	*13.3*	*13.5*	*14.2*	*15.3*	*16.2*
Marine:						
Capture	72.0	69.9	70.2	67.1	71.0	69.2
Aquaculture	4.8	5.3	5.5	6.0	6.5	6.5
Total marine	*76.8*	*75.2*	*75.7*	*73.2*	*77.5*	*75.8*
Total capture	*78.6*	*76.5*	*76.6*	*73.6*	*77.5*	*76.2*
Total aquaculture	*10.9*	*11.9*	*12.6*	*13.8*	*15.3*	*15.8*
Total fishery production	**89.5**	**88.4**	**89.3**	**87.4**	**92.8**	**92.0**
UTILIZATION						
Human consumption	63.8	66.0	65.8	67.8	68.8	69.8
Non-food uses	25.7	22.4	23.5	19.6	24.0	22.2
Population (billions)	4.8	4.9	5.0	5.0	5.1	5.1
Per capita food fish supply (kg)	13.2	13.5	13.3	13.5	13.5	13.6

supply from aquaculture increasing from 0.7 kg in 1970 to 7.4 kg in 2005, an average annual growth rate of 7.0 percent.

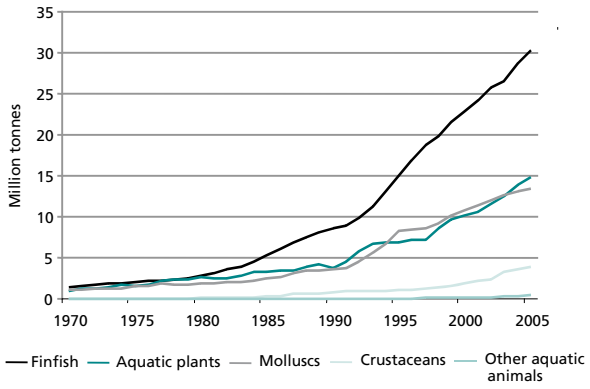
World aquaculture (foodfish, crustaceans, molluscs and aquatic plants) has grown significantly during the last half-century. From a production of below one million tonnes in the early 1950s, production in 2005 was reported to have risen to 62.5 million tonnes, with a value of US$ 76.6 billion. This represents an average annual increase of 6.5 percent in volume and 8.1 percent in value, respectively, over reported figures for 2002. In 2005, countries in the Asia-Pacific region accounted for 91.8 percent of the production volume and 79.6 percent of the value. Of the world total, China is reported to produce 69.1 percent of the total volume and 51.4 percent of the total value of aquaculture production (Figure 3).[5]

[5] The regions match those presented in the analysis of "The State of World Aquaculture" presented to the COFI Sub-Committee on Aquaculture, New Delhi, September, 2006. (FAO Fisheries Technical Paper No. 500).

TABLE 3
Top ten aquaculture producers of foodfish supply: quantity and emerging growth, 2002–2005

Top ten producers in terms of quantity			
Producer	**2002**	**2005**	**APR**
	Tonnes		**Percentage**
China	27 650 815	32 008 686	5.0
India	2 187 189	2 837 751	9.4
Viet Nam	703 041	1 437 300	27.0
Indonesia	914 046	1 197 013	9.5
Thailand	950 718	1 140 057	6.9
Bangladesh	786 604	882 091	4.0
Japan	817 361	737 429	-3.3
Chile	545 655	698 214	8.8
Norway	551 297	656 636	6.0
Philippines	443 537	557 251	8.0
Other	4 681 681	5 559 019	6.0
Top ten producers in terms of growth			
Producer	**2002**	**2005**	**APR**
	Tonnes		**Percentage**
Myanmar	190 120	474 510	36.6
Viet Nam	703 041	1 437 300	27.0
Turkey	61 165	119 177	25.0
Mexico	73 599	117 420	16.9
Republic of Korea	274 625	420 296	16.2
Iran (Islamic Rep. of)	76 817	117 354	15.2
Egypt	376 296	539 748	12.9
Indonesia	914 046	1 197 013	9.5
India	2 187 189	2 837 751	9.4
Chile	545 655	698 214	8.8

FIGURE 4
Trend of world aquaculture production by major species groups, 1970–2005



In terms of foodfish supply, the aquaculture sector in the world excluding China produced 15.8 million tonnes of farmed aquatic products in 2005 (Table 2), compared with about 54 million tonnes from capture fisheries destined for direct human consumption. Corresponding figures reported for China are about 32 million tonnes from aquaculture and about 6 million tonnes from capture fisheries, a powerful indication of the dominance of aquaculture in China.

The growth in production of the different major species groups continues (Figure 4), although the increases seen so far this decade are less than those realized during the extraordinary growth in the 1980s and 1990s. The period 2000–2005 has seen strong growth in production of crustaceans, in particular, and in marine fish. Growth rates for the production of the other species groups have begun to slow, and the overall rate of growth, while still substantial, is not comparable with the increases seen in the previous two decades. Thus, while the trend appears to be continued increases in production in the near future, the rate of these increases may be moderating. Table 4 and Figure 5 present an overview of aquaculture production in terms of quantity and value by major species group for 2005.

The top ten species groups in terms of production quantity and in terms of percentage increase in the production quantity from 2002 to 2005 are shown in Table 5. Production of carps far exceeds all other species groups, accounting for over 40 percent (19.5 million tonnes) of total production of fish, crustaceans and molluscs in 2005. Combined, the top ten species groups account for 91 percent of the total aquaculture contribution to fisheries food supply.

The increasing diversity of aquaculture production can be seen in the list of species groups registering the largest growth from

TABLE 4
World aquaculture production: average annual rate of growth for different species groups (percentage increase)

Time period	Crustaceans	Marine Fishes	Freshwater fishes	Molluscs	Diadromous fishes	Overall
1970–2005	19.2	10.8	9.3	7.7	7.2	8.8
1970–1980	24.6	13.7	6.8	5.8	7.6	6.8
1980–1990	24.6	6.0	12.2	6.9	9.2	10.3
1990–2000	10.1	12.2	10.2	11.3	7.1	10.2
2000–2005	17.5	10.5	6.4	5.1	5.3	6.6

2002 to 2005 (Table 6). Sea urchins and other echinoderms lead the list with a remarkable increase in reported production from 25 tonnes in 2002 to 71 899 tonnes in 2005. In reality, while this does represent an area of emerging activity in aquaculture, this item also reflects an effort made by China to improve its reporting of aquaculture data. Beginning in 2003, China greatly expanded the number of species reported in their aquaculture data, including 15 new freshwater species and 13 new marine species.

Most aquaculture production of fish, crustaceans and molluscs continues to come from the freshwater environment (57.4 percent by quantity and 45.0 percent by value). Mariculture contributes 34.7 percent of production quantity and 40.5 percent of the total value.

Unlike terrestrial farming systems where the bulk of global production is based on a limited number of animal and plant species, over 240 different farmed aquatic animal and plant species were reported in SOFIA 2004, an increase of 20 species compared to the number reported in SOFIA 2002.

It is noteworthy that the growth of aquaculture production of fish, crustaceans

FIGURE 5
World aquaculture production: major species groups by quantity and value in 2005

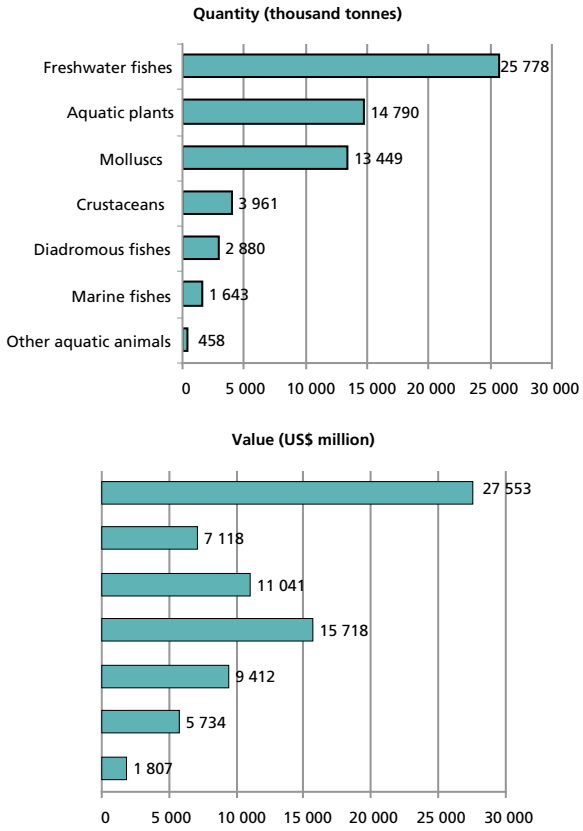


TABLE 5
Top ten species groups in aquaculture production: quantity and emerging growth

Species group	2002	2005	APR
	Top ten species groups in terms of quantity		
	Tonnes		percentage (%)
Carps and other cyprinids	16 727 667	19 541 921	5.3
Oysters	4 332 420	4 615 400	2.1
Misc. freshwater fishes	3 763 902	4 210 737	4.6
Clams, cockles, arkshells	3 458 226	4 175 907	6.6
Shrimps, prawns	1 495 950	2 675 336	22.2
Tilapias and other cichlids	1 490 573	2 025 560	10.8
Salmons, trouts, smelts	1 798 768	1 986 213	3.4
Mussels	1 634 280	1 795 779	3.2
Scallops, pectens	1 228 691	1 274 843	1.4
Misc. marine molluscs	1 389 586	1 107 395	-6.1
	Top ten species group in terms of growth, 2002–2005		
	2002	2005	APR
	Tonnes		percentage (%)
Sea-urchins and other echinoderms	25	71 899	57 065.4
Abalones, winkles, conchs	2 970	333 947	2 619.2
Frogs and other amphibians	3 074	84 879	850.4
Freshwater molluscs	13 414	145 462	290.4
Sturgeons, paddlefishes	4 086	19 648	97.5
Cods, hakes, haddocks	1 450	8 194	80.0
Misc. aquatic invertebrates	12 593	61 756	77.8
Flounders, halibuts, soles	35 938	135 782	64.7
Miscellaneous coastal fishes	386 315	986 684	45.4
Tunas, bonitos, billfishes	9 745	22 915	37.4

TABLE 6
World fish farmers by continent (thousands)[1]

Continent	1990	1995	2000	2003	2004
Africa	3	14	83	117	117
North and Central America	3	6	75	62	64
South America	66	213	194	193	194
Asia	3 738	5 986	8 374	10 155	10 837
Europe	20	27	30	68	73
Oceania	1	1	5	5	4
World	3 832	6 245	8 762	10 599	11 289

[1] Data taken from SOFIA 2006; figures updated on 24 May 2007 by Camillo Catarci.

and molluscs within developing countries has exceeded the corresponding growth in developed countries, proceeding at an average annual rate of 10.0 percent since 1970. By contrast, aquaculture production within developed countries has been increasing at an average rate of 3.3 percent per year. In developing countries other than China, production has grown at an annual rate of 8.7 percent.

Five success stories in aquaculture

Wally Stevens

Executive Director
Global Aquaculture Alliance

Wally Stevens has worked in the seafood industry for more than 35 years, where he has taken on many challenges and held significant leadership positions. In 2007, he was appointed to the position of Executive Director of the Global Aquaculture Alliance (GAA) after his retirement from Slade Gorton & Company, Inc., where he held the position of President and Chief Operating Officer. One of the pioneers of aquaculture in the United States, Mr. Stevens was President of Ocean Products, a small salmon aquaculture company in the state of Maine. From 1970–1987, he worked at Booth Fisheries in several management positions. In 2001, Mr. Stevens was elected Chairman of the Board of the National Fisheries Institute (NFI); today, he is the Dean of the NFI's "Future Leaders" program. For the past year and a half, he has worked as one of the industry's leading proponents for free trade as President of the American Seafood Distributors Association (ASDA). Mr. Stevens graduated in 1962 from Plymouth State University and is active in Alumni Affairs. He is married to Meredith and has three sons.

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1. Shrimp: the most valuable seafood commodity from aquaculture

Wally Stevens
Executive Director
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ABSTRACT

Shrimp is the most valuable internationally traded seafood commodity. Limited fishery production and strong demand have stimulated rapid growth of shrimp aquaculture. From 1997 to 2004, farmed shrimp production grew at 15 percent per year to reach 2.5 million tonnes or 41 percent of total shrimp production. Leading shrimp-producing countries benefited from tropical climate and low labor costs. Another key factor was the ability to adapt quickly on a national level to implement infrastructure changes, adopt new technology, respond to market demands, and adjust to international trade barriers. Governments played a crucial role in providing enabling regulatory frameworks, technical assistance and financial assistance. Private-sector forces such as dominant feed companies, consolidation and integration processes, and strong producer associations also played a key role. The most important technological challenge has been viral diseases, which can cause catastrophic mortality, slow growth or reproductive failure. The primitive shrimp immune system lacks antibodies, which precludes the use of vaccines. Consequently, use of specific pathogen free stocks has become the method of choice to manage disease. Continuing technological advances in such areas as health management, genetic selection, nutrition and pond management are expected to further improve efficiency and reduce cost. Other challenges have included environmental, social and food safety issues. Recent reports of banned antibiotic residues and melamine contamination in China could lead to an unfavorable consumer reaction. Certification is gaining importance as a mechanism for international buyers to assure compliance with environmental, social and food safety criteria.

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Frank Asche is Professor of Industrial Economics at the University of Stavanger. He is also a member of the scientific advisory committee of the WorldFish Center and associate editor of Marine Resource Economics. His research covers all stages of aquaculture from an economic and business perspective, from the production process via issues in the value chain to the market and marketing of the seafood. The development of the salmon industry is a mainstay in his research, but he has also investigated issues in relation to other aquaculture species as well as wild fish. Dr. Asche has published a number of papers in academic journals, as well as more popularized articles in the trade press.

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2. Salmon aquaculture: production growth and new markets

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ABSTRACT

Aquaculture is distinguished from other aquatic production by the degree of human intervention and control that is possible. This control makes innovation possible and is accordingly essential for the rapid technological changes that have taken place since the early 1970s. Environmental conditions can be controlled to a large extent, breeding programmes undertaken and harvesting timed to ensure continuous supplies of fresh product. Salmon is among the most successful aquaculture species so far in that production has increased substantially as technology has become more intensive and industrialized. The control of the production process has also enabled a number of innovations in the supply chain making logistics and distribution more efficient. Moreover, its market has spread geographically and is now global, and new product forms enter the market in increasing numbers. Production is carried out in salmon-indigenous waters, as well as in areas where salmon is an exotic species, and the two largest producing countries (Chile and Norway) are located at the opposite sides of the world. In this paper we look closer at the processes that have made salmon a success story, with a particular focus on innovation. Moreover, we give special attention to Chile, which is today a leading salmon producer despite salmon being an exotic species in that region and long distances to the main markets

INTRODUCTION

Salmon is the most successful finfish species in aquaculture when measured in terms of value. The industry has grown from virtually nothing in the late 1970s to over 1.6 million tonnes in 2006. It is a global species, as Africa is the only continent without salmon aquaculture. However, salmon aquaculture is dominated by two countries, as Norway and Chile make up about 77 percent of the total production. There are several species being farmed, with Atlantic salmon as the most important, with significant quantities of coho and salmon trout and minor quantities of other species.[2] The growth

[1] Corresponding author.
[2] Salmon trout is large rainbow trout that competes in the salmon market. This is in contrast to the small portion-sized trout, which will not be considered here.

in salmon aquaculture has been possible because of a string of innovations that have increased productivity and reduced production and marketing costs, as well as creating new markets. In this paper we will look closer at the elements that have created the salmon aquaculture industry.

Aquaculture is distinguished from other aquatic production by the degree of human intervention and control that is possible. Anderson (2002) argues that the main difference between fisheries and aquaculture is the degree of control, and that the continuum of production modes stretches from a high degree of control in intensive aquaculture to basically no control in unregulated fisheries. Salmon has been at the forefront of this development and clearly shows how control with the production process enables innovations that increase its competitiveness. These innovations start with the input factors such as feed and vaccines, and are important throughout the supply chain from the production of the fish to the product that is sold to the final consumer. Since price, in most cases, is the most important argument with respect to which product in a group of products a retailer will stock, total production cost will be the main factor explaining the competitiveness of a product. By total production cost, one means the total cost of bringing the product to the consumer, which thus includes transportation, processing and marketing costs. Hence, after one has obtained control with the production process, innovations at one level in the supply chain are not more important than at other levels. What is important is their impact.

SALMON AQUACULTURE PRODUCTION

Salmon aquaculture became commercial in the 1970s, but production was tiny, and still as low as 13 000 tonnes in 1980. Total production and production of the most important species (Atlantic, coho and salmon trout), as well as the production of each species of the most important production countries are shown in Table 1. In 1985, total production had reached 80 000 tonnes, and Atlantic salmon's share of the production had increased to 64 percent from 50 percent in 1981. As production continued to increase, the share of Atlantic salmon also increased and in 2006, over 1.6 million tonnes of salmon were produced, with a share for Atlantic salmon of 77 percent. In 1981, salmon trout was relatively much more important than today, as a production of 7 000 tonnes gave a production share of 36 percent. Although production increased, the share was down to 24 percent in 1985 and 14 percent in 2006. Production of coho seems to have flattened out at about 120 000 tonnes, and today makes up about 7 percent of the total. However, it is interesting in Table 1 to note the important role of Japan in the mid-1980s. Moreover, please also note that in 1990, coho was the most important species in Chile, while in 2007 the quantity of Atlantic salmon is three times higher than that of coho.

TABLE 1
Salmon production (in 1 000 tonnes)

Species	Country	1985	1990	1995	2000	2005	2006
Atlantic	Canada	0.4	9.5	32.0	78.8	107.5	115.0
	Chile	0.0	9.5	59.0	167.0	385.0	369.0
	Norway	31.2	165.0	249.0	422.0	572.0	597.5
	United Kingdom	10.3	32.4	70.1	120.0	119.7	128.0
	Total	51.5	251.0	456.1	873.9	1245.9	1266.9
Coho	Japan	8.8	24.0	16.0	13.0	12.0	10.0
	Chile	0.5	13.4	44.0	93.5	106.7	108.1
	Total	9.5	39.4	60.5	108.2	121.2	120.6
S. trout	Chile	0.0	1.9	42.7	79.5	122.6	135.0
	Norway	5.2	3.8	14.7	49.0	59.5	57.0
	Total	19.0	38.8	93.4	177.3	226.1	239.0
Other species		0.2	0.2	13.3	13.7	17.6	27.2
Total		**80.2**	**342.4**	**623.7**	**1177.0**	**1620.4**	**1645.3**

Sources: FAO, Kontali Analyse.

PRODUCTIVITY GROWTH AND LOWER PRODUCTION COSTS

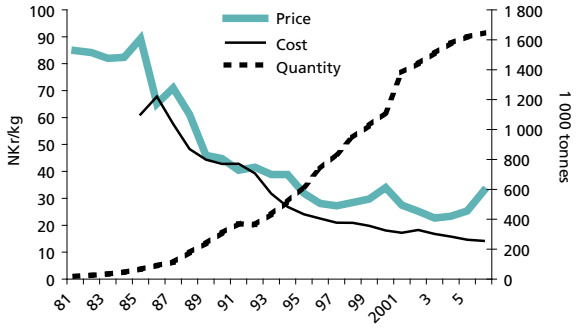
Production of Atlantic salmon increased from about 20 000 tonnes in 1981 to about 1.65 million tonnes in 2006, and the Norwegian export price for fresh salmon in real terms declined from a high of over 85 NKr/kg in the mid-1980s via about 22.50 NKr/kg in 2003 to 32.70 NKr/kg in 2006. As the market for salmon is highly integrated, the price movement has the same main trends for Atlantic salmon from other producers, as well as for the other salmon species. It is also similar for sea bass, sea bream, catfish and tilapia, although the strength of the price decline varies (Asche, Bjørndal and Young 2001).

The decline in the price of salmon has been necessary to induce greater consumption of the product. For this to be profitable, production costs must also be substantially reduced. The main factors behind reduced production costs are productivity growth and technological change. Figure 1 also shows real production cost. One can see that both the price and cost have a clear downward trend, and the gap between them is consistently small. The average price in 2006 was about a quarter of the price in 1985, and the reduction in production cost is of the same magnitude. The important message here is that there is a close relationship between the development of productivity and the falling export prices.

The reduction in production costs has been due to two main factors. First, fish farmers have become more efficient so that they produce more salmon with the same inputs. This is what is normally referred to as the fish farmers' productivity growth. Second, improved input factors (such as better feed and feeding technology and improved genetic attributes due to salmon breeding) make the production process less costly. This is due to technological change for the fish farmers and productivity growth for the fish-farm suppliers. This distinction is often missed, and the productivity growth for the farmers as well as for their suppliers is somewhat imprecisely referred to as productivity growth for the whole industry. In addition, while the focus is on the production process, productivity gains in the distribution chain to the retail outlet are equally important. In the end, consumers are primarily interested in the final price for a product of any quality, and whether a price reduction is due to better feed or better logistics is of little importance. The most important input in salmon farming is the salmon feed, which represented around 52 percent of operating costs during 2004. The share of feed has been increasing (from about 25 percent in the mid-1980s), making the production process more feed intensive. Guttormsen (2002) suggests that substitution possibilities between feed, capital and labour have largely disappeared in the 1990s. This implies that the production process becomes one of converting a cheaper feed into a more desirable product for the consumers. A cost share of one factor, feed, at over 50 percent may seem high, but not when compared to other comparable industries such as pork and poultry production. For example, the cost share for feed for the most efficient poultry producers is over 80 percent. This suggests that there is still a substantial efficiency potential for salmon, and production costs can be further reduced if other factors are exploited even more efficiently.

FIGURE 1

Global aquaculture production of Atlantic salmon and real Norwegian export price 1981–2006 (2006=1) and production cost 1985–2006 (estimate 2006)



Source: FAO 2005, Fishstat database and the Norwegian Seafood Exports Council 2005.

MARKET GROWTH

When salmon aquaculture was commercialized in the 1980s, the markets were defined by where wild salmon was already sold. However, as production increased, the control of the production process allowed a

number of innovations in logistics, transportation, marketing and product development. These have led to market growth as the market has been expanded geographically as well as in the number of product forms.

As production increased, pressure on the prices commenced and new markets were sought. There are substantial economies of scale in transport and logistics and accordingly, producers tended to target one geographical market at a time. The first target was France, a natural choice being the largest seafood importer in Europe, with one of the largest high-end markets. As the geographical area where the product was sold expanded, a number of innovations were made with respect to logistics, preservation and packaging. In particular, the development of leak-proof styrofoam packing allowed airfreight transportation. In the mid-1980s, the trade flow from Norway took a surprising turn as the United States became the largest export market after France due to the use of airfreight. The use of airfreight was important, as it to a large extent removed the barrier that distance had previously represented to a global market for fresh salmon. The geographical size of the market expanded as it became possible to reach virtually any place in the world with airborne salmon. It also allowed producers in any location to access the market, and this can be seen as the main factor behind Chile's success, now the largest salmon producer. The other main pattern has been to expand supply to markets where the freight can be carried out cheaply by road and to allow new sales outlets and product forms to be developed.

Another means of market expansion has been through introduction of new product forms. This implies creating new market segments. With the exception of smoked salmon and the Japanese market, virtually all product forms are fresh. For instance, in France in 1990 as much as 90 percent were sold as whole salmon to the consumer, while in 2000 the share of filleted and other prepacked product had increased to over 70 percent. In addition, salmon became increasingly popular in more value-added products, and there is currently a rapid expansion in the number of product forms available. A major step forward was made by Chilean producers in the early 1990s, with the introduction of the pin bone out fillet. Until then, the United States farmed salmon market had primarily been a market along the eastern seaboard, where whole salmon was presented in the seafood counters. With the pin bone out fillets, the Chileans opened a completely new market in the Midwest and attracted people who until then barely ate fish at all to consume substantial quantities. In fact, product development has been a main engine in Chilean market growth, and Chile currently seems to be the most market-oriented exporter.

How much salmon one is going to be able to sell at profitable prices will be determined as much by market growth as by productivity growth. To a large extent, this will depend on firms in the supply chain's ability to create new markets. As salmon is being sold in most countries in the world, expanding the geographical market is not really an option anymore. An alternative route is then to make the product affordable to consumers that could not buy it before by lower production and distribution costs, or one can create new product forms so that existing markets become deeper. Making salmon more affordable is a strategy that will work in some markets – most people outside the European Union, Japan and the United States cannot afford salmon today, even though prices have declined rapidly. A version of this, income growth that makes salmon affordable, will also help expansion. This seems to be a main driver behind the very high increase in consumption in Russia and Eastern Europe during the last few years. The largest potential may still be in further product development. The stable supplies of fresh fish at relatively low prices have, as noted above, given rise to an increasingly large industry producing value-added products based on salmon. If this process continues, there is a substantial potential for increased market growth here. In particular, in the most advanced markets one can increasingly observe prepacked salmon in counters presented in ways that more resemble chicken or pork than seafood.

Hence, the salmon industry from producers via distributors to retailers is increasingly becoming more like a food industry than a seafood industry.

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Israel J. Snir

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Israel J. Snir is Regal Spring Tilapia's Vice President for Technology and General Manager of Aquafinca Honduras. He was born in 1946 in Israel and is the father of nine children. Dedicated to tilapia since 1968, his first tilapia processing plant, Dag Shan, was built in Israel in 1977 and is still in operation. This was his first and pioneering attempt to convert tilapia farming to an established industry. He introduced fresh and frozen tilapia fillets to the markets in early 1980s. Since 1983, Israel has promoted tilapia culture, processing and marketing world wide. He has been involved in many projects around the world – the more important being in Jamaica, Israel, Africa, Colombia, Ecuador, the United States, Costa Rica and Honduras. For the past six years, he has worked in Honduras, where he manages the Aquafinca Company, part of the Regal Spring Tilapia group. In less then four years, Aquafinca has developed to become a world leader in fresh tilapia fillets. New production technologies, but more so, a unique social and environmental approach, are part of the technology used.

Regal Springs Tilapia – sustainability by social and environmental commitment

Israel Snir
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ABSTRACT

Tilapia is the common name for a vast number of freshwater fishes of the family Cichlidae. This is one of the largest families of fishes, containing more then 1 800 members, many of them in use in aquaculture. Members of the family range from very small ornamental species used in the aquarium industry to large food-size species raised in the fish-farming industry. Tilapia culture and production, mainly of foodfish, has been well documented over the years and appears in ancient documents, is drawn on old cave walls, and is part of the Biblical story. The cichlids, tilapias included, are distributed around the world on both sides of the equator. However, our interest is in the species originating from Africa and the Middle East. In both more recent history and in Biblical days, tilapia is mentioned as the "fish of the miracles" or the "fish for the people". Simultaneously and independently, the culture of tilapia as a common and basic food staple has been developed in various parts of the world. Compared to other cultured species, tilapia culture and consumption are the most widely spread worldwide. Salmon is produced principally by two countries and consumed mostly in Western developed countries and markets; carps are produced and consumed mainly by one country, China; catfish are produced by two or three countries and mostly consumed domestically; shrimps are produced by a few, mainly poor countries who can't afford to eat them, and therefore are exported and mostly consumed by rich populations in a limited number of countries. Tilapia is produced and consumed in over 100 countries and is a staple food for very poor people around the world; however, nowadays, it has also become a staple cuisine in the most expensive restaurants in luxury markets. In more detail, I will focus on a single system/company, the Regal Springs Tilapia group (RST). RST is the largest commercial tilapia vertical producer. This level of production and sales is reached by a nonconditional commitment to quality – of people, of culture, of the product.

Nguyen Huu Dzung

General Secretary
Vietnam Association of Seafood Exporters and Producers

Dr Nguyen Huu Dzung has been General Secretary of the Vietnam Association of Seafood Exporters and Producers (VASEP) – the leading nongovernmental organization in the seafood sector of Viet Nam – since its establishment in 1998. He is also General Director of the Vietnam Seafood Export Market Development Fund (SMF) and Editor-in-Chief of the "Thương Mại Thuỷ sản"[*Seafood Trade*] – a monthly magazine of VASEP. Dr Dzung has close relations with the industry and governmental agencies and a very rich international experience. Prior to taking up the position in VASEP, he was Deputy Director of the Department for Science and Technology of the Ministry of Fisheries (MOFI) and has worked with the Department since June 1984. Before joining MOFI, in 1971–1984, Dr Dzung worked as a senior lecturer for the National Fisheries University of Vietnam. Since working in MOFI, Dr Dzung has been closely involved with the programme for reforming regulatory legislation in the fisheries sector and has actively contributed in setting-up and strengthening the capacity of the National Fisheries Inspection and Quality Assurance Center (NAFIQACEN) – Viet Nam's competent authority in the fishery sector (now NAFIQAVED). He is currently responsible for improvement of quality and export of Vietnamese seafood to international markets and for development and implementation of standards ensuring quality, safety and hygiene in the seafood processing sector. Mr Dzung has a Bachelor of Mechanical Engineering from the National Fisheries University and a Ph.D. degree on Mechanical Sciences from the Lodz Technical University (Poland). He became an Associate Professor in 1992 and has conducted many training and educational activities for fishery inspectors, and the fishing and seafood industry. He has written hundreds of publications and articles.

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4. *Pangasius* – Viet Nam – fairy tale of an unknown species

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ABSTRACT

With the annual volume of live fish harvested in 2006 having reached 825 000 tonnes and an exported volume of frozen fillets and processed products of 286 600 tonnes valued at US$ 737 million, Viet Nam's farmers, processors and exporters have made *Pangasius* the second most important freshwater fish species in the world market, after tilapia. This report presents the wonderful development of the farming, processing and export of this fish during the past five years in Viet Nam. This fast upward trend has been kept in the first quarter of 2007, the export of *Pangasius* from Viet Nam in the first three months of 2007 reaching 80 851 tonnes valued at US$ 206 million, sustaining its high growth rates of 43.7 percent in terms of volume and 55.9 percent in terms of value as compared to the same period last year. Overcoming many technical and trade barriers in the United States and European Union markets, Vietnamese *Pangasius* has achieved a high position in the world and has become a bright phenomenon of the global aquaculture and seafood trade. This report analyses the production and market structure of *Pangasius* exported from Viet Nam during last year, and also highlights the main obstacles, challenges, opportunities and future development trends of sustainable production and trade of *Pangasius* of Viet Nam. It also presents outlines of VietGAP – a newly-developed, comprehensive standard for *Pangasius* production that is designed to be equivalent with EurepGAP and ACC standards.

Douglas McLeod

Chairman
Scottish Shellfish Growers

Doug McLeod has a background in resource economics, an expertise that has been applied in both his original professional incarnation in the international oil industry and now in his second career in the aquaculture sector. As well as operating a small-scale oyster cultivation operation in northwest Scotland, he is Chairman of both the national representative trade association, the Association of Scottish Shellfish Growers, a role he has carried out for almost 20 years, and of the trans-sectoral Scottish Aquaculture Training Association. He spends most of his time representing the interests of the shellfish cultivation industry in what is perceived to be a never-ending series of discussions with government officials, politicians, scientists and regulators across Scotland, as well as in London and Brussels. On the European scene, he is a Past President of the European Mollusc Producers' Association, the multi-national "association of associations" representing the European industry, and a Board member of AquaTT, the pan-European vocational training organization for the aquaculture industry. Internationally, he is a member of the Advisory Committee for the International Conference on Molluscan Shellfish Safety (ICMSS) and a voting member on the Toxin Task Force of the AOAC. In his spare time, Doug McLeod participates in shellfish-related projects, including recently MARINVEST, a technical consultancy to environmental and food hygiene Competent Authorities in China, as well as participating in a broad spectrum of conferences related to shellfish issues.

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5. Bivalves – success in a shell

Douglas McLeod
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ABSTRACT

The historical development in global production by bivalve species is reviewed, noting the minor proportion of exports. The potential for future growth in international trade is discussed in light of two examples of recent export development (Chile and New Zealand). The need for agreed criteria for food safety standards (microbiological and biotoxin) and the failings in the current system are also discussed.

INTRODUCTION

The most outstanding characteristic of the bivalve mollusc sector in recent years has been the rapid and sustained growth in volumes – while capture fishery supplies have doubled from 1 million tonnes in 1970 to around 2 million tonnes in 2005, cultivated volumes have risen over the same period from 1 million tonnes to almost 12 million tonnes, forming a significant proportion of world aquaculture and representing some 26 percent of total output by volume and 14 percent by value.

During the past 15 years (the period of most rapid expansion) global production has risen at an average growth rate close to 6 percent per year. This dramatic growth is largely a reflection of the expansion in production in China, which rose from around 2 million tonnes in 1990 to 9.5 million tonnes in 2005, with Chinese production representing 80 percent of total bivalve aquaculture volumes in 2005.

The expansion in aquaculture production has varied between species, with the greatest increase being for clams. The pattern of output in 2005 was:

- oysters: 4.6 million tonnes (39 percent),
- clams: 4.2 million tonnes (35 percent),
- mussels: 1.7 million tonnes (15 percent), and
- scallops: 1.4 million tonnes (11 percent).

Aquaculture production, as a proportion of total supplies, has reached 90+ percent for oysters and mussels and 85 percent for clams; only in the scallop sector has the capture sector retained a significant role – reflecting the continuing extensive dredging industry – with aquaculture output at around 64 percent.

Drivers behind the global expansion include:

- recognition of the efficiency of filter-feeding bivalves in converting phytoplankton and nutrients into nutritious and high-quality animal protein;
- relatively low capital access requirements;
- frequently, the presence of a natural, low-cost source of seed;
- absence of feed costs for on-growing;
- relative ease of transport (no requirement for tanks, oxygenation etc);
- contribution to domestic nutrition (in contrast to the farming of high-value export "cash" crop finfish and crustaceans, molluscs are an accessible food supply across the planet!); and
- acknowledgement of the minimal environmental impact of bivalve aquaculture.

As filter feeders, feasting on the natural supply of nutrients from the oceans, bivalve molluscs are in reality not being "farmed" in the traditional, manipulative sense of the word, but are being cultivated or "arranged" in more optimal locations (e.g. suspended in the water column or organized in mesh bags and placed on trestles on the foreshore). The impact on the environment is essentially minimal. Indeed, molluscan cultivation differs from other aquaculture operations as being more subject to environmental influences than affecting the environment.

Bivalve exports are a relatively recent phenomenon, rising from 250 000 tonnes in 1990 to around 500 000 tonnes in 2005, and remain a minor proportion of most national production totals. Overall, exports amount to little more than 5 percent of total output, ranging from 16 percent for mussels and 6 percent for scallops to less than 2 percent for oysters and clams.

Success in breaking into international trade is not easy, requiring a combination of critical factors:

- availability of excess (to domestic demand) product;
- competitive pricing and transport systems;
- farmers' organizations and/or trade organizations to offset the disadvantages of traditionally small-scale production units; and
- access to agents in target markets.

TWO EXAMPLES

Chile

Despite the complexities and multiple criteria, bivalve aquaculture can be nurtured with exports in mind, as an instrument of economic development, in addition to supplying incremental nutrition for domestic markets, and two examples in recent years are Chile and New Zealand.

Aquaculture in Chile has grown rapidly in recent years, Chile becoming one of the top ten producing countries, contributing significantly to the economy, with around 69 000 jobs and US$1.8 billion in export earnings (some 60 percent of fishery sector exports), equivalent to 4.2 percent of gross domestic product (GDP). Exports enjoyed a record 25 percent increase in 2005, but now the industry is facing issues of rising costs and international competitiveness.

Production of mussels has risen strongly in recent years, to around 70 000 tonnes in 2004 (95 000 tonnes in 2005), and major investments are being made in the sector, both in production and processing, with the international markets the main target. This growth has been shadowed by a robust expansion in exports to some 18 000 tonnes in 2004. It should be noted that exports are mostly meats, frozen or canned, so it is necessary to uplift volumes by two to three times to compare with "green tonnes" of production volumes. These products are already reaching Europe, with bags of mussel meats retailing in European supermarkets at around € 6/kg.

Turning to another mollusc, abalone landings have also increased from 50 tonnes in 2000 to 205 tonnes in 2005, stimulated by export values of around US$ 24–30/kg. The overwhelming majority of abalone exports are destined for the Japanese market.

New Zealand

New Zealand combines low population, and therefore limited domestic demand, with an extensive coastline and unpolluted waters – these characteristics have supported a significant expansion in molluscan cultivation in recent years: for oysters, with natural settlement on "sticks"; and also for greenshell mussels in both North Island and especially the Marlborough Sounds of South Island, where there has been a rapid increase in sites and leases.

Production of mussels has trebled over the period 1990–2005 from 24 000 to 85 000 tonnes, driven by exports that have grown from 6 300 to 35 000 tonnes, from 26+

percent to 40+ percent of output (as mentioned previously, to compare these volumes with "green tonnes" of production, it is necessary to uplift volumes by a factor of two to three). Geography dictates that exports are largely in processed form, as exports are largely meats and half-shell products, and distributed world-wide, usually frozen.

Oyster production rose from 1 500 to 2 500 tonnes, while exports increased to around 2 300 tonnes, representing at least 80 percent of output and frequently in frozen form.

FUTURE OPPORTUNITIES AND CONSTRAINTS

There is clearly opportunity for further trade expansion, with China being an obvious candidate in view of its scale of production. But although the leading global producer, China barely registers on the international trade scene, with exports at < 50 000 tonnes or 0.5 percent in 2005. The Chinese market clearly absorbs virtually all domestic production (and some imports of around 6 000 tonnes).

Will this situation continue? Is there pent up pressure for exporting to satisfy markets like the EU? Will we experience an avalanche of molluscs onto the international market? Alternatively, will China increase imports to satisfy growing domestic demand due to economic growth? Chinese producers and processors certainly already have a wide portfolio of attractive products.

While overseas markets are an obvious attraction, with the EU representing a major food "magnet" attracting seafood supplies from around the world (Europe is the world's biggest net importer of fisheries products, and its dependency on imports is forecast to continue to rise), molluscan trade is constrained by detailed international shellfish safety regulations.

Major importers, such as the EU, Japan and the United States, have strict criteria on the environmental standards for shellfish cultivation areas as well as limits on the presence of contaminants for shellfish flesh. These criteria cover microbiological, chemical and biotoxin limits, with specific monitoring and measuring regimes, reflecting the established view that molluscs are a "high-risk" food. Any effort to expand the export trade must acknowledge these regulatory constraints; however there are on-going discussions about the relevance, accuracy and appropriateness of some of these criteria. It is rational to inquire: "Are they really for the protection of consumer health, or do they represent non-tariff barriers?"

The standard method of monitoring for biotoxins is the traditional Mouse Bioassay (MBA). However, the arguments in favour of retaining the MBA are being steadily eroded, with the advantages being outweighed by the disadvantages, both for paralytic shellfish poisoning (PSP) and even more so, for diarrhetic shellfish poisoning (DSP).

The development of alternative more accurate, chemical methods using techniques such as liquid chromatography/mass spectrometry (LC/MS) and high performance liquid chromatography (HPLC) should allow food safety authorities to move away from the dubious practice of the MBA to a more science-based methodology. However issues of cost and trained staff remain barriers in some countries.

With regard to microbiology, the identification of *Escherichia coli* as an effective indicator for viral contamination was a major public health breakthrough in the 19th Century, and while it may still remain reasonably accurate for urban areas, *E. coli* can no longer be considered an adequate indicator for remote rural areas. In fact, by using *E. coli* as an indicator, there is a positive correlation between remoteness and perceived pollution, reflecting the increasing efficiency in sophisticated urban water treatment plants, while rural areas generally have higher animal populations, whether domestic livestock or wild.

In my country (Scotland), the most isolated areas have high counts of *E. coli* because of the presence of eider ducks, seals, sea gulls, sheep and deer, none of which pose a great threat to human health, particularly after depuration which removes bacteria! It is

clearly counter intuitive that harvesting areas surrounded by human habitation should have a better classification with regard to human health risk than remote areas.

As a result, I believe it will be essential for the successful growth of international trade in the mollusc sector that a more appropriate microbiological monitoring regime is designed and implemented as soon as possible, reflecting the lower risk to consumer health from bivalves produced in rural areas. This could perhaps be based on classification reflecting demographics (population per hectare), combined with on-going management (closures and re-opening of areas) based on rainfall in the catchment and/or salinity levels. Management systems like these are already in place and working effectively in New Zealand, avoiding the need for long-term closures as a result of diffuse rural "pollution".

In effect, management of environmental events and the impact on shellfish hygiene standards for the protection of human health should be a comprehensive risk assessment exercise, taking into account all the influences, accurately measuring contaminant levels in the shellfish and rationally assessing the effect of the contaminant levels (bacterial, viral, biotoxin, chemical) on human health.

I have deliberately not discussed prices or profitability, as comparing prices across time or products or countries is a statistical quicksand with a vast array of significant criteria and influences, ranging from size and specification, meat yield and appearance to position in the chain – farmgate, wholesale, retail – degree of processing and foreign exchange rate movements.

I believe that despite the wide range in example "pier head" prices for mussels, from US$ 100 in Chile to US$ 1 990 in Scotland, fundamental economics means that molluscs will only continue to be farmed if the price generates sufficient income for the farmer.

CONCLUSIONS

There are great opportunities for a future expansion in international trade in molluscs, requiring an acceptance of the need for hygiene regulations. However, any such regulations must be "fit for purpose", reflecting realities – they must be credible to both industry and consumer, and not act as non-tariff barriers.

Health regulations are essential, but they must be appropriate in method, accuracy, scope and frequency of application.

Regulators should ensure that risk assessment is the foundation of their management of molluscan production and international trade. Specifically, in the management of biotoxin events, a substitution of chemical methods for the MBA should be promoted strongly, and new approaches to microbiological safety in rural areas are clearly required to reflect the measurement of real risk. For any such risk assessment programmes to be effective, there must be clear communication between regulators and industry, and such communication must be acknowledged as an up-front priority, not a secondary issue after listening solely to researchers who are diligently searching for new toxins, creating more analytical methods or driving down the level of detection.

To enable the successful expansion in the international trade in bivalve molluscs – a remarkable food product with high nutritional values and a unique ability to contribute to economic development around the planet – it will be essential for government, regulators, scientists and industry to collaborate to a greater extent than has been evident in the past. And then we can all look forward to a prosperous and healthy future, for our industry and for our planet.

Session 2: Challenges

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Safety of aquaculture products: consumer protection, international regulatory requirements and traceability

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Food and Agriculture Organization of the United Nations

ABSTRACT

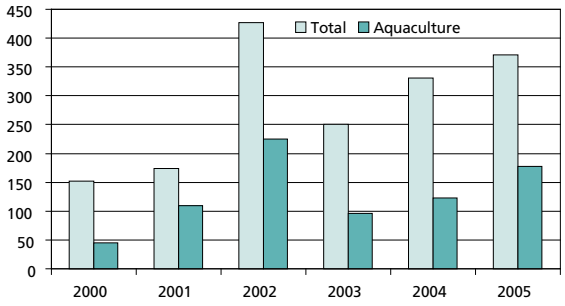
International fish trade has expanded significantly from US$8 billion in 1976 to approximately US$78.4 billion in 2005. Aquaculture production, especially of shrimp, salmon, tilapia, catfish and bivalves, contributes significantly to this trade. Fish and seafood represent a commodity that is widely traded internationally, with a major contribution from developing countries, including in the form of aquaculture products. In fact, the net receipts of foreign exchange from fish trade by developing countries (i.e. deducting imports from the value of exports) increased from US$3.7 billion in 1980 to US$21.0 billion in 2005. This was greater than the net exports of other agricultural commodities such as rice, coffee, sugar, tea, banana and meat combined. Over 75 percent of exported fish and seafood is destined to three major markets: the European Union, Japan and the United States. These three markets are characterized by stringent and exacting requirements for consumer protection and food safety. As a result, the increase in international fish trade has been accompanied by new trends, emerging issues and requirements for market access. These issues comprise i) ecolabelling and environmental protection as a result of the decreasing landings from capture fisheries and the increasing role of aquaculture for fish supply; ii) consumer protection and food safety requirements; iii) traceability along the value chain and consumer information; and iv) the increasing role of retailers and the development of market standards and certification schemes. This paper analyzes these emerging trends and their impact on the future of international trade in aquaculture, the international regulatory framework for food safety and quality and provides some recommendations on how to reconcile promotion of responsible international trade in aquaculture with consumer protection objectives in a transparent manner.

INTRODUCTION

Unlike capture fisheries, aquaculture production has continued to increase markedly. Its contribution to global supplies of fish increased from 3.9 percent of total production by weight in 1970 to 32 percent in 2004. Aquaculture is growing more rapidly than all other animal food-producing sectors. Worldwide, the sector has increased at an average compounded rate of 8.8 percent per year since 1970, compared with only 2.8 percent for terrestrial meat farming systems (FAO 2006).

Total world trade of fish and fishery products has undergone a tremendous development during the last three decades, increasing from a mere US$8 billion in 1976

FIGURE 1
Alert cases involving fish exported to the European Union, 2000–2005



to an export value of US$71 billion in 2004 and an estimated value of US$78.4 billion in 2005. In real terms (adjusted for inflation), exports of fish and fishery products increased by 17.3 percent during the period 2000–2004, 18.2 percent during 1994–2004 and 143.9 percent between 1984 and 2004. Products derived from aquaculture production contribute an increasing share of total international trade in fishery commodities.

Developing countries play an active part in international fish trade, accounting for nearly 50 percent of exports (in value terms). The net receipts of foreign exchange by developing countries (i.e. deducting their imports from the total value of their exports) increased from US$3.7 billion in 1980 to US$21.0 billion in 2005. This was greater than the net combined exports of the other agricultural commodities (e.g. rice, coffee, sugar, tea, banana and meat).

Globalization of food trade, coupled to technological developments in food production, handling, processing and distribution and the increasing awareness and demand of consumers for safe and high-quality food have put food safety and quality assurance high in the headlines. This is exacerbated by the recurrent food safety scares since the 1990s.

Consequently, internationally traded fish products in general and aquaculture products in particular have been subject to close scrutiny for their safeness for consumption. For example, the European Union (EU) alert system for food and feed indicated that fish and fishery products have been often responsible for a large proportion, and sometime being the largest (up to 25 percent), of food safety and quality alerts during the period 2000–2005. Of these, aquaculture products were involved in 28 to 63 percent of alert cases (Figure 1), mainly because of the presence of high residues of veterinary drugs, unauthorized chemicals and bacterial pathogens. For example in 2005, 177 alert cases were due to aquaculture products that contained bacterial pathogens (37 percent), nitrofurans (27 percent), malachite green (20 percent), excess residues of sulfites (13 percent) and unacceptable residues of veterinary drugs (3 percent). Similar safety problems have been reported by the control authorities of other major fish importing countries.

The trade volumes of the incriminated shipments to the EU varied from 1 082 tonnes to over 6 137 tonnes at a value of US$3.8 million to over US$26.5 million (Table 1). Although relatively low compared with the overall value of imports to the EU, the impact can be very damaging to the reputation of a company, a sector or even a country.

To preserve the safety and quality of aquaculture products, the responsibility for the supply of fish that is safe, healthy and nutritious should be shared along the entire chain from primary production to consumption. Producers, processors and distributors are responsible for the development and implementation of good aquaculture practices (GAP), good hygienic practices (GHP) and hazard analysis critical control point (HACCP) systems. Government institutions should develop an enabling policy and a regulatory environment, organize the control services, train personnel, upgrade control facilities and laboratories and develop national surveillance programmes for relevant food safety hazards. Support institutions (academia, research, extension, trade associations etc.) should conduct research on quality, safety and risk assessments, and provide training and technical support to personnel engaged in production, processing and distribution.

In the case of bivalve molluscs, filter feeders that can concentrate pollutants, biological agents and biotoxins, there is a need to control and prevent contamination from chemical pollutants and biotoxins through the implementation of appropriate monitoring and surveillance of the growing and harvesting areas.

International harmonization of safety and quality requirements and equivalence of certification systems can facilitate international fish trade and prevent the use of these requirements as disguised barriers to trade. On the other hand, the safety requirements should be based on sound science to provide the appropriate level of consumer protection. Reconciling both objectives requires an international regulatory and technical framework to support the development of harmonized standards and equivalence recognition systems.

TABLE 1
Estimated volumes and costs of alert cases involving fish exported to the European Union, 1999–2005

Year	Estimated volume tonnes)	Estimated cost (US$1 000)
1999	1 721	7 116
2000	1 341	5 060
2001	1 082	3 821
2002	3 271	14 435
2003	6 137	26 507
2004	2 897	13 211
2005	5 439	19 327

INTERNATIONAL FRAMEWORK FOR FISH SAFETY AND QUALITY

Several regional and international organizations have been mandated to develop agreements, codes of best practice, standards and guidelines for food safety and quality. The most relevant to fish trade are the World Trade Organization (WTO) and its two binding agreements, the *Agreement on Sanitary and Phytosanitary Measures* (the SPS Agreement) and *the Agreement on Technical Barriers to Trade* (the TBT Agreement), and the *Codex Alimentarius*.

The WTO was established in 1995 as the successor to the *General Agreement on Tariffs and Trade* (GATT), founded after World War II. WTO was established following the final act of the Uruguay Round of negotiations, which began in Punta del Este, Uruguay in September 1986 and concluded in Marrakech, Morocco in April 1994. The Uruguay Round was the first to deal with the liberalization of trade in agricultural products, an area excluded from previous rounds of negotiations.

Significant implications for food safety and quality arise from the Final Act of the Uruguay Round, especially from two binding agreements: the SPS and the TBT agreements.

The SPS Agreement confirms the right of WTO member countries to apply measures necessary to protect human, animal and plant life and health. However, these measures must be consistent with obligations prohibiting arbitrary or unjustifiable discrimination on trade between countries where the same conditions prevail and must not be disguised restrictions on international trade. It requires that, with regard to food safety measures, WTO members base their national measures on international standards, guidelines and other recommendations adopted by the Codex Alimentarius Commission (CAC), where they exist. This does not prevent a member country from adopting stricter measures if there is a scientific justification for doing so, or if the level of protection afforded by the Codex standard is inconsistent with the level of protection generally applied and deemed appropriate by the country concerned.

The SPS Agreement requires that SPS measures should be based on an assessment of the risks to humans using internationally accepted risk assessment techniques. Risk assessment should take into account the available scientific evidence, the relevant processes and production methods, the inspection/sampling/testing methods, the prevalence of specific illnesses etc.

The TBT Agreement is a revision of the agreement of the same name first developed under the Tokyo Round of negotiations (1973–1979). The objective of the TBT Agreement is to prevent the use of national or regional technical requirements, or standards in general, as unjustified technical barriers to trade. The agreement covers standards relating to all types of products, including industrial products, and quality

requirements for foods (except requirements related to SPS measures). It includes numerous measures designed to protect the consumer against deception and economic fraud.

The TBT Agreement basically provides that all technical standards and regulations must have a legitimate purpose and that the impact or cost of implementing the standard must be proportional to the purpose of the standard. It also states that if there are two or more ways of achieving the same objective, the least trade restrictive alternative should be followed. The agreement also places emphasis on international standards, WTO members being obliged to use international standards or parts of them except where the international standard would be ineffective or inappropriate in the national situation. Both the SPS and TBT agreements call on WTO member countries to:

- promote international harmonization and equivalence agreements;
- promote the use of scientifically sound risk assessment to develop SPS measures;
- facilitate the provision of technical assistance, especially to developing countries, either bilaterally or through the appropriate international organizations; and
- take into consideration the needs of developing countries, especially the least developed countries, when preparing and implementing SPS and quality measures.

The Codex Alimentarius Commission (CAC) was created in 1962 to implement the Joint Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) Food Standards Programme. The primary objectives of the CAC's work are the protection of the health of consumers, the assurance of fair practices in food trade and the coordination of the work on food standards.

The CAC is an intergovernmental body with a membership of some 165 Member Governments. In addition, observers from international scientific organizations, food industry, food trade and consumer associations may attend sessions of the Commission and of its subsidiary bodies.

The work of the CAC is carried out by several committees: nine general subject matter(s) committees that deal with general principles, hygiene, veterinary drugs, pesticides, food additives, labelling, methods of analysis, nutrition or import/export inspection and certification systems, and 12 Commodity Committees that deal with a specific type of food class or group, such as fresh fruits and vegetables, fats and oils, or fish and fishery products.

The work of the committees on hygiene, fish and fishery products, veterinary drugs and import/export inspection and certification systems are of paramount interest to the safety and quality of internationally traded fish and fishery products, including aquaculture fish.

In the environment of the SPS/TBT agreements, the work of the CAC has taken on unprecedented importance with respect to consumer protection and international food trade. The Codex standards are meant to be voluntary and adopted by consensus. But under the new SPS/TBT agreements, the Codex standards cannot be called voluntary, nor are they fully mandatory, falling in an area in between that looks like voluntarism under duress. This is why the Codex has been undergoing significant reforms to improve its standards' setting and management procedures and the participation of developing countries to its deliberations. Tables 2 and 3 present the most relevant Codex codes and guidelines relevant to aquaculture.

CERTIFICATION AND PRIVATE STANDARDS

As a result of the globalization and expansion of international food trade, the food industry has experienced significant consolidation and concentration in the industrialized countries. This has led to the emergence of fewer but powerful food firms, with substantial bargaining *power vis-à-vis* other players up and down the supply chain. Although wholesale and restaurant chains still play an important role in

TABLE 2
Codex Code of practices and guidelines relevant to aquaculture feeds and veterinary drugs

Code	Title	Year of adoption	Revision or amendment
CAC/RCP 54	Code of practice on good animal feeding	2004	
CAC/GL 16	Codex guidelines for the establishment of a regulatory programme for control of veterinary drug residues in foods.	1993	
CAC/RCP 38	Recommended international code of practice for control of the use of veterinary drugs	1993	
CAC/MISC 5	Glossary of terms and definitions (Residues of veterinary drugs in foods)	1993	Amended 2003
CAC/RCP 61	Code of practice to minimize and contain antimicrobial resistance	2005	
CAC/MRL 2	Maximum residue limits for veterinary drugs in foods	2006	2006 Update

TABLE 3
Codex Alimentarius principles, guidelines and standards relevant to the safety of aquaculture products and certification

Code	Title	Year of adoption	Revision or amendment
CAC/RCP 52-2003	Code of practice for fish and fishery products (Section 6 deals with aquaculture)	2005	
CAC/GL 20	Principles for food import inspection and certification	1995	
CAC/GL 26	Guidelines for the design, operation, assessment and accreditation of food import and export inspection and certification systems	1997	
CAC/GL 34	Guidelines for the development of equivalence agreements regarding food import and export inspection and certification systems	1999	
CAC/GL 47	Guidelines for food import control systems	2003	Rev.1-2006
CAC/GL 53	Guidelines on the judgement of equivalence of sanitary measures associated with food inspection and certification systems	2003	
CAC/GL 60	Principles for traceability/product tracing as a tool within a food inspection and certification system	2006	
CAC/GL 38	Guidelines for generic official certificate formats and the production and issuance of certificates	2001	Rev.1-2005
CAC/GL 48	Model certificate for fish and fishery products	2004	
CODEX STAN 1	General standard for the labelling of prepackaged foods	1985	Rev.1-1991
CAC/GL 27	Guidelines for the assessment of the competence of testing laboratories involved in the import and export control of food	1997	

fish distribution in many countries, the power has been shifting to the end point of the supply chain, the retailers. This is the result of increased consolidation of retailers *inter alia* into supermarkets and the growth of goods produced under a retailer or private label. This supermarket system is expanding rapidly to developing countries in Latin America, Asia and Africa (OECD 2004).

These global developments have been taking place against a setting of increasing influence of civil society and consumer advocacy groups over the agendas of governments, companies and international organizations on different aspects of the food systems. Food demand has been changing with the evolution of lifestyles, demographics and increase in household incomes. Consumers expect transparency in food systems that leaves a trail as the product moves from the producer to the consumer and that makes it possible to trace the origins, the quality and the environmental and social impacts of food production and distribution.

As the last link in the supply chain between producers and consumers, retailers aim at translating and transmitting these consumer demands back through the supply chain to producers and processors. To achieve this, retailers have developed standards that encompass quality and safety, as well as other process and production aspects such as environment protection, labour conditions or animal health and welfare, to reflect their increased responsibility towards consumers and to prevent any risk to their reputation. In addition to regulations and consumer demands, the standards may also cover commercial requirements such as quantities, quality consistency, delivery punctuality and flexibility.

The market standards being currently developed or used in international fish trade primarily address consumer protection and resource sustainability. Small market niches are governed by specific standards such as "*label rouge*" in France, "*Quality Mussels*" in Ireland or Canada or "*organic farmed fish*" labels. Furthermore, some countries and producers' associations have established labels to certify implementation of best practices or codes of conduct[1]. This unprecedented development in market standards raises the following major issues:

- If trade liberalization is to bring benefits to all, including to developing countries, then rising market standards should not constitute a barrier or additional impediments for entry to major markets by producers and processors from developing countries.
- In the absence of regulatory frameworks, the setting of market standards by a company or a coalition of companies or retailers with significant market power may increase the risk of anti-competitive behaviour and the companies may use this power to impose lower prices throughout the supply chain.
- How are the boundaries defined between public regulations on the one hand and private market standards on the other? And who is responsible for what? While governments that use standards as trade barriers can be challenged through the rules of the WTO, what mechanism should be set to deal with companies whose standards constitute technical barriers to trade?

Some argue that meeting and adhering to market standards can have a positive effect, including for developing countries, in particular by spurring new competitive advantages and investments in technological capacity. But some governments and producers' groups fear that these standards may disguise underlying intentions to protect domestic industries and restrict market access or add a new layer of constraints upon their competitiveness by duplicating or adding to existing food safety and quality requirements. Also, the burden of complying with these standards may fall disproportionately on small suppliers for whom the cost of achieving certifiable status is relatively higher.

Furthermore, as certification programmes proliferate, consumers and producers face choices as to which certification programmes carry the most value. Competing certifying claims may confuse consumers, causing them to lose confidence in standards and thus depriving the approach of its value. It also raises questions about which certification programmes best serve consumer protection, the environment, the public and the producers. Thus, the credibility of the standards and of their certification and accreditation bodies is of paramount importance.

The development of market standards and labels and their potential impact on international trade have been the subject of recent debates in many international fora. Sanitary and quality issues are the subject of regular debates within the SPS and the TBT committees of the WTO[2]. Market standards have also been debated at The Nordic Council of Ministers (NTWGFEC 2000), The Commission of the European Communities[3], the International Center for Trade and Sustainable Development

[1] Examples include the Global Food Safety Initiative (GFSI) standard (www.ciesnet.com), the Federation of European Aquaculture Producers' Code of Conduct for Aquaculture, the British Retail Consortium (BRC) standard (www.brc.org.uk/standards), the Aquaculture Certification Council (ACC) (www.aquaculturecertification.org), the Eurep GAP standard (www.eurep.org) the WWF aquadialogues (www.worldwildlife.org/cci/aquaculture_dialogues.cfm), the Thai Marine Shrimp Culture Codes of Conduct and the Code of Good Environmental Practices for Well Managed Salmonoid Farms by Fundacion Chile. The latter are a result of the requirements of importers and retailers.

[2] http://www.wto.org/english/news_e/news07_e/sps_28feb_1march07_e.htm

[3] Communication from the Commission to the Council, The European Parliament and the European Economic and Social Committee. Launching a debate on a Community approach towards eco-labelling schemes for fisheries products.

(ICTSD 2006), the FAO Committee on Fisheries (COFI) (FAO 2007) and the World Aquaculture Society[4].

The debates in these fora highlight that while market-driven standards and labels can offer opportunities to spur competitive advantages and investment in technological developments to expand market shares and extract more value, many developing countries and small-scale enterprises fear that these standards can disguise underlying intentions to protect domestic industry or create additional burden to already highly demanding existing regulatory requirements. The following are possible actions to mitigate the concerns:

- *Increased transparency:* For some exporters, business can be riskier and uncertain because of market standards imposed by importers. Increased consultation and transparency in the development and application of these standards would reduce the risks that exporters confront and enhance market access.
- *Harmonization and equivalence:* Regional and international cooperation is necessary for the development of harmonized and transparent standards and compliance procedures, building on the work of the *Codex Alimentarius* (safety and quality), FAO (ecolabelling, organic fish farming) and ISO (certification, accreditation). More attention should be given to opportunities for mutual recognition of standards and simplification of compliance procedures. This in turn should lead to cost reduction, especially for developing countries and small-scale producers.
- *Technical assistance and phase-in for developing countries:* International efforts to manage the negative impacts of standards could be coupled with similar efforts in regional and bilateral economic arrangements. External funds are needed to support implementation and compliance in developing countries. Where possible, standards could be accompanied by phase-in periods for producers in developing countries.

TRACEABILITY

Traceability is "*the ability to trace the history, application or location of that which is under consideration*" (ISO 9000 2005). When considering a product, traceability relates to the origin of materials and parts, the processing history and the distribution and location of the product after delivery.

In the case of food safety, the *Codex Alimentarius* defines "*traceability/product tracing as the ability to follow the movement of a food through specified stages of production, processing and distribution*" (CAC 2004).

This definition has been further refined into a regulation by the EU to signify "*the ability to trace and follow a food, feed, food producing animal or substance intended to be, or expected to be incorporated in a food or feed, through all stages of production, processing and distribution*" (EC 2002).

Further on, traceability can be divided into internal and external traceability. Internal traceability is traceability of the product and the information related to it, within the company, whereas external traceability is product information either received or provided to other members of the supply chain.

Similarly to a batch, a lot or a trade unit, a traceable unit can be one fish (e.g. one tuna fish), one catch, the catch of a day or of several days, the crop of one pond/cage or of several ponds etc. The larger the unit, the lower the cost of tracing but the higher are the economic and reputational consequences in case of a recall. Inversely, the smaller the traceable unit, the higher the costs and the lower the economic and reputational consequences in case of recall.

[4] World Aquaculture Society. The 2006 Annual Meeting and Conference. May 9–13, 2006. Florence, Italy.

The EU produced a Guidance[5] on how to implement traceability. This guidance indicates clearly that the traceability provisions of the regulation do not have an extra-territorial effect outside the EU. The provisions cover all stages of production, processing and distribution in the EU, namely from the importer up to the retail level, but do not extend to food business operators in non-EU exporting countries.

Before 11 September 2001, the United States traceability systems tended to be driven by the industry, motivated by market incentives and relied significantly on third party safety/quality auditors to verify and substantiate claims on credence attributes. The development of large retail chains has pushed for increased traceability and better food supply chain management to prevent stock-outs or overstocking. However, in 2002, the United States Congress passed *the Public Health Security and Bioterrorism Preparedness and Response Act*, resulting in the United States Food and Drug Administration (US FDA) issuing a ruling (US FDA 2004) in December 2004 requiring all links in the food supply chains and food transporters to establish and maintain records to trace and track their suppliers and buyers by 9 December 2006, although implementation began with large companies in 2005. This regulation requires that domestic and foreign facilities that manufacture/process, pack or hold food for human or animal consumption in the United States, register with FDA and submit electronically prior notice to FDA before the shipment is due to arrive into the United States.

Both EU and United States traceability regulations require food and feed business operators to be able to trace back to the supplier of food, feed or ingredient and track forward the business to which their product has been supplied (also known as "*the one step back, one step forward system*").

Many other countries, both developed and developing, have passed similar legislation mandating traceability in all or some of the links in the food supply chain, including aquaculture production.

Traceability can use either paper or electronic systems, although most are a mixture of the two (Table 4). Paper traceability systems are widespread and have been used for a long time throughout the supply chain. This is a good solution if the number of products is limited. It is cheap and changes can be easily made. However if the number of records becomes too large, it is time consuming, especially to retrieve records, and requires large storage space.

Electronic traceability uses either the bar code systems or the more recent radio frequency identification (RFID) systems. Bar code systems have been in use since the 1970s and are well established in the food industry. RFID technology uses tags that send identification codes electronically to a receiver when passing through a reading area. The tags do not have to be in line-of-sight, and many tags can be read simultaneously. This makes it possible to scan a whole pallet in seconds while passing through a reading area. However, RFID technology is more expensive and is thus a less widely used technology.

One advantage of electronic traceability systems is their ability to handle large amounts of data in a precise manner. For example, records and reports regarding traceability can be adapted to a specific situation, such as a recall of a specific lot.

In summary, traceability systems can be applied to ensure food safety, but also quality or other credence attributes that consumers cannot detect (e.g. organic fish, fair trade). Regardless of whether they are voluntary or mandatory, traceability systems can improve food supply chain management, safety and quality control and minimize the cost of product recalls and withdrawals. Traceability is however not the only means to these objectives, and it alone cannot achieve any of them. Simply knowing where a product is or has been in the supply chain does not improve supply management or

[5] "Guidance on the implementation of specific articles of Regulation (EC) No 178/ 2002 on General Food Law".

TABLE 4
Comparison of traceability systems

	Paper traceability	Electronic traceability
Advantages	• Based on existing quality assurance/stock control documentation systems. • Inexpensive to implement • Flexible in terms of the processing systems to which it can be applied • Data input is easy and precise	• Data input can be automatic • Easy to link additional information (e.g. temperature) • Real time availability of information • Reports and records can be prepared quickly and adapted to the situation • Easy transmission of information to other links in the supply chain
Disadvantages	• Manually intensive • Rely on correct procedures and operations • Trace back information time consuming • Records are not easy to review	• Expensive equipment • Paper bar code easily damaged in harsh and moist environments • RFID technology not yet widely used

safety/quality unless it is well paired with a good delivery system and/or with a safety quality assurance programme.

Noticeable developments in food logistics supported by more refined traceability systems have appeared in the recent decade. Today these are seen as an integral component of the global food distribution system, leading to efficiencies and thus lower prices. These improvements in the food and fish supply chains are also apparent in many cities of developing countries, which has contributed to the expansion of the international fish market during the last decades.

CONCLUSIONS

The globalization and further liberalization of world fish trade, while offering many benefits and opportunities, also presents new safety and quality challenges. The influence of civil society and consumer pressure on producers, processors, retailers and governments to improve management is increasing. Thus, in addition to safety and quality, other issues of global concern such as environmental protection and social requirements are increasingly likely to govern market access and market entry.

The growing influence of wholesale, retail and restaurant chains that control fish markets seems to indicate a trend for increasing use of market standards and certification schemes. However, the extent and implications of this influence and increase for fish trade governance are not known and need to be studied, taking into consideration regional specificities. Should market standards become important measures for fish trade governance, it is imperative to develop an international plan of action to ensure transparency, science-based criteria, harmonization and equivalence, and technical assistance to developing countries and to small-scale producers to ensure coherence with WTO trade measures. *The Guidelines for Responsible Fish Trade* and the *Guidelines for Certification in Aquaculture* currently in development by FAO should take these issues into consideration.

Fish safety and quality assurance in the new millennium will require enhanced levels of international cooperation in promoting harmonization, equivalence schemes and standards-setting mechanisms based on science. The SPS/TBT agreements of the WTO and the benchmarking role of the Codex provide an international platform in this respect.

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Melanie Siggs joined the Seafood Choices Alliance in 2006 to work on development of the programme in Europe, where they are working across suppliers, retailers, processors and non-governmental organizations (NGOs) finding solutions for a sustainable fish industry. Her background lies entirely in the corporate sector, predominantly working in natural resource businesses such as agriculture, food, waste and forestry, most recently with one of the world's largest forest products groups, Finnish conglomerate UPM-Kymmene. Melanie has a breadth of professional experience in strategic positioning, corporate affairs, reputation and brand, as well as a personal passion for responsible business, a subject in which she holds a Masters degree.

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Consumer assurance: market-based quality schemes, certification, organic labels, ecolabelling, retailer specifications

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ABSTRACT

In response to a strong call for responsibly supplied fish, the European marketplace now has a number of ecolabels, some globally recognized and others specific to the retailer or country. This paper gives an overview of the current labels being applied to European fish and fish products, explores their efficacy and necessity, and considers what the label "market" might look like in the future. The majority of these labels apply to wild-caught fish. What labels are being applied to farmed fish? How meaningful are they? Furthermore, the author has sought input from a cross section of leading European retailers and processors on what their requirements are, and their "top tip" for suppliers of farmed fish in the future. The challenges for suppliers to the European market are considered, and the catalyst, strength and authenticity of the sustainable fisheries movement in the European industry are addressed. Most activity has centered on wild-caught, fresh fish, but there is increasing energy now questioning the farmed sector. What is driving this and what might it mean in the future? Finding ways to match responsible (economically, socially, environmentally and ethically sustainable), traceable production with high quality and good value are the demands of the European industry – but are the requirements and the commitment enough to enable the management, investment and possible change that might be necessary?

INTRODUCTION

Before this paper begins, a proposal of terminology is made: it is proposed that these labels, as referred to in the title of the paper, be collectively referred to as "Assurance Labels", which seems to succinctly capture the essence of what they all do. The presentation that preceded this paper was made in Qingdao on 29 May 2007 and sought to give an overview of the following, with contributions made by a number of leading European retailers and processors:

[1] The Seafood Choices Alliance is a global association working on the issues surrounding ocean-friendly seafood. Founded in the United States in 2001, the Alliance works across the seafood industry – from fishermen and fish farmers to distributors, wholesalers, retailers and restaurants – to help create an environmentally and economically sustainable marketplace. The Alliance would like to thank a network of retailers and processors in the United Kingdom and France who contributed to this paper. Farmed fish are an inevitable part of the fisheries portfolio of the future. The industry can offer economic hope to developing countries while making an important contribution towards helping preserve wild stocks and feed a growing global population. Working together we can do it right.

- the label, certification and assurance scheme status in Europe;
- what is expected of an aquaculture label in Europe; and
- is sustainability important in the European market, and why?

THE LABEL, CERTIFICATION AND ASSURANCE SCHEME STATUS IN EUROPE

In Europe, we are privileged to enjoy an extraordinary range of choice of foods, at all levels, from fresh produce to ready-made chilled meals for busy people. As such, for fish buyers and other food buyers across Europe, it is no longer sufficient to supply a diverse range of foods 52 weeks of the year. Ethical pressure and the need to add value and integrity have created a market that increasingly demands to know where that food has come from and how it was produced – the industry is beginning to take responsibility for its choices.

We no longer want value for money, but values for money.

Professor Tim Lang, City University, 2007

The onus of that responsibility is important. Consumers, overwhelmed by information, short on time and wanting to rid themselves of difficult decisions and guilt simultaneously, are tending to shift their responsibility to the retailers where they shop. Given the immense buying and political power of these retailers, this may not be inappropriate, but they cannot take the responsibility alone; it must be shared throughout the supply chain. The retailers are now expected to take front-line responsibility for ensuring that food is not only of high quality and appropriate value, but also ethically produced, has had minimum negative environmental impact and is "fair" to the producer. In return, it is considered that such measures will lead to sustainable business for all; that is economically, environmentally, ethically and socially.

Assurance labels take away a lot of the work and risk for buyers. Credible, robust certification is a Godsend, and where it does not exist, retailers – and other outlets – are actively seeking it. Evidence of this can be seen by the massive – indeed catalytic – statement by Wal-mart, the world's biggest food retailer, that within five years of their announcement, all of their wild-caught fish will come only from Marine Stewardship Council (MSC) certified sources. And such pledges have been made, in different forms, by most of the major retailers – and as such through the supply chains – and now are beginning to be adopted by the food service sector. Commitment to the delisting of so called "red listed" fish – those deemed as the most "at risk" – has been almost universally carried out. We see more MSC and more organic fish coming to market, and a high level of energy at all levels, retailer to scientist, to better understand the state of our seas.

According to the Food and Agriculture Organization of the United Nations (FAO), farmed fish now makes up some 43 percent of the fish supply to meet consumers' growing appetite, while there is much debate over the dwindling wild stocks, as well as the environmental impacts of fishing methods and the wider impacts on crucial ecosystems. So is farmed fish the panacea that can save the wild fish, meet consumer demand and – as some 98 percent of farmed fish comes from developing countries – shift monies into poorer economies? Maybe, if appropriately raised and supplied – and therein lies the difficulty; defining "appropriately". In truth, assurance schemes serve to aid both buyer and supplier by clearly laying out the requirements – assuring one, creating clear goalposts for the other and helping develop confident access to market. In this paper, we will look at what some of the existing schemes look like, explore what the buyers and nongovernmental organizations (NGOs) expect from an aquaculture assurance label and outline some of the work in progress.

We have alluded here to the benefit of a credible assurance label to the buyer, in terms of establishing a product's provenance and appropriateness, but there is another

side to this coin – the buyer's company's brand and reputation are at risk if the fish (or other product) is not appropriately sourced.

Selling appropriately sourced food is a deal breaker in protecting and enhancing a company's brand and reputation. Economists say that a company can recover quickly from a financial faux pas, but it takes much longer, if ever, to recover from a reputational faux pas. In George Williams' paper (this volume), he touches on this for his company, Darden, in the food service sector. George aims to put a dollar value on the company's reputation, i.e. to identify in terms of economic risk, the value of the company's brand and reputation – and in this example this is a one-off figure, whereas the impact of any reputational error will be longer lasting than a momentary dip in financial value and is unlikely to take into account the investment to have achieved said reputation.

So robust, credible assurance labelling can significantly help a company on its road to responsible business, thus meeting its own ethical values while helping to safeguard reputation, but one of the big challenges of labelling is working out who you are trying to talk to and what you are trying to say. What is the audience's interest?

To date it has proved impossible to create criteria for a label that cover all possible aspects as robustly as specifically interested parties might want. For example, the MSC label does not address social responsibility or air miles criteria, although these are being considered. The label Freedom Food (operated by the Royal Society for the Prevention of Cruelty to Animals (RSPCA)[2] in the United Kingdom) addresses only animal welfare issues, which, for some consumers, particularly in Northern Europe, is of paramount importance. Of course, that must de facto touch on other issues such as disease control, but the emphasis is on welfare, and the public knows that if they see a product with the Freedom Food label on it (it is currently on some salmon products), then the animal has been raised, handled and slaughtered in accordance with strict criteria that seek to ensure its well being. Their conscience is clear. What is also interesting to note here is the importance of the brand of the label itself. The RSPCA is a very well known brand in the United Kingdom where the Freedom Food label is seen, and has very high, unprompted recognition awareness at consumer level – this helps to add to its value from the retailer's perspective.

Other labels, such as the Soil Association logo, assure the customer that the product has been produced organically, i.e. within very strict environmental criteria, while the EureGap label is a business to business label, unseen by the consumer (all the others would likely be seen on the packaging at consumer level).

Box 1 gives the principle labels currently operating in Europe. It is not proposed to go through the criteria and purpose of each of these labels; such information is widely available, online, through FAO or via the bodies themselves. These labels cover wild-caught fish.

There are many, many more labels in use (see Box 2 and Table 1) – there are retailer-specific, country-specific and even region-specific labels all in use at the current time. Of course, their credibility and acceptance – and target audience – varies greatly, and only

TABLE 1
Number of products, by label, by country (March 2007)

Countries	Number of products[1]
Switzerland	69 MSC
Sweden	44 MSC + 2 KRAV
France	13 MSC
United Kingdom	87 MSC
United States of America	93 MSC + 7 Ecofish
Japan	14 MSC
Germany	63 MSC
Spain	2 MSC
Italy	25 FOS, 3 MSC

1 MSC – Marine Stewardship Council, FOS – Friends of the Sea

[2] The seventh most valuable charity brand in the United Kingdom. The RSPCA has probably been one of the most loved charities in the United Kingdom since its establishment in 1824. Someone calls the RSPCA every 25 seconds for help about preventing cruelty to animals, and it successfully rehomes nearly 7 000 animals each year through its network of 174 branches. This substantial support increases the RSPCA's relevance to the public and helps drive its brand value of £ 94 million.

BOX 1

Types of labels

Business to Business

- Compliance, regulation; reassuring buyers of a minimum standard of governance

Business to Consumers

- May look at specific set of criteria such as animal welfare, or be a regional quality/ provenance label

Certification

- Tends to go beyond compliance, a continuous improvement process, pushing the industry standards across environmental impacts and other criteria such as animal welfare, ecosystems, social responsibility

BOX 2

Principal labels currently operating in Europe

- Marine Stewardship Council (MSC)
- Earth Island 'Dolphin-safe' International Dolphin Conservation Programme
- Friends of the Sea
- Krav (Sweden)
- Naturland

those that have 3rd part certification processes that are fully transparent, with true stakeholder engagement, that meet the FAO guidelines and that challenge themselves with continuous improvement programmes are seen as credible and robust enough to be fully accepted by the buyers, processors and NGOs across the industry.

The most widely used of these labels is that of the Marine Stewardship Council (MSC). The "Dolphin Friendly" labels that are widely seen on tuna products (some 300) are also prolific – again an example of a label that addresses a very specific area of interest but doesn't touch on other emotive issues such as stocks, wider environmental impacts or other by-catch species.

Friends of the Sea are based in Italy, which may account for some of their success there, but the label has its critics, predominantly due to its lack of 3rd part certification, stakeholder engagement and a perceived lower standard of certification. The NGOs have not given it their support, and we may well see action by them that will challenge this label's credibility.

MSC has the most successful certification label – because it meets all the afore-mentioned criteria. The scheme is not without fault, and the MSC acknowledge mistakes made during their formative years – faults that lessons may be learnt from for the development of future certification schemes. Their process and development make the label compelling, and the more stakeholders are engaged with them, the more it can be challenged to be the ongoing scheme it needs to be for the future; continuous improvement applies to assurance labelling as well as fisheries! Additionally, as the number of products grows and consumer awareness increases, recognition of the MSC logo at a point of purchase increases. That said, it still comes under criticism on two particular counts: a relatively narrow field of criteria and cost. Regularly held up as a "gold standard" and adopted by many of the leading businesses as the label of choice, its status and cost have been seen by some as a barrier. However, MSC is working on a number of ways to make its certification more accessible, while recognizing fisheries in the process of achieving certification.

The lower numbers of products in Spain and France (Table 1) mark two countries where the sustainability has yet to really take a broad hold on the food industry agenda.

The MSC is an example of a certification scheme achieving a good level of international success, but MSC does not have a certification scheme for aquaculture and has publicly announced that it will not be developing one in the foreseeable future. They intend to focus their efforts only on wild-caught fish. So who is going to certify farmed fish to this level of integrity?

ORGANIC LABELLING

According to Datamonitor, sales of organic food in the United Kingdom are rising by some 30 percent a year. The popularity of organic produce is high across Europe, and this is now extending to fish and fish products.

As regards organic aquaculture, there are currently no harmonized regulations at an international level. Certification is carried out mainly based on regulations developed by national or private bodies. Some countries have well-defined, largely accepted organic schemes, such as the United Kingdom's Soil Association, which first recognized farmed fish in 2006. According to FAO, there are currently some 25 organic aquaculture certification bodies. The principle organic certifiers in Europe (see Table 2) are

- Naturland,
- Krav,
- Soil Association, United Kingdom, and
- Bioland

A major issue in the development of harmonized organic aquaculture standards at a European level is the fact that, within the European Commission (EC) organic

TABLE 2
Principle organic certifiers in Europe

Country/certifier	Current product
Naturland, Germany	Shrimp, carp, trout, blue mussel, salmon
Krav, Sweden	Salmon, rainbow trout, brown trout, arctic char, fish from the perch family, blue mussel
Soil Association, United Kingdom	Shrimp, salmon, trout, cod
French Ministry of Agriculture	Trout, salmon, seabass, seabream

production is the responsibility of the Directorate General (DG) Agriculture while aquaculture is the responsibility of the DG Fisheries. Currently, the EU regulations on organic agriculture are undergoing a review, and DG Agriculture is discussing a new Action Plan. The EC is committed to include regulations on organic aquaculture in the revised edition of European organic standards. This commitment has already been approved by the European Parliament and the Council of the EU.

Such confusion at a European level has not prevented the development of products carrying organic labels certified at a national level, but there is controversy over them – particularly relating to feed; should it be organic feed or, in the case of fishmeal, how can it be proven to be from sustainable stocks?

Typical organic standard criteria address:

- sites regularly replenished with pollution-free water;
- fish of natural origin and selection (absolutely no genetically modified organisms (GMOs) or hormonal treatment);
- feed based on controlled meals, oils and so on (no GMOs);
- limited and monitored treatment with medicines (preference for natural remedies);
- low breeding/stocking density;
- longer rearing periods; and
- continuous monitoring of environmental impacts.

WHAT IS EXPECTED OF AN AQUACULTURE LABEL IN EUROPE?

The objective of a good assurance label might therefore be summarized as:

- to provide reassurance of origin through robust traceability; and
- to reassure that appropriate management is in place to minimize negative impact and maximize positive impact, in turn helping to enable responsible practice through the supply chain, protect brand and reputation, and ensure sustainable businesses, throughout the supply chain, for the future.

Beyond this, a credible assurance body does not "stand still" but continually seeks to improve its own operations to ensure positive change through its label and to work to promote its own brand. A good label can build a business case across the three pillars of sustainability; it should help provide:

- an *economic case:* by providing buyers with confidence, and consumers with a clear conscience, i.e. labelling can provide improved access to markets while creating economic advantage at a production level. For example, lower stocking rates often mean less disease, while an emphasis on humane slaughtering, which lessens stress in the animal, has been shown to provide a better quality end product.
- an *environmental case*: seeking to minimize negative impacts, whether through improved siting of ponds or cages, better management of waste, minimizing escapes, limiting the use of chemicals and antibiotics or strict guidelines as to the source of feed stuffs. Appropriate environmental management can help both to protect the immediate environment of the farm and the wider impacts and importantly, help safeguard a long-term future for a robust, viable and "fair" business; and
- a *social case*: social responsibility initiatives have been drilling into the food agenda and take an increasingly greater role in consumer awareness and in generating

concern for the people involved in producing our food. The most visible response in Europe has probably been the enormous growth of the official FAIRTRADE label, now seen across some 20 different commodity products and now being seen on value-added foods as well.

FAIRTRADE certification focuses on people and community welfare, fair prices, working conditions, reinvestment and stakeholder involvement – it concentrates on the social and economic case, but also has significant environmental requirements. Coffee, tea and fruit are predominantly where FAIRTRADE labels are seen, but there is work afoot to consider its possibilities in fish and fish products.

The approval of the NGOs in Europe, and in particular in the United Kingdom (which acts as something of a trendsetter across the European retail scene) is essential for the success of any assurance label seeking credibility beyond the regional level. The environmental campaigning NGOs are strategically powerful, laying the challenge for change. They often take direct "peaceful" action, such as displaying tables of by-catch for the public to see in Central London or hanging banners "UNITED KINGDOM'S WORST FISH RETAILER" over an outlet. They also use "naming and shaming" techniques, and it is within this category that one of the most successful tools to create change has been seen in the Greenpeace League Table. The table ranks retailers according to their fish procurement policy and species sold (Figure1 and Table 3). There are now two such league tables produced by different NGOs, and while some retailers are committed to remaining at the top, others have simply sought hard to move away from the bottom. The effect is the same – all retailers took action and continue to do so. Many of these retailers and processors now work in close partnership with one or more of the NGOs (typically the Marine Conservation Society, the World Wide Fund for Nature (WWF), the North Sea Foundation and Greenpeace). The retailers are ranked according to the rating given to their buying policies and codes of practice:

- all retailers now have a responsible fish sourcing policy;
- most processors now have a responsible fish sourcing policy; or
- most companies with a responsible fish sourcing policy engage in multi-stakeholder engagement across the supply chains

FIGURE 1
Example of a table ranking retailers according to their fish procurement policy and species sold

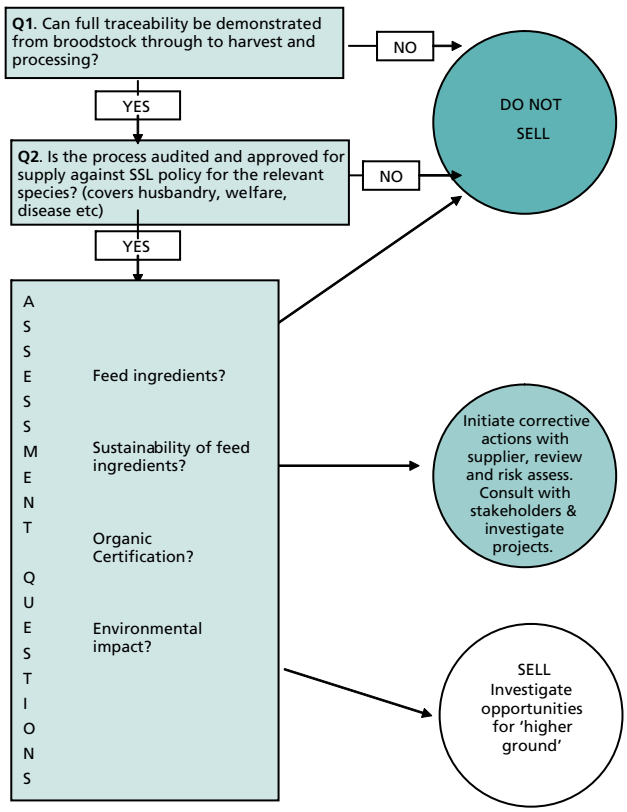
TABLE 3
Ranking of retailers in League Table, 2006 and 2007

Supermarket name	Position in League Table 2006	Position in League Table 2007
M&S	1	1
Waitrose	2	1
Sainsbury's	3	4
Tesco	4	3
Co-Op	5	7
Morrisons	6	6
ASDA	7	5
Somerfield	8	–, No response
Iceland	9	8
Lidl	10, No response	–, Not Contacted
Booths	–, Not contacted	–, No response

CASE STUDY – SAINSBURY'S

Sainsburys are the second biggest retailer in the United Kingdom, with an annual turnover of around £ 17 billion and employing over 150 000 people. Sainsburys currently have around 20 percent market share of the United Kingdom's

FIGURE 2
Confidential farmed species SSL purchasing decision tree



fresh fish market (value and volume) second to Tesco.[3]

Part One – Creating a Procurement Process[4]

The decision tree (Figure 2)

"The decision trees were developed in collaboration with our key suppliers, covering both the farmed and wild caught sectors. The process took several meetings as we wanted to ensure that the final wording for each of the questions were as clear as possible, and not subject to ambiguity. We also needed to make sure that the decision trees just covered the process relating to either farming or wild caught fish, and that we didn't confuse the issue by overlaying some of the social responsibility concerns as these are covered by other policy requirements

As well as ensuring we covered all the technical aspects of the process (whether farmed or wild caught), we also needed to consider the customer perception relating to each of the issues raised by the questions. We also tried to ensure that the flow was logical, not just with regards the process, but also to the relative importance of the issues (hence there are several questions on feed within the farmed decision tree as the specific issues raised by each of the questions questions had different relative importance, either to us, our customers or NGOs)

Once we had agreed on the format and final wording for the questions, we then asked for external review by some of the NGOs to ensure that we hadn't 'missed' any areas that maybe we should have considered."

Alyson Anderson, Technical Manager, Fisheries, Sainsburys (part of the Wal-mart group of companies)

Taking policy to the next level, we can explore some of the specific criteria that will be needed to be included in a successful global label for aquaculture – that can meet the objectives, the procurement policies and fulfill the ethical drive of these major buyers. The following is a list of the key requirements that the retailers, processors and NGOs, are looking for in an assurance scheme for farmed fish. Amalgamated from different sources it is unlikely to be exhaustive, but might be what a final scheme is likely to contain, as a minimum:

- operating in an environmentally and socially responsible manner, including

[3] Source: TNS.

[4] Information about polices of some other retailers and processors in Europe can be found via the following Weblinks: http://www.lyons-seafoods.com/environmental.htm; http://www.youngsseafood.co.uk/youngs/corporate_responsibility.asp; http://www.marksandspencer.com/gp/node/n/46526031/202-0623220-7695843?ie=UTF8&mnSBrand=core; http://www.waitrose.com/food_drink/foodexpertise/meatandpoultryatwaitrose/fishatwaitrose.asp#where; http://www.carrefour.com/cdc/responsible-commerce/our-commitment-to-the-environment/responsible-sourcing/sourcing.html; http://asdacares.gpalm.co.uk/environment/environment_load.html

addressing environmental impact from farm site and management;
- complying with legal restrictions on farm size, discharges, environmental monitoring etc;
- escapes prevention management;
- food safety controls, i.e. veterinary medicines, pigments, feed safety, contaminants;
- positive welfare, including handling, stocking densities and slaughter practices;
- ethical farming – no GMOs, feed sustainability; and
- working/social standards of employees.

As you read this, you cannot help but notice the enormity of the scope of these "headings". It is possible that at least two tandem and complimentary schemes might be needed. One might be a minimal compliance or governance level – still demanding, still robust and still being continually challenged to improve, but perhaps more readily achievable and likely to be taken up by a high percentage of suppliers (indeed at such a level it could become a requirement of entry to market in some countries). The second would go beyond compliance and be that which challenges the former to progress. Those certified to the second level might expect to supply the premium product; or it may be that there is a recognized interim level for those working to move towards Level 2 from Level 1. Buyers need to have suppliers whose business is underpinned by integrity and who are committed to improvement. The frame of such labels might look something like that shown in Table 4.

For the hypothetical labelling system shown in Table 4, label 1 compliance is a level that all producers/suppliers might be required to reach to supply European markets. It could possibly be a business to business label and might supply standard product. Label 2 compliance is a level that might attract a "premium product" status, differentiates itself and is more likely to carry an identification at a consumer level. The additional role of label 2 is also to be the level (the category of supplier and buyer) that will continue to push the standards and push for ongoing improvement in the industry. As the standard is raised so is the compliance level, thus ensuring the cycle of continuous improvement. Within such a system there might also be a process of acknowledging those who are committed and demonstrating a shift from Level 1 to Level 2. Organic status would be likely to sit with a different certification body.

TABLE 4
Hypothetical framework for labelling

For basic compliance (level 1)	Beyond basic compliance/ organic standards (level 2)
Environmental impact controls	
• Permits for capacity/chemical use to control pollution	• Site selected against special criteria
• Escape prevention by risk-assessed cage design and net testing	• Detailed annual benthic biodiversity survey
• Disease control by permissible vaccines and lice control, in conjunction with preventative measures	• Restricted chemical use
	• Require strategic lice control agreements
Welfare	
• Stocking densities defined	• Low stocking densities
• Set maximum feed withdrawal period	• Short feed withdrawal
• Handling and slaughter methods specified	• Specific pumping and stunning methods of slaughter
Food safety/health benefits	
• Veterinary medicines and chemicals control by prescription	• Restricted list of antibiotics/chemicals
• Feed legal for contaminants/pigments	• Specify feed pigments and select, for example, high omega-3 and low PCB/dioxin oils
Ethical farming	
• No GMO seafood grown	• Feed fish from sustainable fisheries/sources
• Key working conditions (facilities, minimum wages, hours)	• Social responsibility audits; working conditions, stakeholder engagement, community benefit
• Feed-sourcing guidelines	
• Approved management plan, including "continuous improvement mechanism"	

Running across all of these categories, within both labels, must sit the process operating principles of schemes that are traceable, 3rd party audited, transparent and have full stakeholder engagement – essential for credibility and acceptance.

One of the challenges to certification not yet touched on here is global harmonization; particularly mutual recognition of different country's schemes, which could be key to ensuring better access to certification for small farmers. The Forest Stewardship Council has somewhat successfully tackled this issue, as their global standards transcend into mutually recognized certification at national and even regional (to pick up small woodlands) levels. They would admit that there is more work to continue to improve this, but their model could help demonstrate how an aquaculture label in development could take advantage of its start up to embrace empowerment at a local level – without, of course, lowering standards.

ORGANIZATIONS WORKING ON AQUACULTURE CERTIFICATION

Organizations that have international aquaculture labels currently are the Global Aquaculture Alliance (GAA) and EurepGap.

EurepGAP[5] is a private-sector body that sets voluntary standards for certification. It started in 1997 as an initiative by retailers. It is a business-to-business label and is not directly visible for the consumers. They have developed harmonized standards of good agricultural practices (GAP), and existing assurance schemes that have completed a benchmarking process are recognized as equivalent to EurepGAP. In aquaculture, they have a standard for salmon and are developing standards for shrimp and several white fish. The shrimp standard is the first to include social standards (i.e. working standards – functional rather than "well being"). EurepGAP is designed to be an equal partnership of stakeholders. All committees have 50 percent retailer and 50 percent producer/supplier representation. It is one of the very few globally operating standardization organizations that enjoys a high level of political acumen, and farmers or farmer groups can only be certified against the EurepGAP criteria by authorized certification bodies, to ensure financial independence.

The Global Aquaculture Alliance (GAA)[6] (Box 3) is a United States based group and, as part of a suite of tools for the industry, provides the only internationally recognized aquaculture certification label at the current time. As such it is used by buyers, and indeed Wal-mart has embraced it for their farmed-fish products. Lyons Seafood, the United Kingdom's biggest importer of shrimp, and other European companies do use it as a Best Practice label, but for buyers generally and for the NGOs, it doesn't go far enough. Could it be developed into the label and brand that stakeholders seem to feel is needed? Probably – indeed it's not so far from that place now, but it will need to reach a place of positive dialogue with the NGOs and, as it stands, is unlikely to provide the leading certification scheme that is required by European buyers.

The brand of the label itself can be important. Consumer recognition is very useful (MSC, FAIRTRADE; labels with high consumer awareness) to buyers and adds value to the certification.

There are also other initiatives, such as the International Principles for Responsible Shrimp Farming 2006, as developed by the Consortium on Shrimp Farming and the Environment (Food and Agriculture Organization of the United Nations (FAO), Network of Aquaculture Centres in Asia-Pacific (NACA), United Nations Environment Programme (UNEP)/GPA, the World Bank and World Wide Fund for Nature (WWF)), but this is not a label or certification scheme. However, such frames

[5] http://www.eurepgap.org/Languages/English/index_html
[6] http://www.gaalliance.org/

BOX 3
The Global Aquaculture Alliance

The Global Aquaculture Alliance has developed practices for responsible aquaculture products starting with marine shrimp. These practices are called Best Aquaculture Practices (BAP) and for shrimp cover the four areas of production, processing, hatcheries and feed production. The BAP standards for shrimp were developed with input from all stakeholders, to include members of the NGO communities and have been endorsed primarily by United States based retail and food service operators.

BAP standards require independent certification by qualified certifiers – in this case, that certifying organization is the Aquaculture Certification Council (ACC). While buyers may want to endorse the standards, suppliers must pass the initial certification examinations and be recertified on an annual basis to assure compliance with BAP. Only then can products carry the certification mark of BAP.

GAA recognizes the following:

1) The importance of sustained involvement of all stakeholders of aquaculture products in the process of standards development and the improvement of those standards over time.
2) The need to broaden the number of BAP aquaculture species to meet the assurance needs of retailers and food service operators. To that end, draft standards for salmon, tilapia, catfish and *Pangasius* will now proceed thought the transparent process of final development so that those species might also be eligible for certification.
3) The realities that aquaculture production in many countries is conducted by a very large number of small farmers. Standards for aquaculture products need to accommodate all producers in what is still a developing industry in developing countries.

Source: Wally Stevens, Global Aquaculture Alliance

can undoubtedly feed into the development of an appropriate international assurance scheme.

There are few stakeholders in the European industry that would advocate the development of more ecolabels or certification processes, which can be confusing and weaken existing schemes. However, slow development, non-acceptance across borders and differing areas of interest or priorities mean that there are already many labels – international, national, regional, area specific, broad ranging and product specific – both in use and in development. This can be confusing both for buyers and consumers. If something can be developed on aquaculture that meets the criteria of demanding North American and European buyers and consumers, has international recognition and ideally, that allows national schemes to feed in to it (like the FSC forest certification scheme mentioned earlier), and possibly even allows other standards to feed in (i.e. ISO standards), then the result may be something extremely useful and appropriate at all levels, without adding to the confusion or reinventing some wheels which already exist, that allows access to market and helps develop a sustainable industry on a global basis. Working with one of the organizations already active in this area that has some traction and a brand in place may be a route to more rapid success, and EurepGap and GAA, or a turnaround of decision by MSC, all offer opportunity for this.

European Commission activity

Aquaculture in Europe grew rapidly over the past 10 years, but that growth has recently stagnated. The EU recognizes the economic opportunity of farmed fish and wants to

address how to develop the business further. As part of this development, the Commission is in stakeholder consultation.[7] It is highly likely that the need for a robust label, as discussed, will come through these consultations, and the EU will add its weight to developing such a scheme. However, that's a great weight that takes a considerable time to move!

It is worth emphasizing that the EU is a union of countries with very different views, cultures and heritage, and not without some internal competition. As very obvious as that sounds, we are always a little guilty of referring to the EU as though it behaves as one united entity, but the truth is there is considerable diversity across the European countries, which means that agreeing upon standards and principles can often be a very lengthy process; at an individual level, each country has its own views and behaviour. For example, in France – with a few notable exceptions such as Carrefour and Findus who are very active in the sustainability arena – the market tends to be more interested in French-produced/local produce, has an emphasis on quality rather than provenance, and prefers French-based initiatives (labels) over international ones.

World Wide Fund for Nature (WWF)

WWF has been actively and strategically working across stakeholders on the development of standards for the industry. They recognize the possibilities for farmed fish to both take the pressure off wild-caught stocks and to feed a growing global population. However, as Dr Jason Clay (Vice President, Global Solutions, WWF) puts it, it will only help if its done right.[8] WWF firstly set about researching and studying the industry and its potential – key species and key impacts. They then formed "dialogue groups" to address each of these impacts – what standards are realistic and achievable, and can industry work with them while still protecting the outcomes. All activity has impacts, but how best to minimize those negative impacts? Those dialogues continue, and it is thought that some outcomes should be seen in 2008. That said, the dialogue, the outcomes and the action all need a "home", and WWF is also exploring the options for where the standards might sit.

EurepGAP

Using their Good Agricultural Practice Business to Business certification schemes as a model, EurepGap has already established governance-style standards in the aquaculture arena and is keen to continue, not least because their members are key European buyers. EurepGap is currently certifying salmon and developing GAP standards for shrimp and some white fish.

There is also action at a country level and at a retail level, keen to safeguard their own products and to put an appropriate label on their produce for consumer reassurance. In reality, a myriad of labels is unlikely to be a positive move, as it generally leads to confusion and "weakens" the impact of the offering certification makes. We are seeing farmed product come through with other labels, for example, welfare and organic.

IS SUSTAINABILITY IMPORTANT IN THE EUROPEAN MARKET, AND WHY?

Should we ask ourselves if this strong move towards responsible business is here to stay? Do we need to develop these frames that help us to work within a more

[7] For details on these consultations see the following Web sites: http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=CertifAqua; http://ec.europa.eu/fisheries/cfp/governance/consultations/consultation_240407_en.htm

[8] Dr Clay's presentation, which includes a table on the impacts and their relative importance, entitled "Strategies for Sustainable Aquaculture", given in Norway September 2006 can be found at: www.aquavision.org/files/Jason%20Clay%20AquaVision%202006.pdf

responsible arena, that allow transparency and demonstrate sustainable practice, or is it a passing fad which will go away if we keep our head down long enough? None of us can accurately predict the future, but what we can be sure of is that we cannot take away that which is done. Business, not fisheries or food-specific business, has made mistakes and has been held accountable for its behaviour, and the western consumer has had her eyes opened to the world of responsibility. Knowingly or otherwise, there is an under current of need to understand where things come from and if they were produced responsibly. It certainly feels as if, not only is it here to stay, but that the level of awareness, the demands for accountability and the scope for delivery of information are probably a long way from even peaking. Many businesses are responding very robustly, and an example of that is Marks & Spencers in the United Kingdom (Box 4). As an own-brand operation, this means that Marks & Spencer's pledge will extend to over 2 000 factories, 10 000 farms and 250 000 workers, as well as millions of customers visiting over 500 stores in the United Kingdom.

In the United States, the ongoing public commitment of the world's largest retailer continues to make headline press, and thus challenge other businesses and raise consumer awareness. Wal-mart employs 1.8 million people worldwide through its 42 000 stores (Box 5).

So, it's not just about fish, but looking specifically at consumer's attitudes to fish we learn from a survey carried out by Seafood Choices Alliance in 2005 that 80 percent of people are concerned about the oceans when asked, and 56 percent are very aware of over fishing; and from Tesco supermarket research, that Tesco focus groups confirm that more customers than ever before are concerned about environmental impact; and from the IGD that over 50 percent of consumers are buying at least one or two higher-welfare products a week.

BOX 4
Marks & Spencers' plan

Marks & Spencer has announced "Plan A", a business-wide £200 million "eco-plan" that will have an impact on every part of M&S' operations over the next five years. The 100-point plan means that by 2012 M&S will:

- become carbon neutral,
- send no waste to landfill,
- extend sustainable sourcing,
- set new standards in ethical trading, and
- help customers and employees live a healthier lifestyle

Source: http://www.marksandspencer.com

BOX 5
Wal-Mart CEO Lee Scott unveils "Sustainability 360"

On February 1, Wal-Mart President and CEO Lee Scott unveiled "Sustainability 360" – a company-wide emphasis on sustainability extending beyond Wal-Mart's direct environmental footprint to engage associates, suppliers, communities and customers. The announcement was made during Scott's keynote lecture at the Prince of Wales' Business and the Environment Programme in London.

"Sustainability 360 takes in our entire company – our customer base, our supplier base, our associates, the products on our shelves, the communities we serve," said Scott. "And we believe every business can look at sustainability in this way. In fact, in light of current environmental trends, we believe they will, and soon."

In an EU survey on the attitude of consumers towards the welfare of farmed animals conducted in 2005, results showed that consumers are:

- concerned about animal welfare,
- looking for welfare-friendly products,
- willing to pay more for them, and that
- 50 percent are very likely or quite likely to switch retail outlets if a higher-welfare alternative is not available. (YouGov, April 2006).

This focuses on the specific aspect of Animal Welfare, but it reflects the growing feeling, and perhaps more importantly, the promiscuity, of consumers. For companies

now, this is a business of ethics that affects their brand and reputation. It appears that the consumer increasingly wants the retailer to take the responsibility for their decisions – the purchasing decisions. He or she wants to know that if they shop at Retailer X, they can do so with a clear conscience and without having to make further consideration as they shop; they want to know and trust that retailer. Focus here has been excessively about retailers, as that's where the purchasing volume sits, but the food service sector (restaurants, public-sector catering, take away outlets, schools and universities) is also rising to the challenge, and let us not forget that the retailers cannot achieve this level of accountability without the full participation of the producers, importers, distributors and processors – traceability is key. The business of sustainability is here to stay, albeit that it will change and develop, and be adopted in different ways.

There are plenty of ethically led companies with responsibility running through their veins right now, and many who are playing catch up, but overall the business base has shifted and it can't go back, only forwards to new places. Everyone will have to be a part of that shift to survive. The questions are no longer what is sustainable business and is it on the agenda to stay, but: How far will industry be brave enough to go to balance the pillars of economic, environmental and social responsibility? How will it be done? And how will we manage the regional differences in such an internationally complex industry?

CONCLUSIONS

In conclusion this paper proposes the following headlines as the "take aways":

- There is huge potential for farmed fish, and if it's "done right" it can be a sustainable industry that can help alleviate pressure on wild stocks and feed a growing population.
- There is a need for an internationally recognized, transparent, 3rd party-certified, stakeholder-participative label; working to FAO guidelines as a minimum with a continuous improvement driver. It will need to:
  - be multistakeholder driven for credibility with buyers, NGOs and thus consumers;
  - be based on economic, environmental and social pillars; and
  - ensure traceability throughout the supply chain.
- It will be important in the protection of brand and reputation, but will need also to develop its own brand to add value to its offering.

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Aquatic animal health management in aquaculture

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ABSTRACT

Aquaculture has been practiced for over 3 000 years, the earliest record being from China, where common carp was kept. Since then aquaculture has developed in various places all over the world, from a basic practice to super-intensive culture. Market demand for seafood and aquatic animals is one of the factors boosting dramatic change in world aquaculture. Intensive aquaculture is becoming a common practice to achieve maximal production from a single crop. This practice introduces stress to the animals, which in turn causes health problems. Inevitably, chemicals and antimicrobial products are subsequently used to solve the problem, resulting in drug residues in the final products. To avoid these problems, the principles of aquatic animal health management should be applied as an intervention, including assuring good site selection, good water supply, appropriate feed, suitable stocking density, a closed aquaculture system and the use of vaccines. Moving live aquatic animals can also cause transboundary disease outbreaks such as white spot syndrome (WSS) and Taura syndrome (TS) in shrimp, epizootic ulcerative syndrome (EUS) in fish and koi herpes virus disease (KHVD) in common carp. Therefore, a proper programme of quarantine should be strongly applied to prevent this problem.

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Aquaculture development and environmental capacity: where are the limits?[1]

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ABSTRACT

Aquaculture relies on many renewable and nonrenewable resources similar to any other food-producing sector in the world. Sustainable development and management of aquaculture thus require a good understanding of the conflicts and interactions between the resource use and resource users. Such understanding contributes to improving governance in resource use, which is an important prerequisite of sector sustainability. Aquaculture is now considered as the "solution" for bridging the supply and demand gap of aquatic food globally. As aquaculture is highly complex, its impacts on the environment will continue to be discussed, debated and scrutinized by the public. While the environmental impacts of aquaculture cannot be generalized, it is important to recognize problems where they occur and ensure that they are redressed or ameliorated locally. Although the major environmental concerns of aquaculture still remain the same as compared to a decade ago, the sector has adopted technologies and various management solutions for mitigating them, including bringing the social environment into greater consideration. The awareness of the importance of better management is increasing. However, there exist many practical difficulties. Improving environmental management and maintaining aquaculture within the limits of the capacity of the environment will only be possible with sound sector management. If the sector is to perform well, resource use conflicts must be adequately managed and effective enabling policy and legal environment must be provided at all levels. The "enabling environment" for sustainable aquaculture must be a result of a comprehensive dialogue and consultation among all stakeholders, government and private, and self-empowerment and self-governance must be considered as viable options while creating it.

INTRODUCTION

Global production from aquaculture has grown substantially, contributing in ever more significant quantities to the world's supply of fish for human consumption. It

[1] This manuscript is based on recent FAO research and reviews on global aquaculture development trends and prospectus and also contains some excerpts from the FAO Fisheries Technical Paper No. 500 – *State of the world aquaculture 2006* (FAO 2007).

now accounts for nearly 50 percent of the world's food fish. This increasing trend is projected to continue in forthcoming decades with the vision that the sector will contribute more effectively to food security, poverty reduction and economic development by producing with minimal impact on the environment and maximal benefit to society, 83 million tonnes of aquatic food by 2030. Aquaculture is now perceived as having the greatest potential to meet this growing global demand for fish (FAO 2007) and will become increasingly important in, to quote a recent popular press story, "this last century of wild seafood"[2].

AQUACULTURE AND THE ENVIRONMENT

Aquaculture is a diverse sector spanning a range of aquatic environments spread across the world. It utilizes a variety of production systems and species. While the impact of aquaculture on the environment cannot be generalized, it is important to recognize problems where they occur and ensure that they are redressed or ameliorated. The environmental "footprint" of aquaculture will almost certainly have to be substantially reduced if it is to meet its potential as the major global source of aquatic products for the world's population. According to FAO (2007), identified cases of negative environmental and natural resources interactions that have been associated with aquaculture include:

- discharge of aquaculture effluent leading to degraded water quality (eutrophication, concern over red tides, low dissolved oxygen etc.) and accumulation of sediments rich in organic matter in farming areas;
- alteration or destruction of natural habitats and the related ecological consequences of conversion and changes in ecosystem functions;
- competition for the use of freshwater;
- competing demands with the livestock sector for the use of fish meal and fish oil for aquaculture diets;
- improper use of chemicals raising health and environmental concerns;
- introduction and transmission of aquatic animal diseases through poorly regulated translocations;
- impacts on wild fisheries resources through collection of wild seed and brood animals;
- effects on wildlife through methods used to control predation on cultured fish; and
- social issues related to the environmental impacts of aquaculture.

Over the past five years, considerable progress has been made in the environmental management of aquaculture, addressing many of these key concerns and improving the efficiency of farming systems. Public pressure as well as commercial or common sense has led the aquaculture sector to improve management, and increasingly it is recognized that aquaculture has many positive societal benefits when it is well planned and well managed. The interactions between the environment and aquaculture include:

- a more efficient use of energy and other natural resources as compared to many other forms of animal production;
- an alternative source of aquatic animal protein that can be less environmentally damaging than some fishing and over-fishing practices; and
- improvements in water and environmental quality through aquaculture farming systems and practices such as integrated farming, low-intensity herbivorous fish culture, seaweed and mollusc farming, and others.

During the past decade, global awareness and sensitivity to the environmental issues related to aquaculture have increased significantly. As a consequence, policy and regulation governing environmental sustainability have been put in place in many

[2] http://news.bbc.co.uk/2/hi/science/nature/6108414.stm.

countries requiring aquaculture producers to comply with more stringent environmental mitigation/protection measures. In some countries, these changes were even initiated by the aquaculture sector itself, usually within the more organized private industry sector to ensure its sustainability and protect operations from poorly managed activities. The private sector has made tremendous advances in the management of its activities, and there are many examples of better management of farming systems that have reduced environmental impacts and improved efficiency and profitability in all regions.

Major environmental concerns

The major concerns related to the negative bio-physical impacts of aquaculture on the environment are associated with wetland and other habitat utilization, abstraction of water, sediment loading into waterbodies, nutrient loading through effluent discharge and resulting eutrophication, groundwater contamination, exotic species introduction, wildlife and biodiversity, and social issues related to resource utilization and access. These will remain major concerns in the coming years, while new concerns will arise that are associated with the increasing interventions in open-ocean aquaculture. Some of the major challenges to open-ocean aquaculture are selection of appropriate species and culture techniques; high start-up costs, particularly due to the need to design and construct culture facilities that can withstand high-energy ocean environmental conditions; the need to obtain financial assistance due to the risk and uncertainty associated with operating under exposed ocean conditions; the need to stay competitive in global markets, the complexities in regulatory framework in permitting; and the lack of knowledge on potential environmental concerns owing to limited experience (Borgatti and Buck 2004).

Land and water resources

Water and land resources are clearly key factors in aquaculture development, and they are commonly used as the primary focus for resource use assessment. In the long term, the continued growth of aquaculture will be constrained by the availability of water and land. These two resources are already in short supply in many leading aquaculture-producing countries due to increasing population pressure and the demands of irrigated agriculture. In particular, information on freshwater resources, including their availability and use is becoming increasingly important given that the degraded state of water use in some areas has resulted in the emergence of regional water scarcities and has highlighted the need to improve water use efficiency. Moreover, aquaculture has to compete for water with other sectors such as irrigated agriculture and industrial and domestic consumption. Irrigated agriculture is currently the largest user of freshwater and will remain so in the future.

Approximately 95 percent of the world's tropical ecosystems and 70 percent of the coastal zone are found in developing countries (Sorenson 2002), some of which are leading aquaculture-producing countries. In the developing world, the population growth rate in coastal areas is significantly higher than in inland areas, and development demands will exert increasing pressure on the utilization of coastal habitats. Aquaculture, along with felling for charcoal and conversion to salt beds and agriculture, and overexploitation by coastal dwellers, has contributed to the destruction of coastal mangroves and associated wetland habitats. Globally the proportion of mangrove destruction attributable to aquaculture is not high, but it remains as a significant causative factor in some parts of the world (Primevera 2000). On the other hand, open-ocean aquaculture or offshore aquaculture, which is broadly defined as the rearing of marine organisms in exposed, high-energy ocean environments beyond significant coastal influence, will tend to increase.

Compared to low-cost fertilized systems, fed aquaculture systems generally make more efficient use of water and space, and thus the use of fishmeal and fish oil in fish

feed for noncarnivorous species groups will be increased. It was recently estimated that aquaculture is using 52.6 percent of world fishmeal supplies and 86.8 percent of world fish oil supplies (Tacon, Hasan and Subasinghe 2006). If aquaculture continues to grow at current rates, it is estimated that by 2010, 56 percent of the fishmeal and 85–98 percent of the fish oil produced will be utilized by the aquaculture sector (Scottish Executive 2002).

Fish meal and aquafeeds

Other concerns related to the negative impacts of aquaculture development are related to the sector's dependence on wild-based fisheries for feed and seed, the increased use of fishmeal, increased capture-based culture fisheries, and issues associated with energy efficiency, carbon utilization, the involvement of small-scale farmers and an over capacity in some coastal areas. Fish seed for stocking in aquaculture systems is either collected from the wild or produced in hatcheries, and may involve domestic sources or importation from other countries. Dependence on wild seed for fish aquaculture declined rapidly in many aquaculture-producing countries in Asia with the success of fish seed production through artificial breeding techniques and the establishment of hatcheries. Nevertheless, in some countries fish seed of several species that is collected from the wild still constitutes a significant share of the seed supply.

The demands placed by fed aquaculture on fishmeal may constrain its future development. As most fish oil and fishmeal is made from small, bony pelagic fishes such as anchovies, pilchards, mackerel, herring and blue whiting, and the aquaculture sector may continue to depend on marine capture fisheries for sourcing key dietary nutrient inputs. In fact, when viewed in wet fish weight equivalents, although only about 20.0 million tonnes or 40.9 percent of total global aquaculture production in 2002 was in the form of aquafeed-dependent finfish and crustacean species, this production was realized through the consumption of an equivalent weight of 21–22 million tonnes of marine pelagics on a wet weight basis (Tacon, Hasan and Subasinghe 2006).

The other concern related to fish feeds is the energy conversion from feed to flesh. Pimentel and Pimentel (2003) reported the average fossil energy input for all the animal protein production systems studied as 25 kcal of fossil energy input per one kcal of protein produced and this energy input is more than 11 times greater than that for grain protein production, which is about 2.2 kcal of fossil energy input per 1 kcal of plant protein produce. According to Goodland and Pimentel (2000), aquaculture (fish farming) is more feed and energy intensive (34 kcal of fossil energy input per 1 kcal of protein produced) than is broiler chicken production (4 kcal of fossil energy input per 1 kcal of protein produced). However, this figure is not representative of aquaculture as a whole, as a significant amount of aquaculture production comes from low-value herbivorous and omnivorous species. More research is needed on these aspects of aquaculture to better understand and develop energy efficient food production systems and to reduce reliance on wild feed sources.

Even though non-fed culture-based capture fisheries may help to maintain or enhance fish population abundance, community structure and ecosystem functioning, negative environmental impacts may arise from ecological and genetic interactions between enhanced and wild stocks. Over crowding appears to be another cause of environmental problems, particularly with shrimp culture in some coastal areas. Such rapid and concentrated development has led to the exceeding of environmental capacity.

Environmental gains and positive environmental impacts

Although they may be significant, the positive impacts that aquaculture has on the environment are not often realized or documented. Technological and managerial innovations such as reduced reliance on fishmeal via use of low pollution feeds, better

feed conversion ratios, lower stocking densities, vaccines, on-farm waste treatment to achieve better effluent control and efficient water use have helped reduce demands on the environment. Increasing recognition of the ecological benefits of mangroves and the use of innovative technological interventions of mixed aquaculture mangrove systems have helped to restore previously degraded mangrove habitats. Integrated rice-fish farming has prevented the use of agricultural pesticides in some areas, with wider environmental benefits. Farmed molluscs and seaweeds act as net removers of excess nutrients and are thus beneficial to coastal water quality. Molluscs are also efficient in bioaccumulation of heavy metals and pollutants and are useful bio-indicators. Aquaculture provides biological control of vectors that have medical importance. Aquaculture of some marine groupers and other coral reef-associated species is being promoted as a means of reducing pressure on wild stocks as well as enhancing populations of endangered coral reef fishes. Moreover, aquaculture provides an alternate and more reliable source of food.

MAJOR CHALLENGES

There are several major challenges that aquaculture development has to face. The ecosystem approach is currently a highly topical issue and is being widely discussed in the context of aquaculture development. The application of an ecosystem approach to the aquaculture sector should consider integration of ecosystem services that are required for aquaculture and optimization of resource use to minimize risks to the sector from ecosystem degradation. Better siting of future aquaculture should be done on a range of scales, both with respect to the receiving ecosystem and with respect to ecosystem services to cultured species. Aquaculture, particularly coastal aquaculture, needs to be used as a tool to rehabilitate degraded coastal habitats. The use of wild fish in the form of fishmeal to feed farmed fish is a direct pressure on fisheries resources. Therefore, to sustain the growing aquaculture industry's ability to contribute to world fish supply, net energy conversion must be improved, reliance on fishmeal in aquafeeds reduced and more ecologically sound management practices adopted.

Responding to market demand and gaining access to international markets will continue to be essential for aquaculture development. New markets have to be developed and the existing markets expanded. It seems that access to some markets can be enabled through development of certification systems for food safety and quality. Increased consumer awareness, pressure from nongovernmental organizations (NGOs) to ensure better health and safety standards, and stricter regulations at both the national and trading block level are leading to new aquaculture processes, and the shrimp and salmon farming subsectors, in particular, are responding to these concerns and market opportunities.

Initiatives are developing along the whole supply chain, from producer to consumer, to promote more responsible aquaculture. There is strong interest in a certified aquaculture product from a wide range of stakeholders. Aquaculture producers throughout the world are recognizing that certification programmes will help them gain a market advantage for a variety of products. Production and marketing based on environmental criteria with relevant certification schemes and labels will play a larger part in the future. Therefore, viable aquaculture certification programmes are timely, urgent and important. However, concerns remain about whether these initiatives can benefit poor, small-scale producers, and also that the proliferation of different schemes may lead to market confusion and added costs of compliance for producers. Providing non-commercially biased information and working with farmers to develop low impact production and alternate systems, combined with market development, can promote environmentally and socially responsible aquaculture. This will continue to require re-evaluation and further development of current practices and their integration into the coastal environment.

Many governments are strengthening their legal frameworks and policies for aquaculture. Often, however, comprehensive policies and associated legal frameworks have been overlooked because development has been seen mainly in technical terms and thus support has been largely focused on improving the technical aspects of production. The recent expansion of the aquaculture industry and the associated increased competition for resources have focused attention on the need for appropriate policy measures and regulatory frameworks to address environmental issues and concerns. Many countries have inadequate capacity to administer their responsibilities in a transparent manner to ensure environmental protection, aquatic animal health, and food quality and safety. Therefore, an enabling policy and regulatory framework for a sustainable aquaculture sector that clearly conveys the rules for the industry and allows the sector to position itself accordingly must be developed. Increasingly, the topic of self-regulation and/or governance is raised, particularly where the decentralization of authority is discussed. The delegation of "power" to farmers to self regulate can only be achieved through associations that are both authoritative and representative of the industry. The development of associative structures is essential not only to promote and develop aquaculture production but also to assist in achieving environmental sustainability. Therefore, organization of the production sector into farmer associations, clusters or self-help groups and empowering them will strengthen compliance with existing and future sector regulations.

CONCLUSIONS

As the aquaculture sector continues to grow in response to the global requirements for aquatic products, this growth continues to raise concern about environmental impacts and management of the sector. Various initiatives are being taken to improve environmental management from farm to policy levels and from country to international levels. While the environmental limits to growth are not known, these efforts will need to continue to be intensified if the industry is to grow within the increasing constraints being placed on the natural resource base upon which the aquaculture sector and the growing number of people on our planet heavily rely. This is a challenge for all of us involved in the aquaculture sector!

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Meeting the feed supply challenges of aquaculture

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ABSTRACT

There is no doubt that the long growth and sustainability of externally fed aquaculture species production (includes all cultured finfish, crustaceans, amphibians, reptiles, invertebrate animals and nonfilter-feeding molluscs; total production estimated at 35 million tonnes or over 55.6 percent of total aquaculture production in 2005) is totally dependent upon the continued availability and provision of feed inputs. It follows from the above that if the current average annual growth rate of fed aquaculture species production is to be sustained at its current rate of 8.9 percent per year (the fed aquaculture sector growing over 108-fold from 322 808 tonnes in 1950 to 35 035 006 tonnes in 2005), then the supply of external feed inputs will also have to grow at similar rates so as to meet demand. Nowhere is this supply more critical than in mainland China, where externally fed aquaculture species production has been growing at an average rate of 11.1 percent per year (growing over 331-fold from 65 961 tonnes in 1950 to 21 860 613 tonnes in 2005, and representing 62.4 percent of total global farmed fed-species production). Moreover, with the noticeable shift in Chinese aquaculture production and policy from just the mass production of traditional lower value, staple filter-feeding and herbivorous finfish species (destined mainly for domestic consumption as an affordable source of high-quality animal protein and essential nutrients) toward also the production of higher-value cash crop omnivorous/carnivorous finfish, crustacean, reptilian, invertebrate and molluscan species (destined for high-end domestic urban markets and/or for export), the sector has become increasing reliant upon imports to source key nutrient sources, including plant oilseed meals, fish meals and cereals. In particular, the paper highlights the current dependency of high-end Chinese fed aquaculture species production upon the use of trash fish for marine finfish/high-value aquaculture species and the use of imported fish meal, plant oilseed meals and corn, and the urgent need for the sector to move away from the increased use of potentially food-grade raw materials as feed inputs and to increase domestic self sufficiency in terms of nutrient supply. Particular emphasis is given to the increased use of high-quality feed-grade raw materials arising from the agriculture and seafood processing sector, including the use of rendered animal byproducts, agricultural plant byproducts, single cell proteins, marine seaweeds and cultured invertebrates.

EXTERNALLY FED AQUACULTURE SPECIES PRODUCTION

In contrast to traditional open coastal farming methods employed for the production of aquatic plants and bivalve molluscs that are based upon the natural availability and consumption/intake of planktonic food organisms and/or nutrients naturally present within the aquatic ecosystem (total production 27.9 million tonnes or 44.4 percent of total global aquaculture production in 2005; FAO 2007a), the culture of all other farmed aquatic animal species is dependent upon the external provision and supply of nutrients and/or feed inputs. Although the production of filter-feeding finfish species (includes silver carp, bighead carp, catla, rohu) amounted to 8.79 million tonnes or 29.0 percent of total finfish production in 2005 (FAO 2007a) and is still largely based upon the consumption of natural planktonic food organisms within the culture environment (the production of which is usually augmented and/or maintained through the external application of fertilizers), there is an increasing trend toward the use of externally prepared aquafeeds for these species, and as such they are also included here in the analysis as potential externally fed aquaculture species.

The main species groups in 2005 dependent upon the external provision of feed and/or nutrient (i.e. fertilizer) inputs included all farmed finfish (30 301 498 tonnes or 86.5 percent total fed species), crustaceans (3 961 200 tonnes or 11.3 percent total fed species), nonfilter-feeding mollusks (includes sea snails, abalone, conchs, octopuses; 333 963 tonnes), miscellaneous invertebrates (includes sea cucumbers, jellyfishes, sea squirts, sea urchins: 151 613 tonnes), turtles (201 853 tonnes), and frogs and other amphibians (84 879 tonnes) (FAO 2007a). For the purposes of this paper, external feed inputs include the use of industrially compounded aquafeeds, farm-made aquafeeds and natural food organisms of high-nutrient value such as forage/trash fish and natural/cultivated invertebrate food organisms.

Although no official statistical data are currently available concerning feed use by the aquaculture sector, it has been estimated that the aquaculture sector consumed about 23 127 000 tonnes of industrially compounded aquafeeds in 2005 (Tacon 2007) or about 4 percent of the total global industrial animal feed output of 635 million tonnes in 2006 (Gill 2007), over 20 million tonnes of farm-made aquafeeds (FAO 2007c), and between 5 to 7 million tonnes of low-value forage/trash fish species (FAO 2005, 2006).

It follows from the above that if the growth of the externally fed aquaculture sector is to be sustained at its current annual rate of over 8.9 percent per year (since 1950) that the supply of feed inputs (whether they be industrially compounded aquafeeds, farm-made aquafeeds, forage/trash fish or fertilizers) will also have to grow at a similar rate so as to meet demand. However, nowhere is this current dependency upon feed inputs more critical than within China (the feed-dependent sector growing over 331-fold from 65 961 tonnes in 1950 to 21 860 613 tonnes in 2005 and representing 62.4 percent of total global farmed fed-species production; FAO 2007) and in particular, concerning the increasing dependency of the aquaculture sector upon imported feed resources (FAO 2007a).

CHANGES IN AQUACULTURE POLICY AND PRODUCTION FOCUS IN CHINA

Prior to 1978, foodfish aquaculture production in China was almost entirely restricted to the polyculture of a handful of indigenous freshwater carps species (98.9 percent of a total reported finfish production of 753 285 tonnes in 1975; FAO 2007a) within semi-intensive and extensive culture systems (government/state owned or owned by collectives), with nutrient inputs being supplied entirely in the form of locally available fertilizers and supplementary/farm-made agricultural feeds and wastes (FAO 1983). However, from 1978 new government policies were introduced that encouraged a more open market and export-oriented approach to aquaculture development. In particular, these free market economic policies encouraged a more diverse type of ownership in aquaculture ventures (ranging from state and individual to foreign owned ventures),

allowed producers to make production and marketing decisions, and promoted diversification of cultured species (including the use of commercially important introduced or exotic species) and the culture of high-value (in monetary/marketing terms) commercial species for revenue generation and export (FAO 2003).

As a result of the above changes, aquaculture production within China has grown over 23-fold at an average compound rate of 11 percent per year, from 1 876 231 tonnes in 1975 to 43 269 413 tonnes in 2005, with the number of reported cultured species increasing from 16 in 1975 (9 fish, 4 mollusks, 2 plants, 1 crustacean) to over 59 in 2005 (32 fish, 12 mollusks, 9 crustaceans, 3 amphibians/reptiles, 3 miscellaneous invertebrates) valued at over US$39.8 billion (FAO 2007a).

Of particular note is the rapid growth of higher-value fed aquaculture species in China, including (in order of production in 2005 by weight and value), Nile tilapia (978 135 tonnes, valued at US$0.99 billion), whiteleg shrimp (808 433 tonnes, US$2.9 billion), Chinese river crab (438 383 tonnes, US$2.21 billion), snakehead (277 511 tonnes, US$0.22 billion), Japanese seabass (249 170 tonnes, US$0.27 billion), other marine fishes (240 878 tonnes, US$0.21), oriental river prawn (205 441 tonnes, US$0.71 billion), softshell turtle (182 610 tonnes, US$0.68 billion), Japanese eel (179 245 tonnes, US$0.33 billion), mandarin fish (175 687 tonnes, US $1.19 billion), swamp eel (162 499 tonnes, US$0.30 billion), Indo-Pacific swamp crab (111 423 tonnes, US$0.24 billion), giant river prawn (99 111 tonnes, US$0.28 billion), red swamp crawfish (88 249 tonnes, US$0.30 billion), swimming crabs 85 274 tonnes, US$0.28 billion), frogs (82 437 tonnes, US$0.31 billion), lefteye flounder nei 76 884 tonnes, US$0.084 billion), giant tiger prawn (75 731 tonnes, US$0.28 billion) and large yellow croaker (69 641 tonnes, US$0.078 billion) (FAO 2007a).

Compared with the production of freshwater carps in China, which has been growing at a brisk rate of 9.1 percent per year since 1990 (increasing from 4 096 614 to 15 111 228 tonnes from 1990 to 2005), the growth in the production of higher-value fish, crustaceans and other animal species has been more than double this at 19.1 percent per year (increasing from 298 427 to 4 114 144 tonnes from 1990 to 2005, respectively) (FAO 2007a). Moreover, total fisheries exports from China over the same period have grown from 369 965 to 2 544,577 tonnes, with export value increasing from US$1.3 billion in 1990 to over US$7.7 billion in 2005, the bulk of fisheries exports coming from the aquaculture sector (FAO 2007a).

MEETING CHINA'S INCREASING NEED FOR FEED AND FOOD

Despite the obvious economic benefits gained from the rapid growth of aquaculture in China, as the sector has grown and production intensified it has also become increasingly more dependent upon the use of external feed inputs and in particular, upon the use of compound aquafeeds (10.36 million tonnes in 2005) (Fang 2006), the use of lower-value forage/trash fish as a direct feed for key higher-value carnivorous aquaculture species, and the importation of key protein meals, including fishmeal and soybeans (FAO 2006). Moreover, although aquaculture products are only second to pig in terms of Chinese meat production (total farmed meat production in 2005: pig meat 51.2 million tonnes, aquatic meat 18.5 million tonnes (calculated), poultry meat 14.7 million tonnes, buffalo and beef 7.1 million tonnes, sheep and goat meat 437 million tonnes) (FAO 2007b), the aquaculture sector still currently represents less than 10 percent of the total animal feed produced in China (Fang 2006); total industrial animal feed manufacture in China reported as 77.5 million tonnes in 2006 and second only to the United States at 151.7 million tonnes (Gill 2007).

Moreover, apart from being the world's largest aquaculture producer (43.3 million tonnes in 2005 or 68.7 percent world total), China is also the world's largest producer of rice (milled: 124.9 million tonnes in 2006, 29.7 percent world total), wheat (103 million tonnes in 2006, 17.4 percent world total), meat (85.6 million tonnes in 2006,

30.1 percent world total), oils and fats (7.9 million tonnes in 2006, 14.3 percent world total), and the world's second largest producer of corn (maize: 142 million tonnes in 2006, 17.4 percent world total) and total oilcrops (58.4 million tonnes in 2006, 14.6 percent world total). It's domestic appetite for key food and feed resources is such that it has now become the world's largest importer of corn (42.5 million tonnes in 2006), oilcrops (31.3 million tonnes in 2006, including 28.3 million tonnes of soybeans), palm oil (5.14 million tonnes in 2006) and fish meal (979 150 tonnes in 2006 (FAO 2007a, 2007b; GAIN 2007a, 2007b).

For example, according to industry estimates, the aquaculture feed sector was the largest consumer of fishmeal in China in 2006, using between 50 to 60 percent of total imports and domestic supplies, followed by pigs at 20 to 28 percent, and poultry/others at 5 to 20 percent (Jin 2006). Similarly, it is estimated that the aquaculture feed sector in China consumed over 5 million tonnes of soybean meal in 2005 (from virtually nothing in 1990) (USDA 2006a); poultry being the largest consumer of soybean meal at 60 percent, followed by pigs at 22 percent and aquaculture at 18 percent[1]. Moreover, it has been estimated that the growth rate of total protein meal consumption in China (includes soybean meal, rapeseed meal, cottonseed meal, sunflower seed meal, peanut meal and fishmeal) over the last four years had averaged 10.8 percent, with soybean meal consumption capturing most of the consumption growth to meet the growing needs of the livestock, poultry and aquaculture sectors (USDA 2006b). Finally, it is estimated that between 55 and 65 percent of industrial compound feeds in China are composed of corn; 72 percent of the corn in China currently being used as feed; 20 percent for industrial production of sugar, starch and biofuel; and less than 1 percent for food (GAIN 2007a).

NEED FOR INCREASED SELF SUFFICIENCY CONCERNING RESOURCE USE

In a country home to 18 percent of the world's poor in which about 150 million people still live on less than a US$1 a day (World Bank 2007), there is an urgent need for China to become more self sufficient concerning resource use and in particular, to move away from the utilization of precious potentially food-grade agricultural and fishery resources as feed inputs. Particular effort should be given toward the recycling of byproducts and wastes arising from the agriculture and seafood processing sector as feed inputs for the rapidly emerging aquaculture sector, including the increased use of rendered animal byproducts, agricultural plant by-products, single cell proteins, marine seaweeds and cultured invertebrates.

By far the largest source of high-quality animal protein available to feed compounders is the byproducts arising from the processing of animal livestock and poultry. For example, the United States generated 9.6 million tonnes of rendered animal products in 2006, including 2 173,200 tonnes of meat and bone meal and tankage, 1 283 000 tonnes of poultry byproduct meal, 720 700 tonnes of porcine meal, 396 700 tonnes of feather meal, 717 700 tonnes of all other inedible products (includes blood meal and raw products for pet foods), 2 930 200 tonnes of inedible tallow and greases, 708 800 tonnes of edible tallow, 137 900 tonnes of lard and 518 300 tonnes of poultry fat (Swisher 2007). However, a recent wild card added to the food vs. feed debate is biofuels, and the possible negative effect that biofuel tax incentives and subsidies will have on the price and future availability and affordability of key food staples currently being targeted for biofuel production by some countries, including corn and animal fats and oils (Caparella 2007).

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An investor's view on investments and financing in aquaculture

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ABSTRACT

When an investor looks at fish farming, he has to make sure that the possible returns are high and outweigh the risks fish farming has. The investor will then look for possible species to farm, evaluating price, availability of juveniles, farming technology and markets. As production increases, will the price go down? Site selection is important, and the investor will look at factors like environmental conditions, infrastructure, legal conditions, the application process, taxes, stability and labour costs (which are not important). It is important for investors in cage farming that fallowing and site rotation is possible, as this makes the investment sustainable. The application process for sites should be simple and fast Rights for sites should be transferable and for long periods, 15 years or more with rights of renewal . Fish farming is difficult to finance, but fish stock insurance and transferable sites make it easier to do. The Norwegian salmon farming industry was funded by 50 percent government guarantees for working capital loans, and this was the basis for fast growth of the industry in the 1970s and 1980s. For new species, investors may have to finance 100 percent of the capital requirements with equity.

INTRODUCTION

This is not a scientific paper, this is a presentation based on my personal experience and view from having worked 36 years in the fish farming industry and having seen Atlantic salmon farming grow from zero to 1.5 million tonnes annual production.

WHY INVEST IN AQUACULTURE?

Why should an investor be interested in aquaculture? The interest is triggered by the gap we all see and hear about between supply and demand for seafood, and this leads to the belief that seafood prices will go up.

WHAT DO INVESTORS DO?

First of all, we will look at how we select the species we want to farm. We will gather information on all topics (see Box 1). After gathering all the information about which species to farm, the question then is: Where do I farm this fish?

Selection of country and site may be the next step. The choice may be different if you are just looking to do something on your own property or in your own area, but many of us will do a proper survey to select the best place world-wide for farming the species we have selected. Box 2 gives the most important factors that should be considered when the country and a specific site to do the fish farming are evaluated.

BOX 1
Important criteria in selection of species to farm

- Availability of juveniles
  - wild
  - farmed
- Hatchery technology
  - broodfish
  - eggs
  - intensive production
  - extensive production
  - juvenile price
  - availability (year round or seasonal)?
  - delivery security
- Feed
  - knowledge about feed
  - wet feed
  - dry feed
  - feed availability
  - feed cost
- Farming technology
  - extensive
  - intensive (recirculation, land-based or in cages?)
- Markets
  - local
  - export
  - product form (live, fresh or frozen)
  - yield
- Price: The most important factor in the selection process.

BOX 2
Factors evaluated for country and site selection

- Environmental conditions
  - temperature and salinity
  - water quality
  - environmental data like:
    - winds, tropical storms
    - waves
    - currents
    - algal blooms
    - contaminants
    - depth
- General infrastructure (shore base)
  - roads
  - electricity
  - harbours
- Fish farming infrastructure
  - feed suppliers
  - trash fish
  - service supplier
  - fish health services
  - equipment supplier
  - R&D support from universities or research institutes

LEGAL, ENVIROMENTAL AND LABOUR ISSUES

In the site selection process, legal conditions may turn out to be the most important issues. Some countries where aquaculture has flourished and some of the reasons why are given in Box 3. I want to quote from a presentation I gave at the European Aquaculture Society's meeting in Trondheim in 2005:

> *"To develop aquaculture you need a willing and determined government. A government that believes the future is in the sea".*

Too many people oppose aquaculture based on poor science and superstition. Without strong government support and an aquaculture law, which promotes investments, aquaculture will never develop. So, legal conditions are important. They are very important.

First, you want to know corporate ownership conditions. These and other important legal issues are listed in Box 4.

If an Environmental Impact Assessment is required, make sure the specific questions and surveys required are well defined and definite. Another area we have learned that is of importance is "compliance". When a permit is issued, what conditions would generally be in the permit and how realistic will they be? This is extremely important to an investor. We want security for our investment. If the conditions are very strict and maybe not even well specified, then you know your investment could be in trouble later. You know that if an authority wants to close down your operation, they can use non-compliance of environmental conditions to do it. So specific and realistic conditions are important.

BOX 3
Some places where fish farming has developed

- Greece
  - many islands, sheltered sites for cage farming, people used to boats and the sea.
  - aquaculture law
  - a very supportive government
  - world leader in seabass and seabream culture
- Chile
  - many islands in the south, long coastline, important fisheries; excellent sites for cage culture
  - aquaculture law
  - a very supportive government.
- Norway
  - many islands, sheltered sites for cage farming, people used to boats and the sea
  - the first aquaculture law in 1973
  - very supportive government

BOX 4
Some important legal questions

- Ownership
  - does the foreign investor have to have a local partner?
  - can foreign shareholder(s) own 100% of a company?
- Legal conditions, right to seawater sites for cage farming
  - size of sites (in tonnes of production or seabed area)
  - length of time:15–20 yr minimum
  - renewal rights
  - annual payments
  - number of sites
  - fallowing
  - site rotation
  - transferability
- The application process
  - how "complicated" is the process?
  - are all stakeholders involved?
  - transparency of the process?
  - is an environmental impact assessment (EIA) required?

We realize we need environmental monitoring and that we have to meet environmentally accepted conditions to develop a sustainable activity, but these conditions have to be specific and realistic. We all know cage farming will have "footprints" on the seabed and a very low increase in nutrients in the water around the cages. This is unavoidable when feeding fish. But we have learned that "footprints" disappear quickly if fallowing and site rotation are possible to do. This is why these simple techniques are vital for sustainable fish farming. For example, fallowing and rotation should be legally mandatory for cage culture.

Remember that corporate taxes are not important. We have to pay taxes in nearly every country and the tax holidays given when you start a new business are not important. In the first years of fish farming the project will not make a profit anyway. A tax holiday from year 5 to year 10 would be a lot more attractive. Stability with regards to permits and regulations is important.

Labour costs and availability of people is an interesting area. Labour costs are not important; however, labour quality is very important. Labour needs to be trained in aquaculture, committed and have a high work ethic

All the above environmental, legal and labour issues are important to consider, to make sure you invest in a project that is sustainable from:

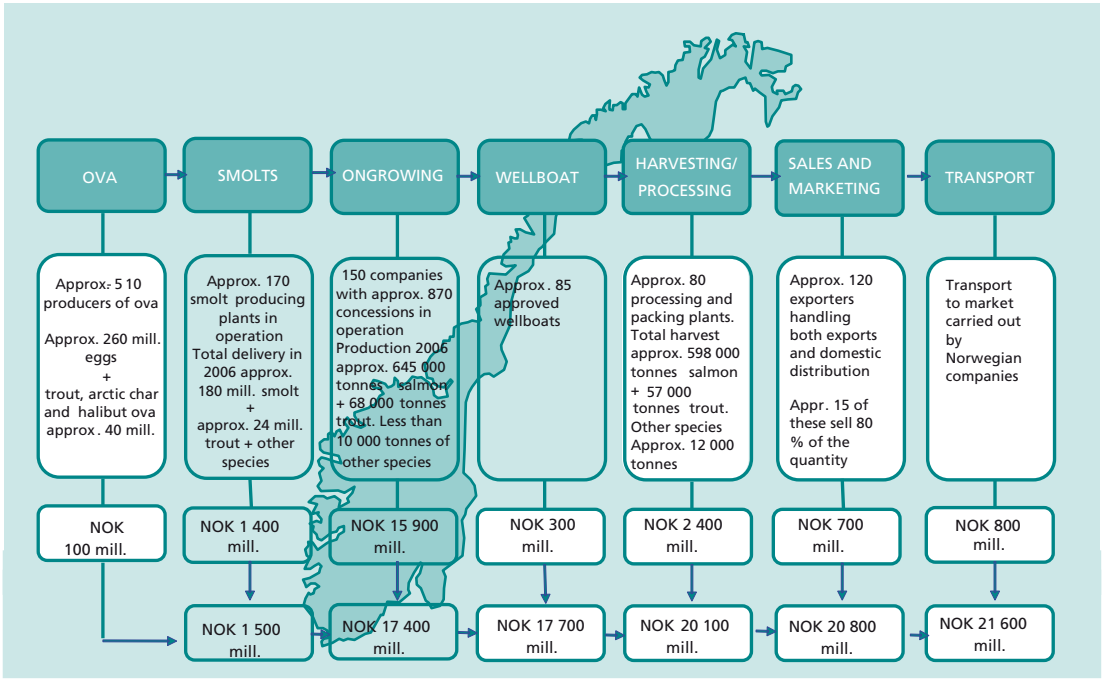
- an environmental point of view,
- a financial point of view, and
- a legal point of view.

They are all important and mandatory conditions.

OTHER INVESTMENT OPTIONS

Do I really have to invest in the actual farming process? If we look at the value chain of Norwegian salmon farming, there are many other options. You can invest in services related to the industry if you think that is less risky. Figure 1 shows the Norwegian salmon industry's value chain.

FIGURE 1
Value of the Norwegian aquaculture 2006E
Farmed salmon, trout and other species



BOX 5
Some examples of business models

- vertical integration
- outsourcing part of the value chain:
  - you supply juveniles
  - you supply feed
  - you buy back final product
  - individual farmers processing & sales
  - farmer responsible for husbandry & labour
- only have hatchery
- only do processing and sales

There are also other business models. You may want to have a vertical integrated business doing everything from broodfish to processing, or you may "outsource" part of the value chain. Some examples of the many business models are given in Box 5.

BUSINESS PLANS

When the species and site selection process is completed, you should prepare a 5 or 10 year business plan for your investment project. This is a very good exercise as it will give you the profitability and feasibility of the project and you have to think through the project from start to end. The outline of a business plan of a fish farming project could be as indicated in Box 6.

FINANCING YOUR PROJECT

With a good business plan in your hands, you are ready to start work on financing your project. Financing of fish farming is not easy. Fish farming is considered by many to be high-risk projects, and many failures in the past make investors sceptical.

You have two basic items you have to finance: equipment and biomass (working security). Equipment can be financed by loans, credit from supplier, export financing, leasing or grants. Maybe 50 percent could be financed by loans, the rest by equity from the investor. Leasing of larger pieces of equipment is possible in some countries.

Financing of working capital to pay for feed, juvenile stock and labour is often impossible via loans. In many cases, these costs have to be 100 percent financed by

equity. But it is not impossible to get bank loans; banks look for collateral. In Norway, fish in the cages can be used as collateral. The basis will be juvenile cost plus 40–50 percent of the expected cost of raising the fish to market size. In Norway, the formula is: part of smolt cost plus part of rearing cost (NKr 4 plus NKr 10 per kg) plus some additions. The farmer pledges the fish to the bank and reports monthly about the development of the biomass. Legislation making it possible to pledge fish as collateral is therefore important.

One of the conditions from the bank is that the fish are covered by insurance. Another important factor for a lender is the "value" of the permit. Transferability of the permit is therefore vital to be able to receive loans for working capital to fish farming. The lender then knows that it can continue the operation and sell it if the borrower fails.

BOX 6

Outline of a business plan for fish farming

- Summary
- Introduction
- Species
- Sites
- Legal conditions
- Technology, products and production
- Market analysis and sales
- Organization
- Investments
- Financial projections
- Financing
- Risks
- Appendices

Feed suppliers are sometimes willing to provide credit terms, will partly finance the working capital requirement. Venture capital is a source of funds that could be attracted to invest in fish farming. But good projects and well-prepared and realistic business plans are what the venture funds are looking for.

In Norway the salmon farming industry's working capital in the 1970s and 1980s was funded by government guarantees. To attract growth in rural areas, the Norwegian Government guaranteed 50 percent of the most exposed part of the required working capital. The capital was provided by a commercial bank on commercial terms, but with a guarantee from the government.

A future market for salmon has made it easier to predict prices and secure the income. The risk has been reduced and financing should be easier.

In Greece and Norway, there are fish farming companies listed on the stock market, and these companies can use the stock market to raise equity and loans in the form of bonds. But in general, fish farming is considered to have a high risk factor and is difficult to finance. In spite of this, I believe fish farming has a bright future and as the industry grows and matures, financing will become easier.

Session 3: Advantages and opportunities

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Since August 2004, Lori Ridgeway has been the Director General, International Policy and Integration, Fisheries and Oceans Canada (DFO). Her responsibilities include trade; international business development; international Fisheries and Oceans Governance; and strategic coordination, research and policy development on crosscutting international affairs in DFO. She is responsible for the development and implementation of the International Fisheries and Oceans Governance Strategy, an umbrella for issues related to international science, international fisheries policy, international oceans and biodiversity policy, international multilateral instruments and international coordination and integration. Ms. Ridgeway is active in many international fora, including serving as three-year Co-chair of the United Nations Informal Consultative Process on Oceans and the Law of the Sea. She is incoming current Lead Shepherd (Chair) of the Fisheries Working Group in Asia Pacific Economic Cooperation (APEC), was Chair of the Organisation for Economic Co-operation and Development (OECD) Committee of Fisheries from 2000–2006, and is active in other fora (UNEP, WTO-Trade and Environment, FAO Committee on Fisheries and its Trade Sub-Committee, other UN fora etc). She has held various positions, including: Director General, Economic and Policy Analysis, DFO (1999–2004); Director of Operations for the Liaison Secretariat for Macroeconomic Policy, Privy Council Office (PCO) (1997–1999); Chief of Expenditure Analysis and Forecasting, Fiscal Policy Division, Department of Finance (1994–1997); Finance Counsellor, Canadian Permanent Delegation to the OECD, Paris France (1991–1994); Analyst, Economic Analysis and Fiscal Policy Branch, Department of Finance (1981–1997); Faculty of Economics, University of Alberta, (1977–1981): and subsequently, University of Calgary, full-time lecturer, microeconomics, macroeconomics and applied resource-based courses.

Globalization and the impact of aquaculture

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ABSTRACT

The comments presented are motivated mainly by the results of a recent workshop sponsored by the Organisation for Economic Co-operation and Development (OECD) Fisheries Committee on "Globalization and Fisheries," where "fisheries" included also aquaculture. The intent of the workshop was to explore those factors that would contribute best to maximizing opportunities being reaped from globalization and minimizing costs. Issues were examined across the value chain in order to maximize understanding of interactions of globalization with production, processing and distribution/markets/buyers/consumers. An integrated picture of some globalization challenges and opportunities is offered, alongside generic conclusions, with a view to their implications for aquaculture, as well as specific issues raised in aquaculture sessions, which may provide context in the light of globalization to some other aspects of the programme. Key messages resolve around observations on: the opportunities provided to aquaculture from the rise in demand for fisheries products; the paramount importance of sustainability/responsible production and high-quality regulation to all aspects of the value chain, as well as integration within it; perspectives on the role of hygiene and quality standards; priorities underlying investment and financing from the perspectives of these players; perspectives on the rise of ecolabels of various sorts; issues in enabling small-scale production into trade, especially in view of increasing concentration in the value chain; and other issues.

INTRODUCTION

This paper is intended to address the issue of globalization and its implications for opportunities in aquaculture. There are many papers at the Conference that show such opportunities on the basis of case studies, including the potential economic and community impacts this will provide as a result. This paper provides some generic policy insights on this issue from an examination of how globalization can affect fisheries, including aquaculture.

Indeed, "globalization" is a key context underlying most current policy discussions in fisheries – which, in this paper, include both capture and aquaculture fisheries. Globalization is a concept that implies a "system" of complex linkages among international participants, including states – a system that needs to work effectively and responsibly. The challenges, opportunities and expectations accompanying increased

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globalization are at the root of some of the most heated policy discussions taking place in fisheries.

Opinions differ on whether globalization is a positive or negative factor in the world economy and community, where these opinions vary according to whether one is facing perceived opportunities or risks from it. The overall goal for the global community should be to understand the policy, governance and other changes needed so that the benefits of globalization can be maximized and risks minimized or managed.

As for aquaculture, this paper takes the point of view that there are many opportunities for responsible aquaculture, especially for developing countries, and especially in light of challenges currently facing capture fisheries, but less so where it is not responsible or not perceived as responsible.

Moreover to a large extent, at least reputationally, the fortunes of aquaculture and capture fisheries are inextricably linked (such as in competition with other food sectors), and both need to be sustainably managed – and perceived to be so – in order to maximize the benefits to both.

This paper also reports on views that globalization can potentially induce a "race to the top" in terms of sustainability and responsibility, if all players in the fisheries value chain work together coherently and capacity building is a major part of the system. This is true for aquaculture as it is for capture fisheries.

In this respect, responsible markets are also as important as responsible producers, on two fronts. On one hand, unjustifiable market standards can impede the functioning of the global system, especially if technology transfer and capacity building are weak, leading to a number of dynamics and lack of buy-in to shared gains of more responsible fisheries. Similarly, large markets that provide an outlet for irresponsibly produced product (whether capture fisheries or aquaculture) to find a way around global norms will undermine the benefits of globalization for all.

UNDERSTANDING GLOBALIZATION

There are no doubt numerous formal definitions of globalization, many of which would reflect an increasing interdependence of markets and citing increased trade flows. This paper urges a broader view of the concept, in order to induce a consideration of a broad set of linkages and spillovers that should be taken into account. Overall, the point of view taken here is that globalization is a force that is creating an ever larger *community of joint interest*, which can go beyond concepts such as increased trade.

Some factors that indicate increasing interdependence among global players – including states – include, for example:

- integration and interdependence (i.e. linking together) of markets and players;
- increased mobility of inputs (e.g. labour and capital);
- freer flows of goods, services and investment;
- increased "reach" of sophisticated transportation and logistics;
- increased transfer of technology and knowledge;
- freer flows of information of all kinds;
- increased linkages and spillovers among activities and issues (both benefits and risks);
- spread of ethical and/or cultural changes and aspirations;
- shared global threats that need cooperative solutions (e.g. climate change, disease, fisheries sustainability, other environmental threats); and
- rise of global institutions dealing with cross-border issues as well as harmonization of domestic policies.

This list is not exhaustive, nor are the items noted mutually exclusive. However, the key point is that they emphasize the *connections between activities and incentives that will cause spillovers from individual agents and states into the broader global community*.

Several papers at this Conference have described how global demand and relationships for fisheries products are changing, including increased global reliance on aquaculture products. The emerging picture from available data regarding changes in production and trade flows is quite clear, including from the FAO's annual *Status of Fisheries and Aquaculture*, and will not be repeated here. It is clear from the preceding illustrative list that such data cannot, however, tell the whole story about the increased complexity of linkages brought about by increased globalization or suggest solutions that will need to be considered, if increased globalization in fisheries is to be managed to maximum benefit[2].

The Organisation for Economic Co-operation and Development (OECD) is an international institution devoted to improving analysis, policy making and "governance" (defined here as the body of law, regulations and decision-making mechanisms) of its member states and increasingly, the broader global community. Similar to other OECD policy committees, the OECD's Committee for Fisheries (OECD-COFI) does analytical work on major issues affecting fisheries that are important to improving domestic polices and governance, engages in policy debate and makes recommendations on policy needs and reform, both for use of domestic policy-makers and by the broader international community. It is hoped that the analytical work of the OECD-COFI will help provide an analytical foundation to broader international debates.

As part of its programme of work, the Committee is undertaking a large project on globalization and fisheries[3] to better understand that which is needed to make the global "system" work better and ensure a wider sharing of its benefits.

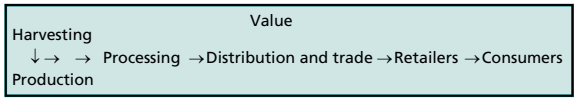
As part of the OECD-COFI globalization work programme, the fisheries departments of the OECD and the FAO, alongside the Committee, recently co-sponsored a workshop on this issue, which brought together over 100 experts in all domains to share views on the topic of globalization and fisheries, including aquaculture (involving, for instance, producers/harvesters, processors, buyers, retailers, government decision-makers). Some high-level observations arising out of these discussions inform, in part, observation in this paper.

A SIMPLIFYING FRAMEWORK: DECOMPOSING IMPACTS OF GLOBALIZATION

As noted, globalization can give rise to a complex set of relationships. A simplifying paradigm can organize our thinking about how globalization affects fisheries and ensure a balanced approach to the issue, rather than just focussing on high-profile issues.

One way is to use as a guide, the stages of production and activity. The "value chain" illustrated in Figure 1 shows the stages at which "value" is added to a product as it is transformed to meet a market need. Value-added increases as one moves from left to right in this chain. The illustration shown in this diagram is very simplified. For instance it does not include the tertiary sector – or related services – spawned by higher-value activities at points throughout the chain, but it is illustrative of a framework that can be used to examine the impacts of globalization in a complete way.

FIGURE 1
Value chain



In Figure 1, the fishing value chain starts on the left, with both harvesting and aquaculture

[2] Moreover, even within economic data, new forms of industrial/corporate organization arising from globalization – including out-sourced production and re-exports, for example – are likely challenging official statistics to tell the whole story of increased economic interdependence.

[3] "Globalization" is also a broader cross-cutting topic at the OECD, intended to be addressed by a number of its policy committees.

"production", and together these products move through to processing. The product is then consumed locally or distributed or traded into markets (sometimes back into production as feed), while some products go to retailers and then to consumers. One can examine globalization impacts on the value chain to better understand:

- the impacts of globalization at each level of activity;
- the linkages up and down the chain from producers to consumers and vice versa; and
- the policy, institutional practices and governance needs at each stage in the value chain in order to maximize benefits and minimize risks of globalization.

That is the goal of the OECD-COFI globalization project. The agenda of the OECD-FAO Globalization Workshop, referenced above, was also organized with such a framework in mind, in order to best organize information and feedback from each community of interest. That workshop did not focus specifically on aquaculture, other than through one specialized session. However, broad lessons from that workshop inform the issue of aquaculture opportunities.

AQUACULTURE IN THE FISHERIES VALUE CHAIN

Before examining the implications of globalization for opportunities in aquaculture, it is important to reflect on how aquaculture generally fits in this picture. Generally, aquaculture and capture fisheries (harvesting) can be considered as distinct activities at the "production" end of the chain, each with its own challenges, but they are often linked (such as feedstock for some species or price changes induced by one activity, such as higher aquaculture production, which can have an impact on production in the other).

However, after these products enter processing, and further to consumers, the source of production can be quite unclear (e.g. consumers may simply consider "fish as food"), and fisheries products from both sources may find their greatest competition from other food products. Thus, whether aquaculture products are consumed depends on a broader set of issues, such as the attractiveness of fish overall (reputation), availability of attractive alternatives, culture and whether consumers trust it and like it. Aquaculture and capture fisheries have joint/mutual interests at the consumption stage, in particular. Thus it is unhelpful, and probably misguided, to consider aquaculture and capture fisheries as "competitors" for consumer attention. However, they do occupy different niches – with differing strengths – in the global value chain, as will be illustrated below.

Some aquaculture activities are aimed only at satisfying basic local needs, similar to artisanal fisheries. But those facing global or regional markets will be trying to gain as much value as possible. We know states want to move beyond just producing lower-value raw materials, with the gains of higher-value activities accruing only to other economies. They want to encourage higher-value activities into their own economies (processing and related services), as it is in the secondary and tertiary activities where income and jobs are greatest. The global challenge is, in one respect, the competition for access to both resources and those higher-value activities.

Sometimes production activities where margins are lowest search for short-term gains through rapid exploitation, lower regulation etc to reduce costs (e.g. illegal, unreported and unregulated (IUU) fishing, race for fish, less responsible aquaculture). Sometimes these activities take place where capacity for strong governance and management is relatively lower. Higher-value activities, however, search for low commercial risk. That is both the challenge and the opportunity for global fisheries, including aquaculture.

Some important general observations from recent OECD-FAO discussions of globalization

Is globalization providing real opportunities? As noted, the debate on globalization as "good" or "bad" depends perhaps on where one sits. Overall, while the above-

referenced workshop did not shy away from issues and challenges, it was markedly positive about globalization, in general.

Globalization will provide opportunities for a wide set of players, providing that certain conditions – most notably responsibility and sustainability – are met. It will be the responsibility of all, including both producers and markets, to ensure that these benefits accrue in a sustainable, resilient and inclusive global system.

In relation to discussions about capture fisheries, it could be said that the aquaculture session was the most positive about the potential gains from globalization. There are challenges to be faced, especially for small-scale producers in Africa and Asia. But important initiatives are underway to overcome these, especially in Asia – including through important partnerships and networks (such as the Network of Aquaculture Centres in Asia-Pacific (NACA) in Asia, and with new aquaculture cooperation networks also starting up in the Americas and Africa) to solve problems, build capacity and share technical knowledge; provide new forms of financing; and new ways of organizing ("clustering") small-scale producers to give them more collective market power.

The issues facing wild fisheries were, in contrast, somewhat more difficult. All fishing states want more from capture fisheries, while opportunities there are diminishing. It takes a strong capacity to properly control fleets, manage common resources wisely (especially when international governance is often weaker than it should be), and to take part actively in international cooperation and collaboration, especially for high-seas issues. Some fishing and trade arrangements are also accused, by some, of preventing developing countries from earning adequate value from capture fisheries. There is a clear advantage in capture fisheries for developed states or those with strong management and governance capacity. Capture fisheries can be hard for new small players, where capacity to exploit and manage capture fisheries may be low, and/or where fishing allocations in high seas may not have been secured.

Increased global demand can undermine fisheries and ecosystem sustainability and the environment unless fisheries are well regulated (including enforcement). If not, this undermines gains for all in the global community[4].

As this paper is focussing on opportunities, this can be restated to say that if the global community wishes to exploit that which globalization has to offer, it is best done by using resources sustainably and ensuring wider ecosystem and environmental sustainability.

Globalization was viewed as also encouraging and enabling responsible production, as the global community finds ways to work together to link demand and supply. For instance, most major markets are in developed states, and increasingly, production will be coming from developing states. Despite well-known challenges for developing states, the workshop (which included many developing-country representatives) took a positive view overall of the merit of health and safety standards, given the realities of demand in major markets that place a high premium on safety and security of food products generally. It was noted that reforms being undertaken to meet these standards and associated capacity building are enabling products to enter more markets than without these standards. There are interesting examples from Africa and Asia, for example, about what can and is being done to enable products to meet exacting standards in developed country markets. The issues raised were more in their application, stability, predictability and transparency, not in their existence *per se*.

And for both harvest and aquaculture fisheries, there are a large and increasing number of nongovernmental players who have resources, tools and influence. Their strengths and knowledge, and resources and information need to be harnessed to help ensure such standards do not provide an unnecessary obstacle to globalization.

[4] Indeed, concern over this risk is the basis of some key debates in the World Trade Organization (WTO) – subsidies discussions and, in some cases, market access.

Specific impacts of globalization throughout the value chain, and implications for aquaculture

Production

Numerous papers have described how rising global demand for fish and seafood cannot be met from harvest fisheries alone. Responsible aquaculture will need to fill the gap. Most capture fisheries are fully subscribed, some fisheries are depleted and need to be recovered, and overall, global harvesting capacity and effort must be reduced from current levels to assure fish stocks stay healthy. Vulnerable ecosystems are also being increasingly protected, which may result in a reduction in fishing opportunities.

As for the number of fishers and income and community needs, similarly, fewer fishers, not more, are needed globally in order to ensure that employment is durable and viable. Moreover, because of lower returns, many capture fisheries are in a cost-price squeeze (especially as energy costs increase), which further inhibits the ability of weak elements of the sector to add substantially to community well being.

Aquaculture can fill the gap of rising demand over the longer term, and make a substantial contribution to income jobs and community well-being, but only if certain conditions are met, so product can get to, and is accepted in markets, and the environment is preserved to allow it to endure. We need to have learned some lessons from wild fisheries in this respect.

Some aquaculture-related activities can assist fisheries or help replace important or iconic fisheries products that have been depleted (e.g. cod) and reach isolated communities in the way that other economic activities might not.

Aquaculture in developing countries may thus face particular opportunities, especially as it can be large scale or small scale[5], and thus suitable for various contexts.

In developed economies, aquaculture growth is levelling off and may not fulfil the potential foreseen in the recent decade. Several developed states, including in Europe, Canada and the United States are re-evaluating policies to reinvigorate the sector, but generally they may not fulfil as large a share of the fisheries products gap filling as earlier foreseen:

- developed countries are generally higher-cost producers and find it increasingly difficult to compete with high-quality lower-cost production;
- some developed countries are facing issues related to securing sites for aquaculture due to increased competition for oceans space (including from non-use);
- aquaculture has faced reputational issues in some states, which in some cases, have caused moratoria from community backlash over environmental/ecosystem risk (sometimes reflecting the effects of active environmental nongovernmental organizations (ENGOs) who highlight environmental and resource risks associated with aquaculture); and
- other alternatives for economic and rural development may be available in developed countries as well, altering perceptions on the balance of risk where it is perceived and lessening the pressure on aquaculture as the sole provider of jobs and income. Activities may focus as well on higher-value activities, including processing and services (see below under processing) sourcing product from other areas.

Processing

Processing is an important provider of jobs and income, especially for women. Processing is the part of the value chain where integration – especially vertical integration among firms – really begins[6]. However, a race for jobs, and subsidies to harvesting or processing to encourage jobs and income, can lead to processing overcapacity that can

[5] And financing and marketing/distribution options for small scale operations are increasingly available

[6] Very few large firms are integrated into the harvesting sector, except in cases where harvesting is very well managed, generally including the use of market-based measures such as individual or enterprise quotas.

filter down the value chain to encourage overproduction and environmental risk, as firms need raw material to earn a return on investment. This may lead to taking risks in aquaculture that might not otherwise have been induced.

Processors taking part in the workshop – and the financiers who provide the investment capital – continually emphasized their need for sustainable supplies of fish and their increasing unwillingness to take on or maintain a large amount of commercial risk. In fact, reducing those risks, especially in public companies, is leading to consolidation in the processing sector. The global value chain as relates to large markets in developed countries is becoming quite concentrated in large public companies. It is this protection of shareholder risk, in public companies, that prevents processors from investing in harvesting unless it is extremely well managed. In any case, for companies large and small, earning a return on investment drives processors increasingly to be searching for reliable and diversified sources of supply.

Increasingly, large integrated processors are explicit in saying they are sourcing their raw material from a wide variety of global – not national – fisheries. Technology and technology transfer better supports the complicated logistics of preservation of product quality, and more countries are meeting necessary standards as well.

In fact, many developed-country processors are moving into tertiary activities, exporting and re-importing products to and from lower-cost processors, and also earning returns from brokering activities, where quality and cost advantages make sense. In Canada, some processors say some "Canadian" product never actually enters the country.

Aquaculture has a number of assets that potentially situate it advantageously in relation to processor demand. These assets include predictable and uniform supply, and more even quality. This allows processing plants to run more effectively, reduce costs and risk, and achieve higher prices due to higher quality. Many wild fisheries – especially less-well-managed fisheries – have more difficulty in maximizing quality and timeliness (managing to market).

One of the major challenges facing aquaculture relates to the small-scale aquaculture sector, where a challenge is to organize small-scale operations so that brokers and buyers can handle logistics and help product enter viable operations, domestically or especially internationally. A second challenge is the issue of sanitary and phytosanitary standards, and ensuring that product can meet necessary standards for relevant markets, and that in doing so, developing countries are not forced into creating a segmented production structure, with a formalized marginalized sector for local producers and communities whose products cannot access international markets – a cycle hard to break out of.

Trade and distribution

The trading system is traditionally viewed as the glue to global flows of inputs, products, services and investment. The trading system continues to face many challenges in fisheries, as for other products. Aquaculture and capture fisheries products are generally not distinguished in the trading system, and indeed are hard to identify in data.

Even though tariffs have fallen and in fisheries they are generally lower than in agriculture, large differences between bound and applied tariffs, tariff peaks on sensitive products in many countries, and tariff escalation (higher on processed product than raw product, to protect domestic processors) can distort the global production system. Tariff escalation will especially affect processing localization. Many argue that certain kinds of fisheries subsidies also both distort production and trade, as well as threaten sustainability of fisheries (especially capture fisheries), the environment, or both. The fisheries sector is also not immune from accusations of abuse of antidumping actions. Aquaculture can be particularly susceptible to the latter, and a number of antidumping actions have been taken against aquaculture products.

While current global, regional and bilateral negotiations on market access will further liberalize trade in fisheries products, it is also the case that this will reduce the advantage of existing tariff preferences for some developing countries and force their products to face greater competition.

Most fisheries-producing nations are now either in the World Trade Organization (WTO) or intending to accede, which will help take account of broader needs over time and provide mechanisms for settling disputes of many kinds. The Doha Development Agenda (DDA) is intended to help "level the playing field" for developing countries while improving the trading system.

Participants at the OECD-FAO workshop focussed mainly on the effects of high sanitary and phytosanitary standards. These are particularly important for aquaculture, especially in relation to contaminants and residues. As noted, the workshop revealed a common appreciation among developing countries' participants for the need for standards, and their role in having built buyer confidence in important markets for product from emerging producers. The real issues seemed to be, rather, in their implementation, variability and lack of transparency and mechanisms for capacity building and facilitation. As well, products can be recalled at borders, creating uncertainty and high transactions costs.

Fisheries can face serious reputational problems, ranging from sustainability and environmental impact to the issue of contaminants. These issues are common to both aquaculture and capture fisheries. Both sectors of the fishery are affected by the fragility of reputational gains that are made for both. A major border problem for an aquaculture product can have serious repercussions on reputation for all fisheries (capture and aquaculture) and vice versa, so quality and safety control matters critically to fish entering trade.

Trade facilitation is a large challenge, as entering markets is difficult for some producers, especially in developing countries. Some international standards are very high (e.g. against contaminants, and antibiotics), are close to zero tolerance (and with no prospects for change), and a great deal of technical know-how and production/processing surveillance is needed to ensure standards are met.

One advantage of aquaculture is its scaleability – it can be large intensive operations or small family-sized fragmented extensive operations. Access to trade and distribution is especially a challenge for small aquaculture operations, although it may be the case that product is trying to enter national or regional trade. However, new efforts at scaling up and "clustering" of very small aquaculture operations into larger operations/organizations are helping to overcome these impediments and ensure that the distribution system is more inclusive of all scales of producers.

As for emerging challenges: that which may be gained in formal trade liberalization and formal trade facilitation to meet states' technical standards may now be being challenged by needs of private standards – especially for sustainability. The issue of ecolabelling is increasingly part and parcel of issues concerning access of products to markets (see below under *Consumers* for a more detailed discussion. Ecolabels will facilitate access to markets for those fisheries capable of being certified. However, at this time, formal ecolabels are only available for capture fisheries, and information-rich ones at that.

The actual trading system will be challenged if private standards (imposed, for example, by buyers or retailers) start to be barriers to trade. Currently there is no international mechanism to allow recourse against private standards, which is an emerging issue. In the framework of the value chain, ecolabelling demands and private standards for sustainability or quality or other technical standards by buyers or retailers that may indeed exceed public standards, intend to use consumer power or buyer power to force more responsible harvesting or production. This possible "substitution" or complementarity of buyer pressure for public regulation (if it is wanting) will have important implications for the trading system.

As noted, aquaculture is behind in not having yet established an international benchmark for aquaculture ecolabelling (guidelines) or in having a key recognized international ecolabel in place. There is a risk that retailers or buyers could choose an existing "branding" label as a "standard" or ecolabelling proxy and build buy-in to it, even if it might not fulfil all requirements of a full-fledged ecolabel as determined by states multilaterally. In this regard, current work underway within the FAO on an aquaculture ecolabelling guideline is an important step forward.

Especially important overall to the trading system affecting both capture and especially aquaculture fisheries will be an integrated traceability system that will integrate health and safety and sustainability needs.

Consumers

The responsibilities of market states affect all states. The expectations of markets will influence whether globalization causes a "race to the bottom" (low common denominator) or encourages a "race to the top" (higher common denominator) for safety, quality and sustainability. Markets that provide refuge for irresponsible product slow down global reform for sustainable fisheries and aquaculture. Markets should not undermine incentives for sustainability and safe products through low standards and/or poor consumer education

The largest markets for fisheries products are in Europe, the United States and Japan. As noted, developed states' markets are increasingly demanding on a range of fronts (quality, convenience, safety, sustainability). Buyers and consumers are demanding food safety (non-negotiable), freshness, diversity, convenience and increasingly, a focus on sustainability, legality and traceability. Some high-profile restaurateurs are a part of this demand, especially for value-added, reliable, uniform (and high quality) product. This puts pressure downward on the entire value chain, through processors (for higher value-added products) to producers who need to provide what is needed by processors and markets. It affects both capture fisheries and aquaculture products. As previously noted, aquaculture product may have a potential advantage in providing raw material for higher-value processed products to meet demands for higher quality and convenience.

The rising power of buyers, retailers and consumers in Europe and North America is one of the biggest market changes of recent years. Indeed, the OECD-FAO workshop learned of the determined efforts of major buyers and retailers to do what regulation and management may have failed to do up to now, by forcing, through buying power, increased harvesting/production responsibility, quality and sustainability. The view of these buyers and retailers was mixed, however, in relation to their obligations as part of the system of capacity building and facilitation, with some arguing that the issue is simple company branding and marketing (and explicitly arguing that their "business is not regulation, capacity building or development assistance"), with others building strategic and capacity-building relationships with suppliers all over the world to enable producers to meet their standards and thus create strategic supply links.

Commercial risk is again at the heart of this issue. Buyers, and through them, consumers, increasingly seek assurance of the quality and sustainability of the source of the products they are buying, and clear and accurate labelling on a range of issues. As far as sustainability is concerned, in addition to ensuring a steady supply source, retailers are demanding proof of sustainability also as a defence against ENGO threats or to create a market advantage of their "brand" among discerning consumers. The United Kingdom is at the forefront of this movement, especially because of more militant ENGOs, but the 2006 announcement by Wal-Mart, in the United States, of demands for Marine Stewardship Council (MSC)-ecolabeled fisheries product has been a major catalyst in this movement.

There is not yet much evidence that consumers are willing to pay more for such labels, however, except perhaps "organic", where prices do command a premium, and

which could be a niche for aquaculture that provides opportunities to prove sustainable practices and high quality. Organic certifiers also engage in capacity building.

More generally, the issue is "which standards? what proof?" Buyers, retailers and restaurateurs complained in the OECD-FAO workshop, and have also complained elsewhere, about proliferation of labels and standards on a large range of issues that is confusing everyone (including buyers) and which can be contradictory[7]. So some retailers are simplifying the terrain by unilaterally choosing ecolabels they will honour[8], and teaching their consumers to respect that as the appropriate standard.

For capture fisheries, the FAO ecolabelling guidelines (2005) help assure some fairness, transparency and rigour in ecolabelling, thereby serving the needs of both ecolabellers and producers. Even so, while guidelines were necessary, they are not sufficient to ensure a "level playing field" among fisheries, as examples exist of differential standards and application within even well known ecolabels such as the Marine Stewardship Council (MSC), where certifiers actually operationalize the MSC standard. Application and requirements can be quite variable, although recently the MSC has shown its desire to reduce this problem through additional codification of their standard to reduce certifier discretion.

However, as noted above, no such global ecolabelling guideline yet exists for aquaculture. The associated risk is that *de facto* standards will be set by retailers from whatever is currently available, and once a "brand" is built around this, it may be hard to adjust later to a different guideline should it be the case[9].

Meanwhile ENGO campaigns will be influential, as they are widely disseminated. Many are anti-aquaculture. This demonstrates the need for collaborative relationships and education and improved aquaculture reputation overall.

CONCLUSIONS

All of the above points to a similar conclusion: aquaculture has opportunities all across the value chain relative to capture fisheries, although higher up the chain, aquaculture and capture fisheries products tend to be complementary. Sustainable responsible production is the *sine quo non* at all stages:

- production: not to undermine own production potential (environment, reputation);
- processors: need security of supply, quality;
- investors and financial intermediation: unsustainability/poor practices are "bad bets";
- exporters: face standards (health and safety sustainability, labelling);
- retailers: to protect their market "brand" and ensure sustainable high-quality supply sources; and
- consumers: sustainability, ethic increasing, food safety.

Health and safety standards, whether perceived as "fair" or not, are said to be "non-negotiable" to many consumers and the states that have put them in place. So the real issue to improve benefits for globalization is to improve their application and enhance systems that will reduce transactions costs for those trying to meet them. Key issues are unpredictability in application, transparency, changeability, multiplicity and confusion,

[7] It should be noted in this respect that many ENGO "campaigns" focus on sustainability of product at a point in time, while ecolabels focus on the management system and could indeed be based on contracts for changes in practices in the future. Thus is it possible for ENGO campaigns and ecolabels to be conflicting as "indicators" of sustainability (e.g. achieve an ecolabel, but be on an ENGO "red" list).

[8] The Marine Stewardship Council (MSC) being the label of choice, mainly as it is the only full-fledged ecolabel currently in place, and has already surpassed over 600 MSC ecolabeled products across most continents.

[9] Nor is there a standard – or even common appreciation – of what is meant by "carbon miles", also an increasing commitment to sustainability. If not applied throughout the entire value chain for fair comparison across products and product source, they can become a misleading and "buy-local" barrier.

lack of capacity and organization to meet them. Harmonization, mutual recognition and capacity building are needed to improve the system.

We need to consider the global fisheries system, including aquaculture, as we do any other economic sector in a strong economy. It needs:

- a strong, stable and predictable regulatory framework;
- one that is enforced and fair; and
- one that includes corporate social responsibility.

This will ensure effective and responsible decision-making, and a flow of resources to their best value over the short and longer runs. Aquaculture is part of that framework, and inextricably linked to capture fisheries in many respects. Responsible producers, responsible markets and freer trade will help ensure benefits of globalization for aquaculture.

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Value-added seafood: opportunities and challenges – a United States restaurant chain perspective

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ABSTRACT

Darden Restaurants, Inc. is a Fortune 400 company listed on the New York Stock Exchange that owns and operates 1 450 casual dining restaurants in the United States and Canada. Company brands are Red Lobster, Olive Garden, Bahama Breeze, Smokey Bones and Seasons *52*. Red Lobster is a seafood restaurant chain, and seafood is also served by the other brands. Darden Restaurants has a long history of working with its seafood suppliers, both in the United States and foreign countries, to add value to the seafood products it serves in its restaurants. Among other benefits, value-added products enhance food quality, quality consistency and reduce kitchen preparation requirements. These benefits make it possible to offer guests an excellent dining experience at a good value. Darden Restaurants is committed to increasing the number of value-added seafood products and is seeking to purchase many of these items from suppliers in the country of origin. Efforts have been positive, but there have also been some challenges. The challenges to selling value-added seafood items can be summarized as follows: 1) creating an item that is appealing to our guests, 2) represents a value and 3) that is safe and meets all United States and Canadian governmental requirements. To better assist the reader in understanding what is required from a casual dining restaurant perspective, an elaboration of these themes is presented.

Thanks to the organizing committees for their leadership role in sponsoring this Global Trade Conference on Aquaculture, a subject of great importance to Darden Restaurants, the largest casual dining restaurant company in the United States. With our four distinctive brands – Seasons *52*, Olive Garden, Bahama Breeze and Red Lobster – we own and operate more than 1 400 restaurants in the United States and Canada – in which seafood plays a prominent role.

Underscoring the global nature of our purchases, we source both wild-caught and aquaculture seafood from more than 30 countries by direct purchases, a procurement practice that is unique in the United States restaurant industry. It is important to note that many of the aquaculture products we purchase have a valued-added component (i.e. headed, peeled and deveined shrimp or filleted, deboned and skinned finfish), and it is our desire to increase the number of value-added seafood items we purchase for reasons I will elaborate upon later.

Food safety and quality are essential ingredients to the success of our brands; and to ensure we fulfill those requirements, we have a Total Quality Assurance Department of more than 50 persons dedicated to this effort. Working from key locations in Orlando,

Florida; China; Thailand; India; Honduras and Ecuador, they inspect every facility that processes seafood for our restaurants.

Why is the sustainable growth of aquaculture seafood so important? For Darden Restaurants it is very simple – continued growth of demand for seafood in the United States and no growth in production from the wild capture fisheries. On the demand side, we have seen the *food away from home industry* grow from US$ 43 billion in 1970 to US$ 537 billion in 2007 – a growth trajectory similar to Darden Restaurants. This growth in locations that typically sell more seafood than is consumed at home offers a growing recognition that seafood is health food and population growth is a recipe for tight supplies. Our internal conservative calculations suggest that we will need an additional 400 000 tonnes (edible weight) of seafood by 2025 just to maintain current per capita consumption in the United States.

As mentioned earlier, we are also committed to increasing the number of value-added aquaculture products on our menus. We believe value-added aquaculture products provide us with a number of benefits, i.e. the restaurant manager can spend more time with our guests because he does not have to spend as much time in the kitchen preparing the meal, they deliver consistent freshness and quality that build customer loyalty, and creative and innovative menu items are often generated during the collaborative process between our brands and the supplier as they work to develop the value-added item.

While it is evident that value-added products return higher prices for suppliers, achieving success is not easy: it requires properly equipped production facilities and a careful and systematic approach to understanding what will appeal to the United States restaurant customer. We believe there are two essential components: in-depth knowledge of consumer food preferences in the United States plus the value-added item must represent a value to the purchaser. To illustrate the value point, a crab cake was developed for Red Lobster that met its taste and presentation requirements, but value was not consistent with the Darden business model, so it did not proceed beyond the development stage. Its rejection, however, did not deter the value-added suppliers, whose ultimate success generated about five million dollars in sales in its first year.

As you consider producing value-added products, it is critical that you ensure their safety and healthfulness. There are three non-negotiable requirements: 1) the item must not contain any ingredient that has the potential to harm a consumer; 2) it must meet all the laws, rules and regulations of the country where consumed; and 3) all ingredients must be traceable. Failure to adhere to these essential requirements can negatively impact the trust a consumer has in the brand that sells the value-added seafood item, thereby causing customer loss and other negative financial implications. For example, with the value of Darden's brands being as much as 50 percent of its market capitalization, a loss of trust in one of its brands caused by a real or perceived food safety issue has the potential for significant negative financial consequences. This is true – not only of Darden, but of any publicly traded company. That's why food safety must be, first and foremost, a priority when you sell value-added seafood products.

We know that real opportunities exist for aquaculture suppliers of value-added products. While producing them will have many positive outcomes for you and your business, it will require a dedicated effort, as it will not be easy.

Let me close by saying that at Darden Restaurants, we welcome the opportunity to work with you and hopefully one day have your value-added aquaculture products on our menus.

Andrew Mallison

Manager – Seafood Procurement
Marks & Spencer plc

Andrew Mallison graduated in Fishery Science and was first involved in aquaculture over 25 years ago, working for Unilever Research in early salmon vaccination trials with Marine Harvest, Scotland. After graduating, he worked in the Australian seafood processing industry for several years, before returning to the United Kingdom. Specializing in developing seafood producers in Southeast Asia, and North and South America, Andrew worked in industries as diverse as Alaskan wild salmon, Peruvian hake and prawn farming in Thailand. Over the last 25 years, he has worked in canning, freezing and chilled seafood, covering most major commercial species. He joined Marks and Spencer in 1996 to manage their procurement of seafood, a range of 25 species both wild and farmed from over 20 countries. Achievements include being recognized as the leading United Kingdom retailer for responsible fishing and farming by Greenpeace and the Marine Conservation Society (United Kingdom) in 2005, 2006 and 2007; and an international award from the Seafood Choices Alliance presented at the 2006 Boston Seafood Show. Andrew is a member of the Scottish Executive Ministerial Advisory Groups for Aquaculture and Sea Fisheries.

Aquaculture – what retailers expect from producers

Andrew Mallison
Manager – Seafood Procurement
Marks & Spencer plc

ABSTRACT

The United Kingdom's market is seeing an increasing trend towards ethically produced foods, consumers buying into foods that are made with respect for the environment, animal welfare and human rights. At the same time, the image of aquaculture has been damaged by reports of antibiotic misuse, cruelty to farm animals and the presence of dangerous contaminants in farmed fish. Producers need to understand the needs of the final consumer and make choices about their farming methods, electing either for the low-cost commodity model or also offering higher-value products aimed at the ethical consumer. Producers should understand that the modern consumer is aware and increasingly better informed of how farm animals and fish are raised and will make purchase choices based on ethical standards.

INTRODUCTION

I am going to cover what retailers, at least in the United Kingdom, expect from producers of farmed fish and hope to provoke some thought on alternative market niches and production strategies. You have already heard about certification schemes and ecolabels, so I am going to concentrate on the consumer.

To help you understand what shapes these expectations, our position in the market place and our customer, I am going to tell you a little bit about Marks and Spencer, then explore some of the trends in the United Kingdom's market. I am then going to cover how the United Kingdom's consumer has been turned off farmed fish and some of the negative attitudes we now have to overcome. Then the important bit on how producers can make choices that affect the consumer, the image of farmed fish and the future market potential of aquaculture products. Finally, our thoughts for the future.

MARKS AND SPENCER

Our business was founded over 120 years ago by Michael Marks, Russian refugee who, because he could speak no English, opened a market stall where a big sign said "Don't ask the price, everything is one penny". He then formed a partnership with Mr Spencer, a local businessman, opened shops and our company was born. Today, our turnover is around US$16 billion, we have over 500 stores in the United Kingdom, a further 220 stores worldwide in 35 countries and employ 65 000 people (Box 1).

Our business covers three main areas: things you can eat, things you can wear and then there is everything else. We are a specialist food retailer and would carry around 3 500 food products, only 10 percent of the number of lines found in one of the United Kingdom's supermarkets like Tesco or Wal-mart/Asda. We only sell our own label and only sell premium products.

Our share of the United Kingdom's food market is around 4.5 percent, but we have a strong seafood business – in areas like fish delicatessen, we trade at around 20 percent share.

Principles

Our business has really been built on five main pillars:

- We are usually a "top up" shop, with customers completing a main weekly shopping trip at one of the supermarkets, then coming to us for the treats, the food for dinner parties or special occasions, or where they just need to know the food is the best available.
- Our quality must be better and different from that of our competitors, or few customers would bother making the extra journey to one of our stores.
- While we charge a premium for our foods, we believe it is still good value, as value is price multiplied by quality.
- Like any business, we must provide a good service to customers, creating products that are convenient, easy to use and offered when and where customers want them.
- We must innovate and provide new ideas and finally, but very important to this morning's discussion, our customers must trust us to meet their expectations.

It is this aspect of our business that made our sales increase when the rest of the United Kingdom's market suffered down turns after bovine spongiform encephalopathy (BSE) in beef, *Salmonella* in eggs and Avian Flu in poultry. The only time we have not seen this effect was in salmon during the polychlorinated biphenyl (PCB) and dioxin scare in early 2004; more on that later.

Trust in foods is becoming an increasingly important brand value but is also becoming increasingly threatened as the media expose bad practice in the food industry, usually driven by cost cutting and a lack of understanding of how the consumer will react to decisions made by the foods industry.

BOX 1

Marks & Spencer plc

- Founded in 1884
- Turnover ca. US$ 16 billion
- 500 stores in United Kingdom; further 220 stores in 35 countries
- 65 000 employees

Ratings

- Most sustainable United Kingdom seafood retailer – Greenpeace 2005, 2006
- Most sustainable United Kingdom seafood retailer – Marine Conservation Society 2006, 2007
- Leading retailer Dow Jones Sustainability Index, 2003–2006
- Leading retailer for animal welfare – United Kingdom Royal Society for the Prevention of Cruelty to Animals, 2006
- Seafood Choices Alliance Global Seafood Champion 2006

Ratings

We think we are on the right track to reassure our customers that we are taking care of the food we sell. Several independent surveys have rated us as the most sustainable seafood retailer in the United Kingdom, and last year the Seafood Choices Alliance honoured us with their global Seafood Champion award for our work in sustainable sourcing (Box 1).

These surveys show how high profile responsible sourcing has become and has driven real change in the retail sector. No one wants to come last.

In case you were thinking this is all very nice but is it profitable as well? – yes, it is. In our preliminary results for the last financial year, profits before tax and earnings per share were up by nearly 30 percent, and we have no doubt that part of this is due to our fulfilling the consumer's need for reassurance.

Trend for Ethical Products

We not only believe our principles are right for our customer but also for the market as

a whole. The United Kingdom is often seen as the trendsetter for other markets, and whether this is right or wrong, producers should be aware of developments in the United Kingdom and be able to take advantage of them should market opportunities arise.

We have seen the trend towards convenient foods as we become time poor and cash rich, towards more prepared foods as we forget how to cook at home, and the change in shopping habits from the big weekly "fill the car at the supermarket" to smaller more frequent purchases, often on the way home from work, to grab something to eat for that evening.

One of the clearest trends however, is for ethical products, and I am just going to go through some of the indicators that convince us we must recognize that consumers are becoming increasingly concerned about how their food is produced.

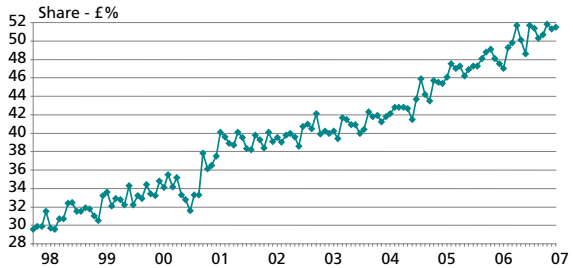
Hen eggs – free range share trends

The graph presented in Figure 1 shows how, over the last nine years, free-range eggs have increased from only 30 percent of the market to over 50 percent. For those not familiar with the idea of free range, the hens are allowed out of the sheds to range freely during daylight hours.

The eggs cost more but look the same as non-free range, probably taste almost the same –so why this increase in market share?

Photographs of hens raised in metal cages, standing on metal mesh, often with faeces from birds above dropping onto those below have been well publicized in the United Kingdom. Feathers are missing and the animal-loving British consumer can't help but find the system of keeping hens, also known as "battery farming", repulsive. On the other hand, photos of healthy hens with fresh grass underfoot, fresh air to breathe and sunshine to enjoy instinctively makes you feel that eggs from these hens are not only going to taste better, but by paying a few pennies more, you are helping the hens have a better life.

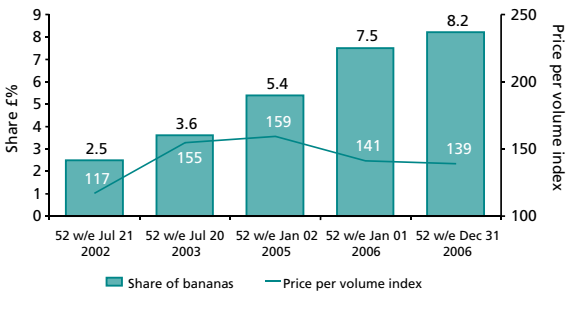
FIGURE 1
Hens' eggs – "free range" share



Fairtrade bananas

I am sure many of you will have heard of Fairtrade, supporting small growers and giving a premium back to the producer. Again price is higher; eating quality may not be that much different but, as you can see, there has been a steady increase of market share, four times higher in 2006 compared to 2002. Now that price is becoming more affordable as volume increases, shown in the graph in Figure 2 as the green line, we expect this trend to accelerate as consumers want to help small farmers around the world.

FIGURE 2
Fairtrade bananas – performance analysis



Organic foods

One of our fastest growing sectors is organic foods, and this mirrors the trend in the overall United Kingdom's food market. Prices are higher but consumers are attracted by reduced use of chemicals, better animal welfare and more "natural" products. Our business has committed to tripling the amount of organic foods we sell over the next five years.

Ethical trading

As we have seen with the emergence of Fairtrade, consumers want to know that workers in developing countries are protected and not exploited. Major international brands have been badly damaged through media exposures of poor working conditions in the manufacture of their goods, risking injury to workers or allowing the employment of children. In 1998, the Government of the United Kingdom set up the Ethical Trading Initiative, where information could be shared and standards agreed, now representing around 200 billion dollars of trade.

Marks and Spencer are a member of the Ethical Trading Initiative and would not trade with any company that does not meet our global sourcing standards and could risk damaging our reputation.

CUSTOMER EXPECTATIONS

Some recent research published by the Seafood Choices Alliance in the United Kingdom had some interesting findings on how the awareness of sustainable, responsible sourcing of seafood had penetrated the market and industry. These findings show that the consumer values environmental impact second only to freshness and above price, that business has accepted the need for sustainable sourcing and, if marketed properly, the consumer is prepared to pay a premium for the products.

Customer expectations of M&S

Over the last few years, we have asked our customers what they expect of us. From 2004 to 2005, the expectation to act responsibly increased from 75 percent to 97 percent and has stayed there. Last year, 78 percent of our customers wanted more detailed information on where our products come from and the standards that we apply to our suppliers. It is very clear to us that the market expects responsibly produced goods, has expectations of retailers and we, in turn, must apply these standards to our suppliers.

Farmed fish at M&S

We sell a lot of farmed fish. Our single biggest species, at around double the second largest by volume, is farmed Atlantic salmon. We also sell a number of other species (e.g. rainbow trout, prawns, Atlantic halibut), and as we progress, more farmed products such as cod, barramundi and maybe tuna will follow.

The demand for seafood is outstripping the ability of wild stocks to supply, and rightly or wrongly, the shortfall is being made up by aquaculture. How we deliver this additional supply is the key message in this presentation. Let's just look at some of the information our customers receive in their daily lives.

What customers see

As I mentioned earlier, in 2004, the United Kingdom's salmon market was hit hard by widespread media reports of dioxins and dioxin-like PCBs in farmed product. The fact that the samples had been taken some two years earlier, before changes to European Union (EU) controls on fish oils in feedstuffs, was not mentioned; and millions of dollars worth of sales were lost as customers stopped buying salmon.

The Government of the United Kingdom referred the issue to an expert group, the Committee on Toxicity, who found that the benefits of eating oily fish far outweighed the potential risk from contaminants and supported the official advice to eat oily fish. However, the damage was done and it took the rest of 2004 for sales to recover.

In Asia, it is not salmon but farmed prawns that have developed over the last 20 years. As with any industry, there have been examples of how prawns should be farmed and how they should not. Groups like the World Wide Fund for Nature (WWF) and the Environmental Justice Foundation have raised concerns about environmental impact, and the industry has responded with Codes of Good Practice.

However, there are still mistakes being made. For a small farmer looking at an outbreak of disease and the loss of his investment, it must be tempting to continue to use illegal antibiotics to treat the crop, and we are still seeing detections of illegal medicines on testing of imports into the EU, further damaging consumer confidence.

As if antibiotics, toxins and ruined farmland were not enough, there are also reports of local people and the animals themselves being mistreated. Add the threat of genetic engineering to create supersized fish, and it all adds up to a scary story (Box 2).

BOX 2
What customer's see about aquaculture in the media

- toxins and contaminants
- environmental impact
- illegal antibiotics
- human rights abuses
- animal welfare abuses
- genetic modification

What customers think

It is not very surprising then that the industry had managed to give itself a real PR problem. In Box 3 you can see that, on the plus side, consumers would eat more farmed fish to save wild stocks and that 65 percent are still going to buy regardless of adverse reports; the downside is that 25 percent would buy less fish if they knew it was farmed.

BOX 3
What customers think

- 54 percent are concerned about fish farming
- 65 percent say it will not change their behaviour
- 12 percent say it makes them buy less fish
- 58 percent say they would be happy to eat farmed fish to protect wild stocks
- 26 percent say if they knew a product was farmed they would buy less

Source: Seafish Industry Authority (United Kingdom)

THE FUTURE FOR M&S

A quick recap. We have a customer who is increasingly concerned about ethical issues, a market place full of negative messages about fish farming and evidence of this resulting in a developing resistance to farmed products. So what are we doing about it?

We are responding to the ethical consumer by trying to tackle the major challenges of the twenty-first century. Over the next five years, we are spending around US$400 million on becoming carbon neutral, sending no waste to landfill, sourcing sustainable raw materials, being a fair partner in the way we buy and taking steps to improve the health of our customers and employees.

This means we are going to be tripling the amount of organic food we sell, and finding ways of reducing the distances traveled by our foods from producer to processor to store. We will be selling more Fairtrade products, and all of our wild fish supplies will be certified sustainable by independent schemes such as the Marine Stewardship Council.

THE FUTURE OF AQUACULTURE

We see farming developing into two main areas and, for producers, the question is which is right for your business. The commodity model is high volume, efficient and primarily cost driven. When opportunities come along to reduce cost, they are taken up but without considering what the reaction from the final consumer may be. The mad cow disease scare in the EU was the result of a decision to use cheap protein from sheep in the feed for cattle, a choice most consumers would find unnatural.

The other model is the niche model, where the product is designed for a particular market or customer, accepting that some aspects of how the fish is farmed may be more expensive, but that the final consumer is willing to pay for this standard. Also implicit in this model is a responsibility for understanding the consumers' expectations

BOX 4
Low-cost or high-value feeds?

Option 1 – cost model
- Cost-driven formulation
- GMOs
- Consumer-averse ingredients (chicken feather meal, pork blood meal).

Option 2 – value model
- Formulated for eating quality as well as growth
- No GMOs
- Consumer-friendly ingredients (close to wild)

BOX 5
M&S "shopping list

Basic requirements that must be delivered
- eating quality
- safe & legal
- value

How fish should be farmed and what we believe our consumer wants:
- respect for workers
- low environmental impact
- attention to animal welfare
- feed materials sustainability and ethically obtained
- No GMO feed ingredients

in the way the fish is grown, ensuring that everything is done as if the final consumer were seeing everything on the farm and at the feedmill.

These two models are not mutually exclusive, and a farmer may be able to segment his production, using some sites for niche, high-value and others for commodity crops. We saw how the United Kingdom's consumers are responding to better farming conditions for free range eggs; the same will happen when consumers look into farmed fish.

Intensive or extensive prawns

Intensively reared prawns now dominate the market, but will they start to lose market share to more extensive production as consumer awareness of farming methods grows?

Low-cost or high-value feeds?

One of the biggest costs in farming is feed, and again farmers need to choose where they are on the scale between the low-cost model (Box 4, Option 1), which is all about cost, and the value model (Option 2). Feed is becoming an increasingly important battleground as the drive for sustainable and ethically sourced ingredients meets the demand for lower costs.

As non-genetically modified (non-GM) soya becomes harder to source and therefore more expensive, will producers move to GM crops? Do farmers know which species go into the fish meal in their feed? Are they well managed or endangered? As a retailer in the full spotlight of the media, we are very clear that low-cost feeds made from GM soya, unknown sources of fish meal or some of the less natural proteins like chicken feathers is a false economy – all it takes is one media report to drive our customers away.

While alternative protein sources may be ethical and perform well, it is the consumer who must be convinced that the feed ingredients we choose are acceptable.

OUR SHOPPING LIST

My presentation was called "What retailers expect from producers". Well, I can't really speak for all retailers, and there are many different markets with different needs. However, for our business, here is what we want. (Box 5)

Aquaculture producers need to decide if the low-cost or high-value model is right for them. How fish is grown and fed is increasingly important to the consumer and the reputation of the retailers. The high-value model may cost more to produce but if that is what the consumer wants, let's deliver it.

To close, I will just leave you with one simple message.

THINK CONSUMER

Linda Chaves

National Marine Fisheries Service
National Oceanic and Atmospheric Administration
United States Department of Commerce

Linda Chaves has had a career with the National Marine Fisheries Service (NMFS) since the late 1970s, working in a number of areas, including development of underutilized resources from the west coast and Alaska, improving market access for United States. fisheries products throughout the world, representing the United States in fisheries trade negotiations and disputes, developing regulatory infrastructure and research proposals for aquaculture development, and overseeing programmes and projects dedicated to seafood and health issues. She has represented the United States in international meetings and fora to advance United States fisheries interests in the World Trade Organization (WTO) and other international fora, including OECD, Asia Pacific Economic Cooperation forum (APEC), and the FAO Subcommittees on Trade and Aquaculture. She was the Director of the national Office of Industry and Trade and the Office of Constituent Services at NMFS from 1993 through 2003, when she was named the National Aquaculture Coordinator. She was subsequently appointed to be the Senior Adviser on Seafood Industry Issues to the NMFS director in December 2004 and now works primarily on fisheries trade, aquaculture, and seafood and health issues.

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The new consumer: seafood and health benefits

Linda Chaves
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
United States Department of Commerce

ABSTRACT

Today's consumer is much more educated, health conscious, demanding and inquisitive about what he or she will eat than the consumer of recent years. Consumers have become very interested in the health benefits and risks of seafood consumption, as well as environmental, social, and sustainability issues surrounding how the food they eat is produced, and of course they want to make sure that their seafood is safe. During the past several years, there has been a growing tide of evidence confirming the health benefits of all seafood, farmed and wild, for people of all ages. As nutrition and medical professionals accept the role of seafood in the diet for reducing the risk of coronary heart disease, new and exciting research suggests that a seafood-rich diet also helps in neurological development of the foetus, infants and children. Other studies have emerged that link diets high in seafood to mental health, the absence of depression and other behavioural disorders, and lower risk for other disease mechanisms. This new evidence should be good news to producers of seafood, particularly aquaculture products. The industry has an opportunity to produce healthy, safe products for an increasingly demanding market. Because the entire life of the cultured species is under its control, the aquaculture industry has the advantage over wild producers to produce a product that meets a nutritional profile aimed at increasing the health of consumers and providing essential nutrients to people young and old.

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Dr Michael Phillips is R&D program manager and environment specialist for the intergovernmental organisation of the Network of Aquaculture Centres in Asia-Pacific (NACA). Dr Phillips received his PhD from the University of Stirling, UK, in 1982 and has been working with NACA in Asia since 1992. Major responsibilities include building the research and development programmes of NACA, involving development of partnerships among governments, industry, scientific institutions, regional and international organisations and donors involved in aquaculture, aquatic resources management and rural development; incorporating environmental sustainability and management into NACA's regional aquaculture development programme; assistance in development of NACA's human resources development programmes, preparation and management of national and regional aquaculture development project activities; and recent emphasis on development of "better management principles and practice" documents and certification for responsible aquaculture. Dr Phillips was a co-director of the Consortium Program on Shrimp Farming and the Environment, that received a World Bank "Green Award" during 2006.

Aquaculture production, certification and trade: challenges and opportunities for the small-scale farmer in Asia

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ABSTRACT

This paper focuses on small-scale farmers in Asia and the challenges and opportunities faced in participating in global market chains for products from aquaculture. The bulk of aquaculture production in many countries in Asia is from small-scale, family-owned operations, perhaps making up to 80 percent of the production. The small-scale aquaculture sector is important for rural development, employment and poverty reduction. Small-scale farms may be diffused through a local area district or highly concentrated around specific resource (e.g. water supply). The small-scale sector, while innovative and a highly important part of the region's aquaculture production, faces increasing constraints, particularly for export crops such as shrimp. These include changing costs and business structures, access to modern market chains, exposure to increased market risks, increasingly stringent standards for food and other requirements, and limited access to markets, technical and financial services and knowledge. The commercial/government servicing, while well developed in Asia, also tends to be less oriented towards the small-scale farmer. Increasing trends towards certification, traceability and quality assurance schemes also risk disadvantaging the sector unless positive actions are taken to involve small-scale farmers and develop focussed strategies to ensure their participation. No certification scheme as yet targets the small-scale sector, but there will be significant social and economic benefits if the sector can be effectively serviced to participate in modern market chains. Some examples of the way forward are provided, including development of small-scale farmer organizations, group certification and services oriented towards the small-scale sector and the business opportunities it represents. These are rather new approaches for aquaculture, but lessons could be learned from other sectors, including agriculture and Fair Trade certification schemes. Recommendations to governments and the business sector for ensuring the participation of the small-scale aquaculture farmer in certification schemes and modern market chains in Asia are included.

INTRODUCTION

This paper focuses on small-scale farmers in Asia and the challenges and opportunities faced in participating in global market chains for products from aquaculture. The purpose of focusing on small-scale farmers is to raise attention to this large and important part of the aquaculture sector and the influence of production and market changes on the livelihoods of the many people involved.

Statistics on the small-scale aquaculture sector are poor, but it is important for rural development, employment and poverty reduction. The bulk of aquaculture production in many countries in Asia is from small-scale, family-owned and operated operations, perhaps making up to 80 percent of the farming community in some countries. Small-scale farms may be diffused through a local area district or highly concentrated around a specific resource (e.g. water supply). The sector, while innovative and a highly important part of the region's aquaculture production, faces increasing constraints, particularly for export crops such as shrimp.

Aquaculture is under transformation. It is not only growing in response to the huge demand for global seafood products and stagnation in capture fisheries, but especially for higher-value internationally traded export species such as shrimp. There is a trend towards a more integrated production-distribution chain with more focus on coordination between the aquaculture farmers, the processors and the retailers and to some extent the consumers and restaurants. It is no longer adequate for the farmers and organizations helping farmers to focus only on increased production; but it is now also important to understand how to link farmers to the production chain, how to produce high-quality and safe products, and how to have on-farm management practices that are highly efficient, taking account of the surrounding environment and social issues related to production. A further factor is the trend towards traceability, certification and improved farm management that is driving costs and responsibilities down the market chain to the farmer.

These global trends require changes in management for both large and small-scale farms to stay competitive. Whereas some larger farms with large product volumes and access to finance usually have the capacity to adapt and benefit from such trends, there are still many uncertainties related to the influence of such trends on small-scale aquaculture producers and their adaptation and participation in modern aquaculture production and market chains.

CERTIFICATION IN AQUACULTURE

Certification is rapidly being introduced to aquaculture, including mandatory and voluntary schemes. There are already a number of voluntary schemes emerging, and the number of certification programmes and labels for aquaculture products is expanding. Development and implementation of certification schemes is considered as one tool to help towards a more sustainable aquaculture production and at the same time link and inform different stakeholders in the production chain (Anon 2007).

At the same time, the trend towards certification risks disadvantaging small-scale aquaculture farmers unless positive actions are taken to involve small-scale farmers and develop focused strategies to ensure their participation. Surprisingly, no certification scheme as yet targets the small-scale sector, but there could be significant social and economic benefits if the small-scale sector can be effectively serviced to participate in modern market chains. Some of the constraints that the small-scale aquaculture sector faces related to certification include:

- small volumes of product from individual farms and large numbers of farms;
- low or no market incentives as yet to become involved in certification;
- complex marketing channels making traceability difficult;
- limited access to market, technical and business knowledge and related infrastructure;

- limited or inequitable access to financial services for investment in changes that may be required for certification;
- lack of formal farm registration and producers groups;
- inadequate traders-credit relations;
- lack of an export product, with farmers producing to least cost to sell within a less wealthy domestic market;
- commercial/government servicing less oriented towards the small-scale farmer;
- risk management strategies of larger traders and buyers requiring large volumes of product working against small-scale farmers producing small quantities of product.

The above issues need to be addressed. It is a matter of great importance to the industry and to a large number of people who depend on aquaculture as their main livelihood to engage small-scale farmers in the development of certification schemes to ensure equitable participation. There is a need to better understand the process, standards, their applicability, and the opportunities and challenges for small-scale farmers to benefit from certification systems.

It is unlikely in the near future that many individual small-scale farms can be easily certified, but one way forward may be to promote group certification or certification of clusters of small-scale farmers, an approach that has been used successfully in other agriculture sectors (e.g. organic products) (IFOAM undated). The nature of small-scale farmers is that they only produce small quantities of product, making it difficult and inconvenient for larger buyers who prefer larger volumes. The need for solutions to allow small-scale farmers to participate in market chains requiring certified aquaculture products is therefore evident.

EXAMPLE FROM INDIA

As part of a technical collaboration between the Marine Products Export and Development Authority (MPEDA) and the Network of Aquaculture Centres in Asia-Pacific (NACA) on shrimp disease control and coastal management in India, a village demonstration programme was conducted from 2002 onwards. The objectives of the programme were to:

- reduce the risk of disease outbreaks and improve shrimp farm production;
- organize the farmers under "self help groups"/"aquaclubs" for sustainable production; and
- produce better quality shrimp in a socially acceptable, environmentally sound and economically viable manner.

The programme was successful in improving organization of the small-scale sector and reduced risks, with nearly 800 shrimp farmers now participating across all of India's shrimp aquaculture producing states. Key elements of success include:

- the development of locally appropriate "better management practices" (BMPs) formulated with farmers, based on a science-based epidemiological study of shrimp disease risks and the International Principles for Responsible Shrimp Farming (MPEDA/NACA 2003, FAO/NACA/UNEP/WB/WWF 2006); and
- support to formation of farmer clubs (so-called "aquaclubs") within villages and within "clusters" of farmers. Clusters were defined as a group of interdependent shrimp ponds, often situated in a specified geographical locality and dependent on the same water source.

One of the most significant outcomes of this project is the reduction in disease prevalence and improved farm profitability as a result of BMP implementation in aquaclub farms. Successful implementation of BMPs reduced disease prevalence and increased the number of planned (normal) harvests leading to better crop outcomes, improved efficiency in use of key inputs (feed, seed) and profits. Another key to success was the development of farmer clubs, leading to a number of key benefits including:

- regular information exchange/sharing of knowledge on BMPs among farmers within the group and increased awareness among farmers;
- cooperation in buying high-quality farm inputs (seed, feed, lime etc.) at competitive price;
- increased interaction between farmers and input suppliers/farmed product buyers;
- stronger bargaining power of clubs in the purchase of farm inputs and sale of harvest, in the former case leading to reduced prices for bulk purchase;
- increased cooperation in sharing common facilities and in area improvements such as deepening of water inlets and unclogging of water supply/drainage canals;
- collective approach to dealing with common problems, including local environmental protection, especially protection of common water sources; and
- facilitation of farm licensing and formal registration of clubs with government. The formal registration has also recently opened opportunities for group members to access financial support from local banks.

Although the farmers are not yet formally certified, a farmer club and cluster management system in place provides a basis for moving forward towards voluntary certification.

WAYS FORWARD

The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector but faced with many problems and constraints in the modern trade and market environment. The sector is socially and economically important and cannot be ignored. Fortunately, recent experiences show that there are ways to assist small-scale farmer participation in modern market chains and trade.

One important way is the organization of farmers into producer groups. Examples from India and elsewhere show organized farmers can speak with a louder voice in negotiating prices for inputs such as feed and seed and potentially also have a better platform for more organized marketing and price negotiation when selling the product. A farmer group also allows buyers and extension facilities to have a focal point and hence reach a larger number of farmers with reduced costs. The way forward then is for public and private-sector investments to assist the small-scale sector to adapt and participate in modern market chains for aquaculture products. The public investments needed include:

- development of policy that is more favorable to the small-scale sector and at the very least, based on the requirements and realities of the small-scale aquaculture farmer;
- technical and marketing services that are more oriented towards small-scale aquaculture producers, as well as the small-scale traders and businesses associated with the sector;
- facilitating access to financial and insurance services in rural aquaculture farming areas;
- market access arrangements that support small-scale producers;
- information services that cater to the needs of rural farmers;
- encouraging private investment in small-scale aquaculture production and services;
- social "safety nets" for the most vulnerable producers and traders; and
- orientation of educational and research institutions towards supporting the small-scale aquaculture sector.

Trade rules and guidelines, including certification guidelines, also need to consider carefully the needs and realities of the small-scale sector.

There are many opportunities for private investment to support millions of small-scale farmers. Private-sector investments are needed in:

- technical and marketing services for small-scale aquaculture producers;
- information services;
- microfinance and financial services;
- insurance services; and
- input packaging and delivery for small-scale farmers.

We also consider that there is a business case for investment in the small-scale sector. In India, for example, an investment of US$ 80 000 in technical servicing in 2006 led to crop improvements worth US$ 2 million. Given that 70 to 80 percent of producers in Asia are small-scale, an investment in servicing the small-scale sector could therefore be a potentially profitable one.

"Corporate social responsibility" (CSR) also has a role to play in private-sector involvement in small-scale farming, particularly the larger retailers and trading businesses that are becoming increasingly powerful. These larger businesses should be encouraged to adopt more CSR initiatives in the aquaculture sector, such as

- facilitating market access for small-scale aquaculture producers;
- providing technical and financial assistance to small-scale producers to comply with market requirements; and
- developing brands and marketing favorable to aquaculture products from smaller producers.

Certification and quality assurance schemes are also needed that are relevant and practical for small-scale aquaculture producers. A focus on the advantages from small-scale producers should also be possible with regard to both environmental and social issues related to the production. Development of a small-scale certification scheme oriented towards "Fair Trade" as applied to some agriculture products should also be explored.

While many challenges clearly remain, with many questions, it is time to recognize the crucial role of small-scale aquaculture farmers in Asian aquaculture production and trade. The small-scale sector is the largest producer and the "mainstay" of Asian aquaculture. It is an innovative sector but faced with many problems and constraints in the modern trade and market environment. It needs investment from both public and private sector to compete and thrive in the modern aquaculture scene. There are many opportunities for assistance and investment. Ideas and partnership are certainly welcome!

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Manfred Klinkhardt is a marine and fisheries biologist. Prior to starting his work as a freelance journalist in the seafood business, he worked many years as a scientist at the University of Rostock (Germany). His main working fields include the biology of spring-spawning herring (migration patterns, spawning behaviour, influence of environmental factors on mortality of herring eggs), the embryology of some fish species (salmonids, cyprinids, percids), and the chromosome structures of fishes. Since 1997, he has been working as a seafood journalist, mainly for the international journal *Eurofish-Magazine* and German *Fischmagazin* (member of the editorial team). Manfred Klinkhardt is author or co-author of several scientific and popular books. He has published extensive reports about the seafood industries of Iceland, Norway, Spain, the Netherlands, the United States of America, Canada, Chile, Viet Nam, Thailand and others.

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Bjørn Myrseth has worked with salmon farming since 1971 and has been involved with starting fish farming companies in Norway, the United Kingdom, Canada and the United States, as Managing Director of Sea Farms AS. This company was listed on the Oslo Stock Exchange as the first fish farming in 1985. From 1987, he has been Managing Director and one of the owners of Marine Farms ASA. This company started farming of salmon in Chile and the United Kingdom in 1987 and of seabass and seabream in Greece the same year. Today Marine Farms ASA has operations in the United Kingdom (salmon), Spain (seabass and seabream), Belize (cobia) and Viet Nam (cobia). In October 2006, Marine Farms ASA was listed on the Oslo Stock Exchange. The Company has about 300 employees and a turnover of about US$110 million. Bjørn Myrseth has given presentations at many international meetings on topics related to aquaculture. He has been President of European Aquaculture Society from 1992–1993. He received as Master's Degree in Fishery Biology from the University of Bergen in 1971.

New aquaculture candidates

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ABSTRACT

Global aquaculture is growing at a breathtaking speed. The quantities produced every year are not only increasing, the range of species farmed is also broadening. Some of them will probably remain niche products in the foreseeable future but others have the potential to conquer the world market. The time it takes from the development of efficient farming technology to large-scale production of a fish species is constantly decreasing. The success story of *Pangasius* proves that – provided the quality and the price are right – it often takes only a few years for a "new" fish species to capture the world market. While most fishes are currently still produced in the freshwater segment, it seems that the future will soon belong to marine species. This article presents several species that are considered to be particularly promising candidates for aquaculture. A lot of them are already produced in aquaculture but have still not made the definitive breakthrough – some of them for technological reasons, others due to economic considerations. At present, there are two fish species that are considered to stand a particularly good chance of market success: Atlantic cod (*Gadus morhua*) and cobia (*Rachycentron canadum*).

INTRODUCTION

All over the world new fish and seafood species are being sought that could be suitable for production in aquaculture. Two issues play a particularly important role in the selection process: has the technological side of farming been mastered, particularly reproduction, and is it possible to farm the species at a reasonable cost? The question of cost is of great significance for all species that have to face competition on the market from similar products from capture fisheries. While aquaculture producers have to pay for fry, feed etc. and also bear the risks involved in farming, fishermen can harvest what nature offers them at considerably less expense.

SEABREAM (FAMILY SPARIDAE)

One of the most interesting families for aquaculture is seabream (Sparidae). Apart from gilt-head seabream (*Sparus aurata*) of which 110 705 tonnes were produced in 2005, particularly in the Mediterranean region, other species are also produced worldwide. Total production of Sparidae in 2005 was 245 217 tonnes. Japan produced 76 082 tonnes of *Pagrus auratus*, and China 44 222 tonnes of unspecified Sparidae species. Beyond that, of the nearly 110 species in this family, other species that are regularly or occasionally produced in various quantities include:

- *Sparus hasta;*

- *Diplodus puntazzo;*
- *Dentex dentex;*
- *Pagellus erythrinus;*
- *Acanthopagrus schlegelii;* and
- *Acanthopagrus latus*

During the past few years, Spain's aquaculture industry succeeded in developing farming technology for red seabream (*Pagellus bogaraveo*). Although this fish species is susceptible to stress and the survival rate of the eggs and larvae is currently only 5 percent (industry standard for gilt-head bream is over 30 percent), there is sufficient stocking material available to ensure industrial production on a small scale. Spain registered an annual production of 118 tonnes in 2005, and production is expected to reach 300 tonnes in 2007. At present, the industry is trying to close the farming cycle completely and to build up a spawning stock from farmed fish. Because the fish are not ready for spawning until they are six or seven years old, this will take some time. The fry are transferred to net cages in the sea at a weight of 10 g. Red seabream grows slowly, so it takes about 36 months for them to reach 700 to 1 000 g (mortality is 10 percent at this time).

BARRAMUNDI (*LATES CALCARIFER*)

Barramundi, also called Asian seabass, has really already long lost its status as a candidate for aquaculture, for it is in the meantime farmed in considerable quantities in some Asian countries. In 2005, 30 970 tonnes were produced worldwide, over 90 percent of them in four main producers: Thailand (13 900 tonnes), Taiwan Province of China (7 862 tonnes), Malaysia (4 191 tonnes) and Indonesia (2 935 tonnes). In spite of this, it is still probably not wrong to call barramundi one of the "rising stars" of aquaculture, for in other regions of the world farmers only began taking an interest in this fish species during the past few years. Viet Nam and China have purchased fry to build up their own stocks. A barramundi farm has gone into operation in Massachusetts in the United States and in India, too, the species is considered a promising candidate for coastal mariculture. Already in the year 2000 a hatchery was opened in the Sirkazhi (Tamil Nadu) District.

Australian barramundi production rose more than a hundredfold from 15 tonnes in 1990 to 1 763 tonnes in 2003. One of the advantages of this diadromous migratory fish species is its salinity tolerance, which makes it possible to farm it in fresh, brackish or seawater. Barramundi grow quickly, particularly during their first year. It takes only 18 months from the fry to a 3-kg fish. Fish of this size are used for fillet production, while those weighing 400 to 600 g are used for portion fish.

The bottleneck in barramundi farming is fry production. Normally the fish lay eggs five to six times a year. Efforts are being made to optimize production of larvae and to eliminate *Artemia* from the farming process. Some hatcheries have already succeeded in at least partially replacing live feed with formulated feed. Fish that are raised on dry feed are even said to grow more quickly and uniformly. It is important that the fry are the same size to prevent cannibalism.

GROUPER (FAMILY SERRANIDAE)

About half of the 450 known members of the family Serranidae are traded under the unspecific name of "grouper". Due to high pressure from fisheries, 70 percent of grouper stocks are in the meantime considered to be overfished. Groupers are particularly susceptible to overfishing; they grow relatively slowly, can live to a considerable age and do not reach maturity until late in life.

It would thus seem very reasonable to farm groupers in aquaculture. About 15 grouper species are farmed regularly throughout the world. Most of these species belong to the genus *Epinephelus*, and it is mainly the two species *Epinephelus coioides* and *E. malabaricus* that are farmed. Other important groupers from aquaculture are:

- *E. amblycephalus;*
- *E. fuscoguttatus;*
- *E. lanceolatus;*
- *E. sexfasciatus;*
- *E. trimaculatus;*
- *E. quoyanus;* and
- *E. bruneus.*

Developments in grouper aquaculture (*Epinephelus* species) have been dynamic. A total of 9 410 tonnes was produced worldwide in the year 2000. By 2005, production had already risen to 65 055 tonnes. China and Taiwan POC are mainly behind this growth. China, which appeared in the FAO statistics for the first time in 2003 with a production of 26 790 tonnes, was already the biggest grouper producer in the world in 2005 with 38 915 tonnes. Despite high growth rates, however, aquaculture has so far only played a subordinate role in market supply. It is estimated that 15 to 20 percent of the groupers consumed worldwide come from aquaculture.

The biggest problem in grouper farming is obtaining fry. Although some species can already be hatched, most of the fry used for farming are caught in their natural environment (capture-based aquaculture). It is estimated that every year about 60 million juvenile grouper are caught to stock farms (for comparison, the total number of fry originating from hatcheries throughout the world is less than one million).

In spite of some success in more recent times, hatching groupers still poses a problem. Nearly all grouper species undergo sexual change. Usually the fish are initially female and do not become male until a later age. Spawning is governed by several interior and exterior factors simultaneously (e.g. hormone level, tides, temperature, moon phases) that are not easy to simulate under farm conditions. Feeding the larvae is also a problem. Reproduction is furthest developed in Taiwan POC, where two-thirds of the groupers in aquaculture are said to come from artificial reproduction. Taiwanese farmers apparently bring forward the fishes' sexual transformation by injecting hormones and thereby increase the share of male fish in the stock. There are ten big hatcheries in the country that hatch 15 grouper species more or less regularly, particularly *Epinephelus coioides*, *E. malabaricus*, *E. lanceolatus* and *E. fuscoguttatus*, to supply the country's approximately 600 grow-out farms.

SABLEFISH (*ANOPLOPOMA FIMBRIA*)

Sablefish, also called black cod, is one of the most valuable commercial fish species in the North Pacific. Its white, fat-rich, tender flesh is part of the standard range at sushi and sashimi restaurants. The most important market for sablefish is Japan. Due to its high market value, this fish would be excellently suited to aquaculture. Although there have been several attempts to farm sablefish, all of the projects failed so far due to financial or biological problems. Another farming project began in British Columbia (BC), in western Canada in 2003 with the establishment of a commercial hatchery. The company hopes to build up its own spawning stock from wild catches and then perfect reproduction and hatching technology.

As is often the case when farming marine fish species, feeding the larvae is a big problem in sablefish farming too. Hatching success fluctuates strongly from batch to batch, and there are occasional setbacks. Backbone deformations are frequent in the fry. Such defects are hardly detrimental to survival but the fishes are not very attractive and thus difficult to market. The investors who are behind the sablefish hatchery have also set up a grow-out farm with 12-m net cages on the Sunshine Coast (BC). Within two years, the fish there will have reached a marketable size of 2.5 to 3 kg. The main buyer is Japan.

POMPANO (*TRACHINOTUS* SPP.)

Some species of the genus *Trachinotus* (family Carangidae) are particularly popular in certain parts of the world. Capture fisheries fluctuate strongly from year to year, with a downward tendency. In 1983 the catch still amounted to 55 234 tonnes; in 2005 it was only 4 525 tonnes.

Due to the constantly good demand for these fish, pompano species are promising aquaculture candidates with good market predictions. Hatching and farming technology are still at an early stage, however, and production volume fluctuates very strongly. Some 330 tonnes were farmed worldwide in the early 1990s, but in 2005 production was only 55 tonnes (34 tonnes from Singapore, 18 tonnes from Hong Kong, SAR). An American company is currently making a new start with producing *Trachinotus carolinus,* which is one of the most expensive fish species on the United States market.

CROAKER (*ARGYROSOMUS* SPP.)

In several European countries interest has grown in farming croaker, also called meagre or corbina. Aquaculture production is currently only 800 tonnes but has displayed considerable growth over the past few years. A total of 33 tonnes was produced in 2000; 800 tonnes in 2005. The main producer is Spain with 347 tonnes, followed by France with 267 tonnes and Italy with 186 tonnes. The species already grows very well at temperatures of 16–20 °C, and it has a high market value, particularly the larger fish weighing over 2 kg.

A further species of this fish, Japanese meagre (*A. japonicus*), is farmed in southern Australia. The main buyer for this species is the United States. This white fish is considered an inexpensive substitute for Chilean sea bass (*Dissostichus eleginoides*).

ATLANTIC HALIBUT (*HIPPOGLOSSUS HIPPOGLOSSUS*)

Despite good progress Atlantic halibut is not farmed on a large scale and probably never will be. The high production costs and market prices paid for this fish species make farmed halibut a niche product. Experts believe that total production, which amounted to 1 445 tonnes in 2005, could stabilize at around 3 000 to 5 000 tonnes during the coming years.

The market for Atlantic halibut is probably viewed too optimistically in many forecasts, however. In Europe, the species can only be sold in larger quantities in Norway, Sweden and Great Britain. North America would be a lucrative market were it not for the competition from Pacific halibut (*H. stenolepis*), of which more than 40 000 tonnes are still caught per year in the Pacific.

Halibut farming is complicated and costly. It takes about five years to farm the fish to a marketable size of 5 to 7 kg. The biggest problem is supply of fry in sufficient quantity and good quality. Usually the fry are kept in on-shore tanks until they reach a weight of 1 to 1.5 kg before they are put into cages in the sea. This lengthy phase in land-based tanks pushes the production costs up. Although the price for fry fell from €7 to 3.60 to €2.50 per fish, it is still relatively high. In spite of attractive market prices, there are only a few companies that make profits with halibut farming; and if market supply continues to rise, prices might even fall.

TUNA

Capture fisheries of the most important tuna species (albacore, yellowfin, skipjack, bigeye, bluefin) rose from 3.84 million tonnes in 2000 to 4.25 million tonnes to in 2005. This rise was mainly the result of higher catches of skipjack (over 50 percent) and yellowfin (30.5 percent). The high-quality bluefin species that are particularly popular on the sushi and sashimi market account for only 0.9 percent of the total catch. This gap is a chance for aquaculture. Tuna farms have been set up in several different regions around the world within just a few years. It can at present only be guessed just

how much is produced there. FAO figures name a total production in 2005 of 22 995 tonnes. According to the tuna farming industry's own figures, however, they already produced approximately 32 500 tonnes in 2004. The main tuna-farming regions are the Mediterranean (Spain, Croatia, Cypress, Italy, Tunisia), Central America (Mexico) and Australia.

Tuna farming is a typical form of capture-based aquaculture: young tuna are caught in the sea and put into net cages where they are grown to a marketable size. This technology was first used in 1985. To stock the huge net cages in the sea (which sometimes have a diameter of up to 100 m), young fishes are mostly caught at a weight of 15 to 45 kg. On average, the tuna are fed for three to six months in the sea cages, during which time their weight usually increases by a third. Inexpensive fish species such as herring, sardines, anchovies and sardinellas or mackerel serve as feed. Harvesting is usually carried out on order when the quality and size of the fish fits demand and the prices are right. The tuna produced in aquaculture are mainly species with a high market value:

- northern bluefin (*Thunnus thynnus thynnus, T. tonggol*);
- southern bluefin (*T. maccoyii*);
- bigeye (*T. obesus*);
- yellowfin (*T. albacares*); and
- albacore (*T. alalunga*).

In volume terms, bluefin species account for more than 90 percent of production. They get the highest prices on the market.

Although farmed tuna only accounts for 4 percent of the Japanese tuna market (450 000 –500 000 tonnes), it is of great significance because it is traded almost without exception in the high-price toro (belly of the fillet) segment. While the share of toro is only 30 percent in capture fisheries, it is practically 100 percent in the aquaculture sector. This led to oversupply of high-value species and to a considerable price drop on the sashimi market. Supply of bluefin, for example, rose by more than 50 percent (80 percent of growth came from aquaculture). The Japanese sashimi market is now divided in two, with a high-price segment for wild tuna from capture fisheries, which gets top prices, and a mass market for farmed tuna, which offers sashimi at affordable prices. Because the Japanese market, which up to now bought nearly all of farmed production, now seems to be largely saturated, the further development of tuna farming will partly depend on whether new target markets can be developed. The industry currently harbours great hopes in the United States, whose demand for premium tuna (sushi, sashimi, barbecue) is about 45 000 tonnes per year.

There are still some unsolved problems in the tuna-farming sector: routine reproduction of fish to replace capture-based aquaculture and the development of a dry feed that could be used as the sole feed. Although there has been some progress in both areas, the industry is still a long way off a real breakthrough.

Environmental organizations are critical of tuna farming. The World Wide Fund for Nature (WWF) demands a moratorium for Mediterranean fish farms. In their opinion, farming endangers the overfished tuna stocks because there are no regulations, supervision or control of catches for stocking the farm cages.

YELLOWTAILS (*SERIOLA* SPP.)

Yellowtails have long been produced in aquaculture in Japan. During recent years other countries have also entered this field of aquaculture. Although it is possible to raise some species from the egg, stocking material is still mostly caught in the wild. In 2005, 172 594 tonnes of yellowtail were produced worldwide, 159 741 tonnes by Japan. Nearly all of the Japanese farms produce *Seriola quinqueradiata*. In other regions of the world, two other *Seriola* species are farmed: yellowtail kingfish (*S. lalandi*) and amberjack (*S. dumerili*).

TABLE 1
Characteristic features of the three *Seriola* species

	S. dumerili	*S. quinqueradiata*	*S. lalandi*
Common name	Amberjack	Yellowtail	Goldstriped amberjack, yellowtail kingfish
Max. length	180–190 cm	150 cm	250 cm
Max. weight	80 kg	40 kg	97 kg
Distribution	Circumglobal, subtropical waters	North West Pacific, subtropical waters	Circumglobal, subtropical waters
Market size	3.5–5.5 kg for sashimi	Up to 6 kg for fillets, 3.5–4.5 kg for sashimi	Up to 4 kg for fillets and sashimi

All three *Seriola* species have white, tender flesh with a very pleasant taste. The meat of farmed yellowtails contains more fat than that of caught fish, and this is a particular quality feature in Asian countries. For this reason, yellowtails are among the few fish species for which demand for farmed fish is greater than for wild fish. The prices paid for farmed yellowtails are more than twice as high as those paid for their wild counterparts.

The bottleneck that is holding expansion of aquaculture back is obtaining fry for stocking. Japan has placed restrictions on the removal of juveniles to protect wild stocks, and only about 40 million juveniles can be caught per year. During the past few years, however, even this quantity was rarely exhausted and the catches often amounted to only 25–30 million fish. The farmers prefer fry weighing between 30 and 100 g. To catch the fish, fishermen make use of the juveniles' typical behaviour: they are often found beneath flotsam, and so the fishermen use fish aggregation devices (FADs), which are floating rafts made of plants or other materials. After the fish have gathered there, they can be caught using small purse seines, lift nets or hand nets.

Farming is mainly done in floating net cages, but occasionally in fenced-off sea bays. The farm location is largely decisive for its success, for yellowtails are demanding fish. A slight current, clean water and constantly high temperatures (the fish stop eating at temperatures of below 15 °C) are prerequisites for healthy fish and good growth. Regular sorting by size prevents cannibalism. If fed well, the fish grow quickly. Fish stocked at 50 g can reach weights of 200–700 g in three months. Weights of 600–1 600 g are possible after six months and 700–2 000 g one month later. The fish are fed with fresh or frozen fish: preferably sardinella, horse mackerel or mackerel. Feeding only sardines and anchovies is less suitable because their unsaturated fatty acids oxidize quickly and can cause vitamin B1 deficiency in yellowtails. The food conversion ratio (FCR) is usually between 5 and 7:1. In principle, pellet feed is also possible if the fishes have been conditioned to eat it. About half of all Japanese yellowfins are already farmed using special dry feed. The fish are mostly transported live for the sushi and sashimi market.

With regard to production volume, Japan is the world leader in yellowtail farming. The industry's profitability has decreased, however. The reasons for this are mainly to be found in rising production costs (feed) and lack of stable supplies of fry. Added to this is the fact that in the meantime other countries have also recognized the market potential of *Seriola* species, with the result that competition has become harsher. Today, *Seriola* species are also produced in Taiwan POC, Australia, New Zealand, Ecuador and Viet Nam. Spain has started test production on a small scale, and Italy, Croatia, Greece, Malta and France are also examining the possibility of farming the species. In contrast to Japan that has stuck to *S. quinqueradiata*, these countries mainly farm *S. dumerili* and *S. lalandi,* which have a higher market value. Some key features of *Seriola* spp. are given in Table l.

STURGEON (FAMILY ACIPENSERIDAE)

When wild sturgeon stocks were still in good condition and supplied enough caviar, there was not much interest in farming these fishes. However, the situation has changed

fundamentally in recent years because the natural stocks are strongly overfished and the quantity of wild caviar available on the world market has fallen drastically. Since 1997, trade with sturgeon and sturgeon products has been regulated by the Washington Convention on International Trade in Endangered Species (CITES). Twenty-three sturgeon species were put on the CITES Appendix List II and two species on List I. Since then, CITES permission has been necessary for trade with sturgeon and sturgeon products on the world market.

This decline in sturgeon fishing has led to new chances for aquaculture. The attractive market prices for caviar are awakening hopes that the difficult and expensive farming of these fishes might be profitable and lucrative in investors and farm operators all over. According to FAO statistics, 328 tonnes of sturgeon were produced in aquaculture in 1990. The figure named for 2005 was 19 648 tonnes. China is the biggest producer with over 15 000 tonnes. The following are the main sturgeon species currently produced in aquaculture:

- Siberian sturgeon (*Acipenser baeri*);
- white sturgeon (*A. transmontanus*);
- Adriatic sturgeon (*A. naccarii*);
- spoonbill (*Polyodon spathula*);
- sterlet (*A. ruthenus*);
- waxdick, Danube sturgeon (*A. gueldenstaedtii*); and
- bester (hybrid of beluga and sterlet).

SEA URCHINS

Sea urchin roe is one of the most expensive seafood delicatessen products in the world. In Japan, sea urchins are traded for between US$6 and 7 per piece depending on size and type, and people pay about US$340 per kg for the roe. Wild stocks of sea urchins that come into question are often under pressure, however, or are overexploited, so that aquaculture presents itself as an alternative.

The attempts made so far to farm sea urchins have not been very successful. In the past, for example, farmers tried to grow them in polyculture together with fish. The sea urchins would, it was hoped, feed on the algal growth on the nets. In practice, however, this source of feed proved to be insufficient, particularly since the algae were often covered by a layer of fish faeces. Apart from that, the net cages could no longer be cleaned by hand on account of the risk of injury through the sea urchins. In spite of these and similar drawbacks, interest has risen again in sea urchin farming during the past few years. A long-term study conducted in Australia revealed that sea urchin farming could be a million-dollar business.

In Norway, an automatic cage system was developed for sea urchin farming. It consists of a floating raft from which latticework boxes are hung into the water on ropes like the rungs of a rope ladder. The boxes are lifted automatically to the surface for feeding and control purposes. Due to the high level of automation, two operators are sufficient for managing a farming facility of 3 000 m^2. The system is also said to be suitable for other species, e.g. abalones.

Marketing sea urchin roe might prove a problem, however, for sales are almost solely limited to Japan, which absorbs 90 percent of world production. Concentration on just one buyer creates a strong dependency and would make this branch of aquaculture highly susceptible to disruptions.

ATLANTIC COD (*GADUS MORHUA*)

Atlantic cod are distributed throughout the northern Atlantic, the Baltic Sea and the Barents Sea. It is a very adaptable species with separate stocks inhabiting a wide range of environments. Cod stocks have declined and are now considered to be below safe biological levels in many areas. Over-exploitation of wild cod has led to a sharp

increase in the market value of cod and has stimulated great interest in the farming of this species. In response, research into cod farming has been carried out in several northern countries, in particular in Norway, Canada and the United Kingdom. Key elements needed for launching a profitable industry appear to be almost in place, but cod farming is still in an early start-up phase, Cod farming is a tricky business – far trickier than salmon. To reach profitability, farmers have had to overcome a number of obstacles, including cannibalization, premature sexual maturity and low survival rates that plagued early efforts.

Production methods and practices are rapidly being improved, and it is hoped that in the near future a year-round supply of premium-quality farmed cod will become available. In order to meet market demands, the aquaculture industry has focused on a step-by-step development. Much of the farmed cod that has been sold until now has been wild sea-ranched cod, caught as medium-sized fish during the spring fishing quota by small coastal fishing boats. These cod are held in ordinary net cages and are fed for 6 to 9 months until they are slaughtered in autumn-winter, when they weigh between 4 and 5 kg and quality is at a peak. Captive fattening up to commercial size was developed in Europe (Scotland, Norway and Iceland), in Canada and in the United States (Maine).

Cod rearing in captivity for sea-ranching has been carried out for over 100 years in both Norway and Canada. Until the 1970s, the objective was to produce fry to replenish local wild populations. Interest in "real" cod aquaculture based on fry that are hatched under controlled conditions was developed in the 1970s and 1980s. In 1977, cod were reared from eggs to mature fish for the first time in captive conditions. Farmed cod live in their own net cages that have been developed for cod farming, much like salmon farming. During a two to three year period, the fish reach a slaughter weight of between 3–4.5 kg.

Controlled cod production from broodstock to ready edible fish is an extensive process. The two-year farming cycle of cod is comparable to that of salmon. Wild cod become sexually mature at between 2 and 7 years old. Age of maturation varies between stocks and is linked to the growth rate of the fish. The cod matures – depending on the location – from January to March, yet the production of eggs and larvae can take place all year round. Fecundity is huge. It is not uncommon for a mature female to produce 250 eggs per g of body weight. Therefore, a captive female of 3.5 kg can lay between 3 and 5 million eggs. Cod eggs are small, typically 1.3–1.5 mm in diameter. Hatching starts after a period of 10 to 14 days at a temperature of 6–8 °C. When they hatch, the cod larvae are 3.5–4.5 mm in length and, compared to salmon, are relatively undeveloped. The larvae feed on their yolk sac for about a week, then on live planktonic prey, and later on artificial food (micro-particles). After approximately 35–40 days, the cod larvae undergo metamorphosis so that they become recognizable as fish.

For years the cod farming industry was hindered by a lack of juveniles. Even today the production of sufficient numbers of juveniles remains one of the biggest problems facing cod farmers. Up until now the preferred method to get fertilized eggs has been natural spawning. Males and females ready to spawn are placed together in land-based vats where the females spawn without human influence and the males fertilize each spawn the natural way. Sex and state of maturation can be determined quickly and easily with the use of an ultrasound scanner. The vats are stocked at densities of 5–10 kg/m^3 with a ratio of 1:1 to 1:3 females to males. Cod are termed "batch-spawners" because females do not release all of their eggs at one time. Mature females typically produce 15–20 batches of eggs at intervals of 60–75 h during a period of 40–60 days. During spawning season the quality of the eggs from any one female cod may decline.

The fertilized eggs float freely in the tanks and are collected from a sieve collector that stands in the water outlet of the vats. Then the eggs are disinfected and transferred to incubator tanks to be bred in darkness. The 6–8 °C cold seawater in use has been

filtered and sterilized with ultraviolet light. Under such conditions the tiny larvae hatch after two weeks. Two production methods are used to ensure survival of fry through the critical phase: one is in land-based tanks; the other is based on fry set out in small closed sea lakes or in plastic bags in shallow sea areas. Both methods produce good-quality fry.

Cod larvae are usually stocked at 50–100 animals/liter, although higher stocking densities are possible provided water quality is maintained at high levels and sufficient amounts of feed are given. Light should be given continuously throughout the larval stage. Algae are also added to the larval tanks. There are many reasons why algae are required and essential for successfully rearing cod larvae. Prey animals such as rotifers and *Artemia* are used as a food source. The timing of the introduction of each type of feed varies with the growth rate of the larvae. It is essential for the larvae to start feeding on these organisms before their yolk-sac reserves are used up (circa 6–8 days post-hatching), otherwise starvation and mass mortality will result. When the larvae have reached a certain stage of development, *Artemia* are introduced. Rotifers should continue to be fed for 5–7 days after the introduction of *Artemia* to allow the larvae sufficient time to adjust. Neither rotifers nor *Artemia* are nutritionally sufficient to sustain the cod larvae and they must therefore be "enriched" with commercially available supplements. The type and application of these enrichments can be crucial to the success of a hatchery.

Weaning onto formulated diets begins approximately 35–40 days post-hatch, while *Artemia* are still being fed. Recently it has become possible to wean earlier – a significant improvement since live feed production is very costly. Survival through to weaning is commonly only 5–25 percent, although this figure is improving with better practices. Survival rates are affected by outbreaks of bacterial diseases, notably vibriosis. Good hygiene helps to prevent these outbreaks. The major challenge during the nursery stage is preventing cannibalism. Cod are extremely cannibalistic between 2 and 4 months old. The effects of this can be very serious if left unchecked. Frequent grading using a floating bar grader and provision of sufficient qualities of feed contribute to overcoming this problem.

The on-growing stage of the cod production cycle is almost identical to that of salmon. Much of the necessary technology, equipment, infrastructure and experience are already in place. Juvenile cod are ready to be stocked into sea-based net cages if they are approximately 6–7 months old, completely weaned and have a weight of 30–100 g. Generally, farmed cod are easy to keep in farms and tamer than salmon. For instance, they swim towards visitors instead of fleeing away. As a demersal species, cod keeps itself low in net cages. Their optimal growth temperature is about 12 to 15 °C. Cod accept densities of up to 40 kg/m^3. The formulated feed is a special protein-rich mix in the form of dry pellets. The feed is primarily based on marine raw materials such as fishmeal and fish oil. Cod is a lean fish that stores fat in its liver, while the fillet has a high content of protein. Higher fat levels in feed result in enlarged livers that can have over 15 percent of the total body weight. This means a significant reduction in the edible yield of fish.

Cod cannot utilize high amounts of carbohydrate because this will lead to a diabetes-like state in fish and decrease utilization of fat and protein. On average, the protein content of feed is between 50 and 55 percent, but there is no protein from land animals. A part of the fishmeal can be replaced by good vegetable raw materials – mainly soy meal – without affecting meat quality and taste. The lipid content in the feed ranges from 12 to 18 percent. The fish oil used contains mainly anchoveta from South America because of its high omega-3 content. The feed pill also contains vitamins and a mineral mixture.

Growth performance is considered good with feed conversion ratios of 1:1. At present, many cod hatcheries are using wild-caught broodstock, although captive

reared fish are now becoming available. Breeding programmes can be developed with the aim of selecting better-performing fish. However, domestication of cod has been an expensive and time-consuming process for the aquaculture industry.

In 2002, Norway started a National Breeding Programme for cod close to Tromsö, both in a land-based facility and a floating net-cage farm. Two hundred cod families are included. Breeding is targeted on fast growth, disease resistance, better feed utilization and late maturation. For evaluation of individual performance, each offspring is tagged with a radio transponder before being released into the sea cages.

To become a commercial reality, a year-round supply of eggs and juveniles for cod farming is required. The short length of the spawning season is therefore a potential problem. Research has succeeded in producing eggs outside of the natural spawning season through manipulation of water temperature and day-length (photoperiod). In this way the spawning season can be extended or shifted. Because farmed cod experience high growth rates, they tend to mature earlier than wild fish. This may occur prior to reaching market-size, with a consequent loss of performance and condition. Experiments have shown that this may be prevented by using lights as is done in salmon farming to delay grilsing. However, in the case of cod this method has not yet been fully developed and must be perfected further.

In comparison to salmon, the cod farming industry still has only limited knowledge of fish health concerns. During the on-growing stage, cod are susceptible to a number of pathogens. Vibriosis has proved to be a problem, although vaccines have been developed in Norway and Canada. This is a definite advantage for farmed cod, both in terms of growth performance and more importantly, for sales and marketing. Extensive research is being done to prevent outbreaks of disease. However, development of effective vaccines requires much time. Important progress would be the development of special weaning diets to replace live rotifers and *Artemia*, which can be a critical risk point for introducing pathogenic bacteria.

The main challenge of cod farming seems to be vibriosis and bacterial furunculosis. Several outbreaks of classical vibriosis even in vaccinated cod were reported in recent years. Furunculosis was confirmed for the first time a few years ago in farmed cod in Norway. Since then, the disease has been reported in an increasing number of fish farms along the coast. Up to now, three different variants of the furunculosis bacterium have been registered in diseased cod. Furunculosis vaccine that has been developed for salmon does not provide satisfactory protection for cod. Fortunately, viral diseases are not yet a problem. Cod can also experience problems with sea lice (*Caligus* spp.), which can be treated in the same manner as for salmon. While wild cod are prone to infestations of tapeworms and roundworms, first experience with farmed cod shows a very low incidence or absence of these organisms.

The outlook for cod farming is excellent. Cod is a well-introduced species, and there is a large and established market for this species in Europe. The United Kingdom cod market alone has been estimated at 200 000 tonnes, of which 85 percent was imported from Iceland, Russia and elsewhere. The decline in wild catches has resulted in a long-term increase in prices. Production is growing, but more slowly than expected in previous years. The journal *Fish Farming International* wrote in 2003 that Norwegian cod production could reach 175 000 to 225 000 tonnes by the end of the decade and soar to 400 000 tonnes by 2015. Compared with this very optimistic forecast, reality can only be disappointing. In 2006, Norway just reached a total production of 7 000 tonnes – far behind the projections. But independent of this it is a sure thing that cod farming after salmon will be the second big wave of aquaculture in Norway.

This is on condition that prices of farmed cod remain strong. Cod farming can only be viable and feasible provided certain economic preconditions are met. However, there are at least two unpredictable risks. First, it is well known that the volume of production will have a direct effect on price. Due to protein-rich feed and high

juvenile production costs, cod farming is expensive. As long as the production volume is low, farmed cod can be marketed at premium prices in niche markets, but as volume increases prices will inevitably fall. The second unpredictable risk for cod farming is the state of wild cod stocks. If wild cod stocks recover it would definitely have an effect on market price. Markets could shift back from farmed to caught cod again.

Even under these circumstances cod farms can survive. Like many other species that come from aquaculture, farmed cod has remarkable advantages over its wild counterpart in terms of year-round supply, traceability and freshness that should ensure a good demand for this product.

COBIA (*RACHYCENTRON CANADUM*) (Bjorn Myrseth)

The cage culture of cobia started on the early 1990s in Taiwan Province of China, the first successful larviculture occurring in 1994 (Liao, Su and Chiang 2001).. Today, cobia is farmed in the United States (Puerto Rico), the Dominican Republic, Martinique, Panama, Mexico and Belize in the Caribbean. In Asia, farming is taking place in the People's Republic of China, Japan, Viet Nam and Thailand. Experiments have been carried out in Reunion in the Indian Ocean. In the United States, cobia is also farmed in recirculation aquaculture systems in Virginia. The estimated world production of cobia is given in Table 2. China is the biggest producer, with an annual production of 20 000 tonnes (Dr. Jiaxin Chen, personal communication).

Cobia requires warm water to do well, growing best between 25 °C and 30 °C. According to Chang *et al.* (1999), feeding stops at 19 °C and mortality occurs at 16 °C. and at 36 °C. Cobia is a euryhaline species, feeding well at a salinity of 4–35 ppt (Chang *et al.* 1999).

Cobia has all the domestication traits we would like to find in cultured fish. The life cycle is closed; the fish spawn naturally in tanks and hatchery production of larvae is well established. The growth is fast, and in tropical waters the fish reach a size of 5–6 kg in just one year after hatching (Figure 1). Cobia can be handled without being damaged and do well in cages at a stocking density of 10–15 kg/m^3. They grow well on "standard" marine diets with "low" fat content (15 percent fat). Craig, Swarz and McLean (2005) have shown that a large portion of the fishmeal can be substituted with soya protein without reducing growth. The feed conversion ratio (FCR) is generally low, being 1.4–2.0.

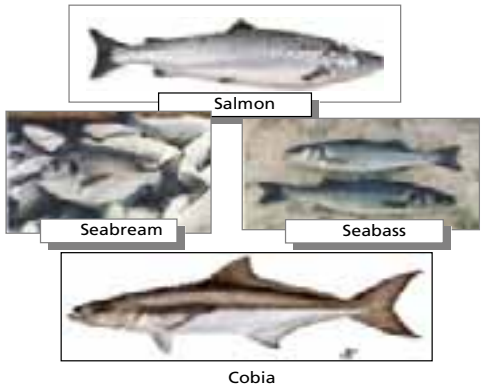
The flesh of cobia is white and firm, tolerates heat well and has excellent eating qualities. It can be boiled, broiled, grilled or deep-fried and is good when eaten raw as sushi and sashimi.

The short-term challenges to cobia culture include diseases and market developments. Both areas require more research and attention. In the long term, improvement of feeds

TABLE 2

Production costs, seabass/seabream, salmon and cobia

	Seabream / Seabass	Salmon Norway	Cobia China
Feed	2.00	1.24	1.87
Fry	1.05	0.31	0.17
Labour	0.94	0.22	0.31
Other	0.44	0.32	0.19
Depr.		0.14	0.43
Total	4.43	2.23	2.97
Finance	0.81	0.09	
Ex cage cost	5.24	2.32	



Target USD 2 / kg for cobia

FIGURE 1
Comparison of growth of cobia with that of some other cultured species

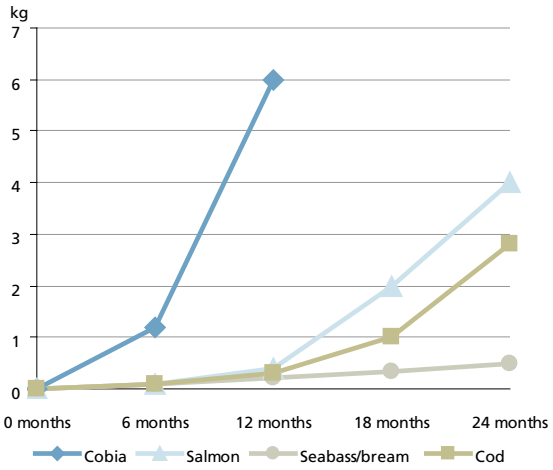
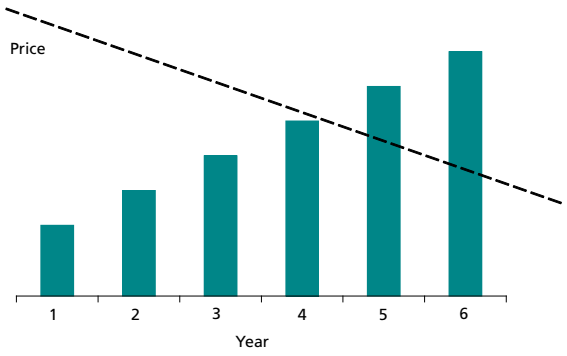


FIGURE 2
As aquaculture production of a new species goes up, price will normally go down. The challenge then is to reduce production costs at the same time to keep production profitable.



and flesh quality will be important, and work on all aspects of the rearing cycle will be needed. We very often see that increased production of farmed fish species influences their price and that with increased volume, prices must be reduced. To remain profitable, costs will have to be reduced more quickly than the reduction in price (Figure 2).

Dr. Jiaxin Chen (personal communication) has given production costs from China for cobia reared in cages. Table 2 compares these costs with those for other farmed fish. It is obvious that it should be possible to reduce the cost of cobia production to US$ 2 per kg ex. farm. However, this will take time, and improved efficiency will be required in every step of the rearing cycle.

Looking at the development of aquaculture for some other fish, the production volume for salmon has grown from nothing to more than one million tonnes over 30 years, that of cultured tilapia has grown from 700 000 tonnes in 1995 to 1.8 million tonnes in 2004, and that of Asian catfish (*Pangasius*) has risen from 50 000 tonnes to 1 million tonnes in only ten years. Liao and Leaño (2007) claim:

> *"it is projected that the cobia culture industry is very likely to exceed 1 (one) million tonnes annual production in the future. This will take more than 10 years to achieve but not as long as 30 years as cobia could become the "tropical" salmon".*

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Session 4: China

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Current situation and prospects of the domestic aquaculture product market in China

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ABSTRACT

China is the largest producer of farmed seafood in the world, the total aquaculture production reaching 33.93 million tonnes in 2005. In China, the market for aquatic products is abundant in variety and sufficient in supply. Recently, the market system for aquaculture products has been developing very rapidly, and the total turnover of aquaculture products has been increasing steadily. The consumption of aquaculture products in mainland China has been increasing year after year. Per capita annual consumption by urban and rural households was 8.35 kg and 3.29 kg, respectively, in 2005 and is estimated to reach 10.23 kg and 4.17 kg, respectively, in 2010. In the future, production will increase through culture strategy changes and via science and technology development in aquaculture. It is estimated that the total production from aquaculture will reach 45.5 million tonnes in 2010, and thus the market for aquatic products has bright prospects for the future. The import/export of aquaculture products is estimated at 4 million tonnes and is expected to account for 30 percent of the total seafood trade by 2010.

INTRODUCTION[1]

The development trend of Chinese fisheries has transformed into "aquaculture dominance"

Since the founding of the People's Republic of China in 1945, Chinese fisheries, influenced by the idea of stressing fishing and neglecting aquaculture, have been relying on the marine fisheries and thus have been restricted from development. After the implementation of the policy of reform and opening-up, China, as one of the world's large fishing countries, has carried out the policy of "zero growth "in fishing production and "summer fishing ban". In addition, based on China's actual conditions, the government adjusted the development priority of fisheries and realized a historic transformation from "fishing dominance" into "aquaculture dominance".

The policy of reform and opening-up and the establishment of the aquaculture dominance principle have promoted the fast and vigorous development of marine and freshwater aquaculture in China. At present, more than 70 percent of the world's aquaculture output is from China, which brings about changes in the structure of production of the aquatic products. With the sound development of China's breeding industry, the output of Chinese aquatic products has remained number one in the world for 11 consecutive years.

[1]Source for data: Statistical Yearbook of China's Fishery, China Statistical Yearbook, 1999 to 2005.

SUPPLY OF AQUACULTURE PRODUCTS IN THE CHINESE MARKET

Location of supply sources of aquaculture products close to local market

The output of marine aquaculture in 12 coastal provinces and cities plus that of inland areas accounts for 70 percent of the total output in China. If that of Hunan, Hubei, Anhui and Jiangxi provinces is counted, the output of sea aquaculture in those areas comprises up to 90 percent of the total output in China.

Currently, all areas in China are developing the culture of various aquatic products with wide distribution. As a result, the sources of supply of aquatic products are located closer to the local markets, and thus the market supply has become more convenient and timely.

Increasing supply volume of aquaculture products in the market

In recent years, China has witnessed the sound development of the breeding industry. The total output of aquaculture products keeps increasing, which effectively guarantees the supply of aquatic products to the Chinese domestic market. In 2005, the total output of aquaculture products in mainland China was 33.933 billion tonnes, including 20.085 billion tonnes from inland aquaculture and 13.848 billion tonnes from marine aquaculture. The facts indicate that the market for aquatic products is becoming more prosperous.

Aquaculture products accounting for half of the supplies in aquatic market

The breeding industry in China has been growing rapidly with an increasing proportion of aquaculture output to the total output of aquatic products. Influenced by the policy on the structure of the Chinese fishery industry, the output from marine aquaculture has increased significantly faster than that of inland aquaculture for a period of time. Currently, the proportion of the output of inland and seawater aquaculture to the total output of the aquaculture industry has been gradually increasing. For instance, in 2005 the outputs from inland and seawater aquaculture grew by 5 percent and 3 percent, respectively, in proportion to the total output of aquatic products, as compared with similar figures for 1999.

Five major sorts of products of sea and freshwater aquaculture developing with special features and making market supply abundant

In line with the aquaculture and local conditions, both inland and seawater aquaculture are developing production in five main commodities, namely fishes, shrimps and crabs, shellfishes, algae and other species. This development has enriched the supply of aquatic products in the Chinese market.

Of the five main commodities, fishes account for the largest absolute amount. The production of common fishes such as grasscarp, silver carp and bighead carp, carp, Crucian carp, white bream, triangular bream and black carp accounts for 65 percent of the total output of freshwater aquaculture, while cultivated shellfish account for the majority of production from seawater aquaculture.

Increased market supply of processed aquaculture products

The amount of aquaculture products being processed is increasing gradually. The products to be processed include common eel, tilapia, silver carp, large yellow croaker, *Macrobrachium rosenbergii*, prawn, *Penaeus vannamei*, swimming crab, mud crab, oyster, mussel, ark shell, scallop, clam, razor clam, kelp, *Undaria pinnatifida*, laver and pearl powder. However, most of the aquaculture products on sale are fresh fish, which require less processing. For example, the total amount of freshwater aquaculture products processed accounts for only 5 to 10 percent of the total quantity of aquatic products processed in China and only 2 percent of the country's total output of aquatic products.

Quality of the market supply of aquaculture products is constantly improving

In China, the aquaculture industry's development strategy is "high quality oriented", with the aim of producing safe and healthy aquatic products. According to the basic requirements of the Chinese market access system for aquatic products, the aquaculture industry in China is supplying pollution-free, green and organic aquatic products of high quality to consumers.

CIRCULATION OF AQUACULTURE PRODUCTS IN THE CHINESE MARKET

Market supply system of aquatic products in China is improving gradually

The main form of the circulation channel of aquatic products in China is: from the producing areas of the aquatic products → to the wholesale markets in the producing areas → to the wholesale markets in the sales areas → to the markets and supermarkets of farm produce → to the consumer (hotels, restaurants, cafeterias, home).

The circulation channels and network of various aquatic products in different forms constitute the market supply system of aquatic products in China. In this system, the wholesale markets play a significant role. Meanwhile, the commercial outlets such as various markets and supermarkets of farm produce, large supermarkets and large food shopping areas are also the main supply channels of aquatic products.

In addition, the laws and regulations, standards, and inspection and testing systems of the aquatic products for quality safety are improving, which has effectively guaranteed the safe, high-quality, sufficient and highly efficient supply of aquaculture products.

Trade in various wholesale markets of aquatic products is developing rapidly

The wholesale markets of aquatic products in mainland China have developed rapidly, with a growing turnover in domestic market of aquatic products. In 2004, the turnover stood at CNY 237.01 billion. The volume of business was 22.50 million tonnes, which accounted for 46 percent of China's total aquatic production.

In 2000 and 2004, the number of wholesale markets of aquatic products in China with a turnover of over CNY 100 million reached 52 and 72, respectively. In large wholesale markets of aquatic products, wholesale is the major trading mode, while other trading forms are playing an active role too. For example, in 2004 the turnover of the wholesale markets of aquatic products was CNY 52.25 billion. The volume of trade of wholesale business was CNY 47.42 billion and of retail business, CNY 4.83 billion. In addition, the volume of trade of retail business accounted for 10 percent of the total turnover.

The agents of aquatic products are active in the distribution

Based on some research, the author holds the view that there are now relatively few large-scale aquaculture enterprises in China. Eighty percent of the aquaculture output is from private businesses. Due to the dispersed distribution of aquaculture production and waters, as well as the asymmetry of production and marketing information, the intermediary businessmen, agents and big marketing companies of aquatic products play a major role in facilitating the fishermen to send their aquatic products from the producing areas to the local wholesale markets. The agents of various aquatic products are aware of the circulation links, and they link the markets of aquatic products at various levels in the marketing or producing areas swiftly. They are playing a vital role in meeting the urban consumption demand for various fresh aquatic products.

WIDE RANGE OF DIFFERENT CATEGORIES OF AQUACULTURE PRODUCTS IN THE CHINESE MARKET

Taking Shanghai as an example, the volume of trade in aquatic products is on the rise year by year. At present, about 400 000 to 500 000 tonnes of aquatic products in Shanghai markets are consumed, with abundant species ranging from common fishes

like Crucian carp, to high-grade aquatic products like river crab, to various rudd and shellfish, as well as imported aquaculture products like salmon. The major varieties being traded in Shanghai's aquatic product markets include grass prawn, lobster, black tiger prawn, *Macrobrachium rosenbergii*, river shrimp, river crab, mud crab, *Siniperca chuatsi*, perch, snakehead, river eel, softshelled turtle, salmon, bullfrog etc. According to the statistics for several large wholesale markets of aquatic products, the total output of the above aquaculture products reached 130 000 tonnes in 2004.

Prices of aquaculture products in the market tend to be steady

As the production is constantly growing, the market price of aquatic products, which has decilined in varying degrees, is currently tending to be steady. Taking Shanghai as an example, from 1995 to 2004 the market price of the common aquaculture products such as grasscarp, black carp, white bream, silver carp, spotted silver carp, carp and Crucian carp tended to be steady, while the price of special aquatic products like river crab, softshelled turtle, *Siniperca chuatsi* and river eel had fallen.

Aquaculture products are becoming upmarket food

Some traditional top-grade products like river eel, *Siniperca chuatsi*, softshelled turtle and river crab are entering ordinary households thanks to the gradual decrease of prices. Some imported species like largemouth bass and channel catfish have been accepted by the markets with a relatively stable consumption volume. The concentrated consumption of high-grade aquatic products during traditional festivals and holidays is diminishing. At the same time, aquaculture products have become upmarket food regardless of seasons and holidays.

Further increase in quality awareness of the consumption of aquaculture products

In recent years, affluent Chinese people have been paying more attention to high-quality meals. All consumers focus on the improvement in the production environment of aquatic products, gradually intensifying the demand for high-quality aquatic products produced under safe and sanitary conditions.

Analysis of the influence of aquaculture products' import and export on the domestic market in China

The consumption of imported aquatic products in mainland China is continuously on the rise. China imports more than 700 000 tonnes of edible aquatic products, if fish meal, products processed with foreign-supplied raw materials and imported products of other industries are excluded. The major imported commodities are 300 000 tonnes of frozen fish, 120 000 tonnes of shellfish and some shrimps and crabs. Import of aquaculture products plays an important role in supplementing species of domestic origin consumed in China. For instance, the import of grass shrimp bred in Thailand and of sea-farmed salmon from Norway can satisfy the demand for medium and high-grade aquatic products in the market.

The Chinese Government attaches great importance to the export development of aquatic products, especially the exportation of various kinds of sea-farmed aquatic products, which not only meets the demands of the international market, but also improves the global competitiveness of China's aquaculture industry.

Analysis of consumption volume in the market of aquaculture products

Cities and towns in China serve as the major markets of aquatic product consumption. The Chinese consumer's average expenditure on aquatic products and food expenditure is increasing year by year, the former accounting for 7 percent of the total expenditure on foods. At the same time, the rural aquatic product market is developing vigorously.

According to statistics, the annual consumption of various aquatic products (including aquaculture products) per capita by urban and rural families reached 12.48 kg and 4.49 kg in 2004, respectively. From 1999 to 2004, the annual rate of increase in consumption by urban citizens was 3.83 percent, while consumption by rural citizens grew by 3.28 percent.

ANALYSIS AND PROSPECTS OF STABLE DEVELOPMENT IN THE CONSUMER MARKET OF AQUACULTURE PRODUCTS IN CHINA

Analysis of motivation to increase consumption of aquatic products

Consumption motivation one: the consumption of aquaculture products will increase with the expanding population.

China's population will increase by 10 million each year in the future. According to a related analysis, household consumption of aquaculture products will increase by 85 000 tonnes over that of the previous year if the annual consumption volume of aquatic products per capita by Chinese citizens is 8.50 kg. The annual increase of aquaculture product consumption would be 200 000 tonnes more than the previous year if other forms of aquatic product consumption (such as expenditure on meals in restaurants and other eateries) are included.

Consumption motivation two: the rise of gross domestic product (GDP) per capita and income leads to year-on-year increase of consumption volume.

China's GDP per capita has greatly increased since the implementation of the policy of reform and opening-up, reaching CNY 14 040 in 2005. Meanwhile, as the Chinese people's income has also increased drastically, the annual per capita consumption by volume of aquatic products in urban and rural areas is increasing year by year.

Studies indicate that a similar phenomenon in aquatic product consumption with a feature of "high income with high consumption and low income with low consumption" appeared during the decade from 1993 to 2003. For example, the per capita consumption of fish and shrimp by those Chinese residents with the lowest income was 6.66 kg in 2003, while it was 16.77 kg for the residents with the highest income. Therefore, the increase in aquatic product consumption is obviously influenced by the income level of the Chinese people.

Consumption motivation three: with the enhancement of healthy consumption awareness, the proportion of aquatic product expenditure to food expenditure is going to rise.

At present, the majority of Chinese residents are constantly pursuing a healthy way of life and paying more attention to nutritional and healthy foods. Aquatic products, a kind of healthy food with high protein and low fat, enjoy high popularity among the Chinese people, who attach increasingly higher importance to their consumption.

Consumption motivation four: the process of urbanization transforms agricultural populations into urban residents, thus increasing the consumption of non-staple food like aquatic products.

Urbanization transforms a great percentage of the agricultural population into urban citizens engaged in non-agricultural sectors. At the same time, these peoples' consumption habits are also becoming closer to that of urban areas. The consumption volume of aquatic products by urban residents is two times larger than that of their rural counterparts, therefore, the transformation from agricultural population into urban citizens speeds up the consumption of aquatic products and other secondary foods.

Consumption motivation five: the aquatic product consumption in western regions is certain to increase with China's great development in western economy

Statistics show that aquatic product consumption per capita in the western regions is lower than that of eastern China, which results from differing cultural customs and consumption habits. But the economic development and mobile population in

this region are bringing changes to people's customs and habits in aquatic product consumption. According to some statistics, the consumption volume of aquatic products in China's western provinces represents different degrees of growth in the past few years. Therefore, with more frequent economic exchanges between the western and eastern regions, aquatic product consumption in western regions is going to show huge potential in development.

Consumption motivation six: the expenditure on meals out of home is rising every year, which promotes the increase in aquatic product consumption

The proportion of urban citizens' expenditure on meals out of home to food expenditure is going up rapidly, rising from 8.0 percent in 1992 to 20.8 percent in 2005. The expenditure per capita on such meals was CNY 607.23 for Chinese urban residents in 2005. Aquatic product consumption accounts for an important part of people's expenditure on meals in restaurants and other eateries, which contributes partly to the rising consumption of aquatic products.

Consumption motivation seven: in Chinese residents' consumption structure of "fish, meat, poultry and eggs", the proportion of aquatic product consumption is going to rise.

The analysis of changes in consumption structure of "fish, meat, poultry and eggs" indicates that the aquatic product consumption of urban residents accounted for more than 19 percent of the total consumption volume of fish, meat, poultry and eggs, while meat took up 52.2 percent in 1985. However, in 2003, the proportion of aquatic products rose to 23.2 percent, up 4 percent; while meat declined to 41.3 percent, down 8 percent. Furthermore, the consumption of poultry and eggs both increased to a certain extent. A similar phenomenon also appeared in rural areas.

The proportion of aquatic product consumption to the total of fish, meat, poultry and eggs rose from 10.5 percent in 1985 to 16.8 percent in 2003, while the consumption of meat declined from 70 percent down to 54 percent. All these fully indicate that Chinese people have begun to pay great attention to aquatic product consumption, which is playing an increasingly important role in the present dietetic structure.

Sustainable development of the aquaculture industry in China will ensure market prosperity

The market-oriented aquaculture industry in mainland China will continue to develop via the quality-profit growth mode, relying on scientific and technological advancement to ensure enough supply in the aquatic product market. The estimated annual rate of increase in aquaculture products is about 6 percent. China's aquaculture products may reach 45.5 million tonnes in 2010, accounting for 75 percent of the total products.

Meanwhile, China carries out scientific and technological innovation, reasonably utilizes water areas for aquaculture to gradually improve the output per unit area and breeding quality, and intensifies the restructuring of aquaculture production, which leads to the successful development of various kinds of new high-quality aquaculture species. China's aquaculture industry can thus realize sustainable development as well as ensure the further advancement and prosperity of its aquatic product market.

Prospects of stable development of aquaculture product market in China

Analyzing from the consumption volume of aquaculture products, Chinese residents' annual consumption of aquaculture products per capita is steadily on the rise. Their consumption reached 8.35 kg and 3.29 kg in urban and rural areas, respectively, in 2005, and is estimated to reach 10.23 kg and 4.17 kg in 2010. At the same time, expenditures on meals outside of the home (including that on aquatic products) are likely to account for 25 to 30 percent of the total food expenditure.

The development of the Chinese market is linked to global development. China will continue to develop its import and export of aquatic products, the total volume

of aquaculture products among the total import and export accounting for about 30 percent. To further enrich the supply of species in the domestic market, China needs to import one million tonnes of edible aquatic products each year. It is estimated that in 2010 China will export four million tonnes and import four million tonnes of aquatic products, including foreign-supplied raw aquatic materials for processing and one million tonnes of imported edible aquatic products.

As the import and export volume of foreign-supplied raw aquatic materials for processing accounts for less than 10 percent of the total supply volume in China's aquatic product market, if excluded, no obvious impact will be made on total domestic consumption. Therefore, the domestic suppliers can meet the domestic demand for aquaculture and other aquatic products in mainland China.

Looking to the future, opportunities and challenges coexist. Aquaculture is still the main field where China's fisheries will make further progress. The policy of "aquaculture dominance" will remain the guiding principle for the long-term development and modernization of China's fisheries. China's aquaculture products market exhibits a trend for growth.

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Ms Xiao Fang began working in the Bureau of Fisheries, Ministry of Agriculture in 1990, after graduating in food engineering from Shanghai Fisheries University. Since then she has devoted her time to research in fish processing, market distribution and trade policy. She is responsible for the negotiation of fisheries subsidies and has been involved in the negotiation of free trade agreements between China and related regions or countries. Since 2006, she has been Director of the Marketing & Processing Division of the Bureau of Fisheries, Ministry of Agriculture, China.

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Export and industry policy of aquaculture products in China

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ABSTRACT

As the major country in aquaculture and seafood trade in the world, China has been adjusting its production structure continually to explore the most applicable and profitable aquaculture and fisheries process, keeping sight on both domestic and global markets. In 2006, the export value in aquaculture exports was reported to account for 50 percent of the entire export value for fish and fishery products. Also, the exports for some major aquaculture species such as eel, shrimp, shellfish, crab, tilapia and catfish, have a regional distribution, professional production and industrial business operation. However, further improved capability in quality and safety control for aquaculture products and how to achieve a high-quality and stable raw material supply should be the key issues for China's seafood exports, because there are problems and factors still affecting the exportation of Chinese aquaculture products.

INTRODUCTION

I'd like to express my gratitude for this opportunity to make a presentation. My topic is "Export and Industry Policy of Aquaculture Products in China". Yesterday, Mr. Li Jianhua, the Director-General of the State Fishery Administration under the Ministry of Agriculture, made a full elaboration on the progress and experience of China's aquaculture industry, as well as its contribution to China's trade. Now, I will focus on some statistics in this regard for your reference.

INTRODUCTION TO THE PRODUCTION AND EXPORT CHANGES OF AQUACULTURE PRODUCTS IN CHINA

Since the adoption of the fishery development principle "Breeding Predominance in China" in 1985, the Chinese fishery sector has experienced two important stages in its development: the total output of aquatic products leaped up to number one in the world in 1990; while in 2002, the export of aquatic products ranked the highest in the world. China has evolved from a country previously confronted with an insufficient supply of fish into a large fishery producer and a major aquatic products exporter (Table 1).

The decade from 1996 to 2006, which witnessed a vigorous development in the aquaculture industry in China, is also the most significant period in the history of Chinese fishery development. The proportion of output from sea-farming to fishing has improved from 56:44 in 1996 to 68:32 in 2006, with an aquaculture growth rate of 12 percent in the decade. The export of aquaculture products has tripled in the same period. Although the exported aquatic products still dominate the fishery in China in general, the percentage of exported aquaculture products has gradually been

TABLE 1
Summary of Chinese fishery production, 1996, 2006

	1996 (10 000 tonnes	2006 (10 000 tonnes	Growth rate, past ten years
Total output	3 288	5 290	61%
Including sea-farming output	1 863	3 594	93%
Proportion of sea-farming to fishing	56:44	68:32	12%
Export volume	80.2	301.5	276%
Including export volume of aquaculture products	24	118	391%
Export proportion of aquaculture products	30%	39%	9%
Export value proportion of aquaculture products	39%	49%	10%
Proportion of aquaculture products exported as raw materials	2.5%	8.2%	5.7%

approaching that of the products obtained from fishing. Especially when processing of foreign supplied-materials is excluded, exported aquaculture products have accounted for 80 percent of the home-derived aquatic products in China. A basic aquaculture production layout has been shaped that comprises some high-value species, some special species like the four major fish commonly consumed in China (herring, grasscarp, silver carp and bighead carp), together with sea cucumber and abalone for the domestic market, as well as an industrial belt of advantageous aquaculture products (including eel, prawn, tilapia, yellow croaker, shellfish, channel catfish, river crab and algae, to name but a few) for both domestic and international markets.

Table 1 shows that only 8.2 percent of the aquaculture products were exported in 2006; most of them were thus consumed in China, which indicates that the Chinese aquaculture industry is, in general, not relying on export except for a very few species. Next, I would like to introduce the export situation of the major aquaculture species.

Shrimp

The year 1996 witnessed an annual output of shrimp of 89 000 tonnes, of which 15 000 tonnes (22 percent of the total output if converted to the raw materials) were exported; while in 2006, the annual output jumped to 1 240 000 tonnes and 27 tonnes (44 percent of the total output if converted to the raw materials) were exported. Great progress had been made in the exportation of some intensively processed products meeting the international market demand such as “ebi ten” (breaded shrimp) and tail-on shrimp. In 1996, frozen shrimp for raw material and frozen shrimp meat accounted for 77 percent of the total shrimp export, while intensively processed products accounted for only 23 percent. But in 2006, this number jumped to 74 percent of the total. This dramatic change was due not only to improved processing techniques, processing capability and quality safety of the raw materials, but also to some trade sanctions imposed by some countries that actually accelerated the transformation of China’s aquaculture processing industry.

The current problems in shrimp exportation mainly lie in the increase of production costs and in the instability of raw materials supply.

Shellfish

In recent years, shellfish has had a large export potential with strong momentum. In 2006, the shellfish export volume surpassed that of eels, ranking second with 292 000 tonnes of export and amounting to 13 percent of the output in terms of raw materials, while in 1996, the proportion was just about 5 percent. The key to the shellfish export development lies in the R&D and a breakthrough in processing technology to gradually improve the processing capacity based on international tastes. In addition, with the development of the economy, the overseas Chinese’s needs for shellfish also accelerated the export growth.

The main problems in terms of shellfish export lie in food safety issues like shellfish poisoning, microorganisms etc. Moreover, the different criteria used for dividing sea-farming waters in different countries could affect the trade of shellfish.

Eel

Eel is one of the earliest sea-farming species in terms of exportation from China. About 85 to 95 percent of aquaculture products are supplied for export. The past decade has witnessed great export fluctuations, with an average level of around US$700 million.

The main problems facing eel export are firstly, drug residues and secondly, that the increased trading volume has not been accompanied by parallel benefits.

Tilapia and *Leiocassis longirostris*

These are new sea-farmed species in China, 30 percent of which are for export characterized by improved capacity in processing fillets. The major problems are the single-product market and some influence on the export due to the discrepancy in criteria of drug use and risk evaluation in different countries. Another problem is that the supply of raw materials suitable for processing is not constant.

MEASURES AND PROBLEMS

The majority of problems confronting China's aquaculture products' export sector are related to food-safety issues, which account for 60 to 70 percent of the total, followed by disorderly competition. The Chinese Government takes effective measures to solve these two problems.

Food safety measures

The law on criteria

China's Ministry of Agriculture and State Environment Protection Administration have been jointly compiling and publicizing the *Report on the State of the Fishery Eco-environment in China* each year since 2001. The Chinese Government published the catalogue of forbidden veterinary drugs in 2002, and the *Regulations on the Quality Safety of Aquaculture* in 2003. The *Administrative Methods for Aquatic Seeds* was amended in 2004, while the new *Regulations on Administration of Veterinary Drugs* was published in 2005, endowing fishery departments with supervisory rights over drugs. Meanwhile, the local standards for veterinary drugs were upgraded to the national ones. The *Law of the PRC on Quality and Safety of Agricultural Products* was put into effect in 2006. In 1997, the *Tentative Management Measures for Quality Safety of Shellfish Production* was formulated by China's Ministry of Agriculture. Also, a series of drug use standards and pollution-free production standards have been publicized successively in the past five years.

Administrative supervision

Implemented in 1999, the national plan of control on drug residues in aquatic products has been intensified in recent years. In 2006, 2 546 samples were tested in their origins with the acceptance rate for drug residues reaching 97 percent. The Chinese Government has strengthened its administration on aquaculture since 2002, regulating production and paying great attention to carrying out such archival systems as production records and drug usage records. The marine and fishery law enforcement was launched to push the quality safety of aquatic products in 2006, and any drug-use case that violates the related law and orders will be punished with no exemption. In several quality safety cases, China's Ministry of Agriculture and local fishery departments have imposed severe punishment on enterprises that violated related laws. The Ministry of Agriculture will further enforce this work in 2007 by carrying out the registering system of export origin. Based on domestic control, stricter management

will be implemented according to the importing countries' requirements. From 2001 to 2006, many provincial and municipal governments in China invested to construct centres that combine fishery environment promotion, disease prevention and control, as well as testing for product quality safety. All of these centres are responsible for government supervision and control.

Administrative guidance
Since 2001, all aquaculture farms are required to formulate practical operating regulations and to implement confirmation of pollution-free origins and products, as well as to standardize basic construction.

Taking action to resolve vicious competition

The Chinese Government tries to develop trade associations, fully display major enterprises' leading roles and establish cooperative and economic organizations specialized in agriculture. China is working to strengthen communication and consultation with other countries and is exploring how to set standards for market access, thus resolving trade disputes.

Displaying the potential for consumption of aquatic products, balancing export surplus and mitigating export pressure so as to ensure stable development

China's recent rapid economic rise drastically improves its power of consumption. China has attracted worldwide attention for its huge dynamic and potential market. In 2006, China imported 700 000 tonnes of aquatic products for domestic consumption, an increase of more than three times from the 200 000 tonnes imported in 1996. In the past two years, the prices of some shellfish in China's domestic market are equal to that in the Japanese market. Many enterprises enjoy the benefit of a two-way choice in supplying products for both export and domestic markets. For foreign countries longing to export to China, the Chinese Government has successively established the China-ASEAN Free Trade Zone and the China-Chile Free Trade Zone, and the construction of free trade zones between China and Australia, New Zealand and Iceland is well under way. In terms of the World Trade Organization (WTO), the average import tariff on China's aquatic products is about 9.5 percent, lower than that of many other countries. Our goal is to develop the aquatic product trade through the government's unremitting efforts. However, the development of the aquatic product trade is still faced with many problems.

The quality safety of aquatic products
The conventional scattered model of aquaculture brings some difficulties to government control.

The supply scale stability of qualified sources
Some aquatic species are difficult to produce and process because of the techniques used, low quality, scattered production or smallness of scale, while others are heavily seasonal and can't meet large and regular orders placed from the international market. Meanwhile, the rapid increase in the export of aquatic products depends mainly on large-scale investment and increases in quantity. Exports based on fish used for raw materials account for a high percentage, while fine and further processing and high-quality processing contributes comparatively little, the added value of products thus being low.

The fierce competition among developing countries with similar industrial structure
Developing countries often share a similar export industrial structure, exporting similar products and targeting the same markets, which can lead to sharp increases in supply. However, the demand of certain import markets increases slowly, which can cause

a plummet in trading price and fierce competition between countries. If they trade freely according to their comparative advantages, developing countries are likely to be confined to industries that are labour intensive. Therefore, they may face difficultes in advancing their technology and be at risk of an unstable trade structure, which can result in an unreasonable use of fishery resources and energy.

Annual increases in export cost

Developing countries are faced with financing difficulties. Enterprises in developing countries also need to increase their investment in technological reform, quality and safety control for producing and processing, and on inspection and quarantine. Only in this way can they reach the ever-improving technological standards of the importing countries. In addition, developing countries face challenges such as annual increases in labour cost and difficulty in recruiting new workers.

Low level of organization and management

In the markets of developing countries, the industrial management mechanism has not been established in a comprehensive way, thus creating problems that cause decreased enterprise profits and low social benefits such as:

- blind mass production of advantageous products,
- low prices caused by competitors, and
- disorder in export competition.

Furthermore, once trading disputes appear, nongovernmental organizations (NGOs) scattered in developing countries cannot coordinate with each other on behalf of their countries and enhance management in the domestic market for the interests of the enterprises in those countries.

Unavoidable trade friction and conflict

Importing countries will use every possible means to restrict aquatic product import with the purpose of retrieving trade deficits or mitigating adverse impacts on their domestic industries. They will establish stricter standards and issue more related laws and regulations by means of both legitimate and more subtle ways.

GOALS OF CHINA'S FISHERY INDUSTRY AND POLICIES AND MEASURES FOR PROMOTING TRADE OF AQUATIC PRODUCTS IN "THE 11TH FIVE-YEAR GENERAL PLAN"

The goals of China's fishery industry in "the 11th Five-Year General Plan" are to ensure the supply of safe aquatic products, increase fishermen's income, promote sustainable fishery development and facilitate harmonious development of fishing communities. Under the plan, China will:

- ensure the supply of safe aquatic products based on the premise of quantitative increases in aquatic products, continuously improving their quality safety level and keeping an effective supply in terms of quantity and quality;
- ensure increasing income of fishermen and sea farmers so that they get annual increases in income by implementing related government policies of improving the comprehensive efficiency of the fishery, increasing employment opportunities and reducing their burdens;
- promote the sustainable development of the fishery industry by vigorously developing a resource-conserving and environmentally friendly fishery by transforming the growth mode so as to optimize the allocation of resources, environment and essential factors of production. (We should make efforts in carrying out an aquatic creature protection action plan and preventing the decline of fishery resources as well as the deterioration of the aquatic environment, so as to create favorable conditions for sustainable fisheries development); and

- facilitate the harmonious development of the fishing community to build a new socialist fishing community characterized by developed manufacturing, favorable environment, affluent livelihood, harmony and stability by strengthening fishing infrastructure like fishing ports, organizing more training programmes for fishermen and sea farmers and optimizing the economic structure in the fishing community.

Specific policy measures

These include:

1) Adhering to the principle of "focusing on aquaculture, with the combination of aquaculture, fishing and processing, and taking appropriate means in accordance with local conditions and placing particular emphasis on advantageous fields"; pursuing sustainable development with high quality, high efficiency, a good ecosystem and sound safety; controlling the fishing intensity and strengthening the protection of fishery resources and the environment.
2) Continuously optimizing industry structure, enhancing self-innovative capability and transforming growth mode in order to build a modern fishery industry system characterized by a rational structure of aquaculture, fishing, processing, logistics and leisure fishing.
3) Sparing no efforts to accelerate the construction of industrial zones boasting advantageous aquatic products, so as to push forward the innovation of conventional aquaculture models as well as upgrade traditional fishery industry; intensifying the development of the fishery's original and fine species systems, and disease prevention and control systems to facilitate a healthy and ecologically friendly aquaculture industry.
4) Implementing a quality safety strategy and improving the overall level of the quality and safety of aquatic products to provide safe sources for export and to establish a responsible government image in the international community; enhancing the transparency of quality safety information and improving the distribution of information to ensure its smooth transmission.
5) Quickening the step to realize industrialization and effectively improving systematization to establish high-level export-oriented enterprises of large scale and strong influence; establishing a number of export-oriented trade federations, thus coordinating export order in a better way.
6) Insisting on the coordinated development of both domestic and international markets and encouraging aquatic products from all foreign countries to enter the Chinese market so as to promote aquatic product consumption and the development of aquatic product trade. The annual China International Fisheries Expo provides favorable conditions for trade and exchange and has become the largest of its kind in Asia and the third largest globally.

Wu Hougang

President
Dalian Zhangzidao Fisheries Co., Ltd

Wu Hougang has been in charge of the Finance and Manufacture Department of the Dalian Zhangzidao Fishery Group Co., Ltd. since he became employed in 1988. In 1996 he was promoted to General Manager of the group and has been acting as President of the board since 1999. He is also Deputy Chairman of Liaoning Provincial Fisheries Association, Deputy Chairman of Dalian Industry & Commerce Association, and Chairman of Dalian Sea cucumber Association.
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Natural Choice Sea Products, professional process management – shellfish ecological aquaculture and safety control in the north of the Yellow Sea

Wu Hougang
President
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ABSTRACT

This report provides an overview of the production and trade status of shellfish in China, the major producer and exporter of shellfish worldwide. Dalian City of Liaoning Province, as the major origin of the yesso scallop (*Patinopecten yessoensis*) in China, has developed ecological breeding in order to carry out marine exploration and extension for aquaculture, by focusing on its marine conservation activities. Therefore, drawing on conservation measures of ocean environment and ecological aquaculture technology, the report presents Dalian Zhangzidao Fishery Group Co., Ltd. as a leader in safety control and management systems for the culture of *Patinopecten yessoensis*. This includes marine environmental inspection, purification and comprehensive quality supervision.

INTRODUCTION

Dalian Zhangzi Island Fishery Group Co., Ltd, a fishery group originating from the Yellow Sea, now has developed into the "National Key Leading Enterprise in Agricultural Industrialization" and a listed company. I would like to share the following experience with you, which is crucial to our development

First, we have established an ecological aquaculture method that fits the sea condition and is characterized by large-scale production of shellfish and seabottom multiplication. Second, we take it as our responsibility to produce high-quality, safe sea products, paying attention to the management of processing quality from the origin of products to the market. Our aim is "To be the manufacturer of high-quality, safe and healthy choice aquatic products across the world", for which we have been making unremitting efforts.

THE DEVELOPMENT OF ZHANGZI ISLAND FISHERY

Dalian Zhangzi Island Fishery Group Co., Ltd. was founded in 1958. It is located at Zhangzi Island, which is regarded as "a pearl on the Yellow Sea". It is a large-scale, comprehensive, fishery stock-holding group covering a wide range of businesses including choice aquatic products breeding, multiplication and the processing and sale of aquaculture products.

The sea area

The company now having the right to exploit a seawater area of 60 000 ha along the Yellow Sea, the Bohai Sea and the East China Sea, boasts the largest yezo scallop aquaculture base and is the largest domestic group independently exploring the largest sea waters in China. The excellent natural environment and high primary productivity provide favorable conditions for developing the multiplication and culture of choice aquatic products.

The industry

Dalian Zhangzi Island Fishery Group, Ltd. is the first corporation in China to adopt the large-scale bottom-sowing multiplication of choice aquatic products, the newest offshore multiplication model, facilitating the coordinated development of economic efficiency, aquatic ecology and environmental protection. The company, boasting breeding facilities for various choice aquatic fry with the total of 25 000 waterbodies, is the high-quality breeding farm for yezo around the country and the comprehensive raw material farm in Liaoning Province. It has five advanced aquatic products processing factories with an annual processing capacity of 10 000 tonnes of scallops and 10 000 tonnes of other aquatic products, as well as an annual refrigerating capacity of 10 000 tonnes.

The management of the group

For many years, the group has kept a good business operation. Especially since the reform in 2001, it has been maintaining an annual growth rate of over 20 percent. The "Zhangzi Island" stock has become a listed company on the Shenzhen Stock Exchange.

The integration of industry, education and research

Zhangzi Island Fishery has been designated a "National-recognized Enterprise Technology Center" and has etablished cooperative relationships with the China Institute of Water Resources and Hydropower Research, the Institute of Oceanography, the Chinese Academy of Sciences and the Ocean University of China. They have also created a new method of industry, education and research, the "strategic cooperation and joint programs". At present, projects in more than 20 frontier areas of fisheries are being implemented, such as those under the research programme "Project 863" in the 11th Five-Year General Plan.

Honors of the group

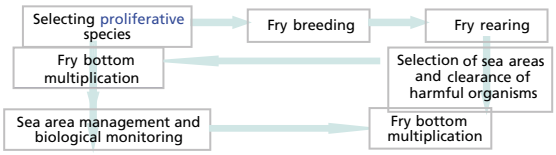
The group has become a "National Key Leading Enterprise in Agricultural Industrialization", while the brand-name "Zhangzi Island" is "China's Famous Brand", and has been certified by the British Retail Consortium (BRC), the International Standards Organization (ISO 9001) Quality System Certification, Hazard Analysis Critical Control Point (HACCP) and Organic Food Certification, so its products are considered as pollution-free and Grade AA Green Food. The main products of the group are stichopus, disk abalones and yezo scallops, which are certified as "products with the mark of country origin". These series of products are available in thousands of supermarkets in such countries and regions as the United States of America, Australia and Taiwan Province of China.

THE ECOLOGICAL BOTTOM MULTIPLICATION METHOD FOR LARGE-SCALE SHELLFISH AQUACULTURE

The Ecological Sea Bottom Multiplication Method is shown in Figure 1.

General introduction to proliferation

FIGURE 1
The Ecological Seabottom Multiplication Method



According to the criteria for selecting organisms used in proliferation such as the environment, market demand, economic value and research ability, Zhangzi Island has formed the fishery proliferation system focusing on the scallops, sea cucumber and abalone, supplemented by sea urchins, conch, blood clam, clam and fish. The company has explored an area of 60 000 ha for aquaculture, 40 000 ha for yezo scallop bottom multiplication, 3 000 ha for blood clam bottom multiplication, 1 000 ha for disk abalone bottom multiplication and 1 000 ha for sea urchin bottom multiplication. It is the largest yezo scallop aquaculture production in the country and the company has independently explored the largest sea area in China. The corporation currently boasts an annual production capacity of 2 000 tonnes of yezo scallops, 400 tonnes of stichopus, 500 tonnes of blood clams, 100 tonnes of disk abalones and 300 tonnes of sea urchins.

Seed multiplication and breeding

The goal of the company is to breed fast-growing high-quality seed with stress resistance. Now the company can produce 4 billion yezo scallop seed, 200 million stichopus seed, 20 million disk abalone seed and 10 million sea urchins every year. With the conquering of the tough task of semi-artificial fry collection of yezo scallops in the natural maritime environment, the yearly output of seed can now reach 1 billion on a stable basis. To achieve the aim of breeding large-size seed in a set period, we have created a three-level breeding technique, and seed output has reached the stipulated utilization ratio (above 80 percent).

Seed proliferation by releasing

The selection criteria for choosing areas suitable for raising all the species have been set up. Investigations on the areas to be sowed must be carried out to determine the multiplication area according to the above criteria before bottom breeding, and all harmful organisms must be completely removed.

Construction of sea farms

Basic studies on the influence of sea farm construction on breeding behaviour and studies on the effects of artificial reefs and the construction of algal fields have been carried out. Over a period of five years a total of 50 million CNY has been invested in research and construction of a fish reef suitable for the multiplication of all kinds fish. During this time, we made use of 2 000 hm of sea area. Meanwhile, the ecological and economic benefits are obvious – the marine biomass per unit in the areas where the sea farm was constructed has been improved by 20 percent.

Harvesting

Harvesting is carried out with the method of diver collection and the use of a beam trawl.

QUALITY CONTROL FOR FOOD SAFETY FROM ORIGIN TO MARKET

Product quality safety shows the management ability of the corporation and even more, its core values. Therefore, it relates directly to the survival and development of the corporation. We have been strictly following the HACCP quality management system. Products marked with the Zhangzi Island Brand trademark have passed the

health standard authorization of the United States Food and Drug Administration (US FDA) and the European Union (EU). Every processing procedure is carried out with advanced techniques and under strict control, ensuring superior quality of the product. There has never been an accident concerning food safety, and the "Zhangzi Island" brand has provided consumers with safe "Choice Aquatic Products".

A GENERAL PROFILE OF THE SEA

Zhangzi Island is located in northern Huanghui and at the southern end of the Changshan Archipelago. The nearest distance from the southern coast of Liaodong Peninsula is 44.4 km, with an area of 1 000 km^2 and a coastline of 58 km. As it is located at the confluence of the northern Yellow Sea and the southern Liaoning seacoast, it is generally dominated by the cold water of the northern Yellow Sea, and thus the water is of high quality and the environment is superior. It is meets the Grade I of Quality Standard for State Seawater and is the cleanest seawater in China.

The control of seawater environment

We mainly focus on the control of hydrodynamic forces, hydrology, hydrochemistry, pollutants and biological organisms. The company carries out a thorough investigation of the water quality and associated microorganisms on a monthly basis (altogether 28 locations will be investigated) and entrusts the Aquatic Products Quality Supervision and Testing Center, Ministry of Agriculture (Dalian) to carry out monthly water quality testing (altogether 16 locations will be investigated).

Management for the breeding process

Provisions for Supervision and Control over the Catching of Shell Product in the Aquaculture Area in Zhangzi Island has been enacted to set a clear distinction between aquaculture area and temporary aquaculture area and to stipulate clearly on the process of breeding, harvesting, purchasing and transporting of seed. No chemical is allowed to be used in the multiplication process so as to ensure the natural growth of scallops in a natural environment. The use of contraband chemicals is prohibited.

Temporary maintenance for equipment and purification treatment

We have invested 120 million CNY on the largest shellfish purification centre – Jinbei Plaza – with a total floor area of 22 000 m^2. The daily processing of shellfish products can reach 200 tonnes, with a purification capability of 100 tonnes. With the latest ozone sterilization technology, our purification capability, quality and instrumentation have all reached the most advanced level in China. The yearly output of frozen products is 6 000 tonnes, 3 000 tonnes of which are cold-stored. After we adopted the newest and most advanced processing technology – "New Technical Gas Processing Technology", the yearly output of nutritional instant food is now able to reach 1 500 tonnes.

Product processing management

The monitoring centre with China's most advanced instruments for monitoring physicochemical parameters, microbes and heavy metals ensures the quality of our products in the market. The world's most advanced instruments and techniques have been introduced to carry out research and the designing of optimal processing technology.

Zhou Deqing

Director
National Center for Supervision and Test of Aquatic Products (NCQSTAP)

Zhou Deqing was born in June 1962. He heads the National Center for Quality Supervision and Test of Aquatic Product (NCQSTAP) and is Associate Director of the Key Laboratory of Sea Fisheries Safety and Environmental Control of the Chinese Academy of Fishery Sciences. He also is the Commissioner of Aquatic Products Process & Utilization Branch of the China Society of Fisheries and a member of the Food Professional Committee of the Chinese Association for Quality Inspection. Dr Zhou covers all aspects of processing and utilization, quantity safety and control of edible aquatic products. From 1984 to 1999, he was an instructor of biochemistry and food science and from 1999 to present, has been employed at NCQSTAP. From 2000 to 2006, Dr Zhou visited the United States and Europe several times and reviewed quality and supervision systems for aquatic products in developed countries. His principal research includes residue limits of fishery drugs in seafood safety; he published *Fishery Safety* as editor-in-chief, and has written over 30 articles on this subject. He has been involved in the foundation of the Ministry of Science and Technology of China (MOST); the "Research and Establishment of Food Safety Supervision and Precaution System for Aquatic Products" and in the "Introduction and Establishment of Current Aquatic Products Quality Control System". He applied for research on formaldehyde in fishery from the National Natural Science Foundation. As a professor, he supervises PhD students.

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Quality safety for aquaculture products of China and its management

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ABSTRACT

In 2005 the total aquatic production in China reached 51.02 million tonnes, and per capita consumption was about 38 kg. The rapid development of aquaculture not only supplied abundant high-quality aquatic products for domestic and overseas markets but also greatly contributed to international trade. The safety aspect of aquatic products attracted the public's attention because of the rapid development of fish culture and international trade. It also directly affected the advancement of the fishery economy, as well as promoted a sound development of international trade. During the past two years, great technological progress has been achieved in our country in the area of quality and safety of aquatic products, especially during the period of the "10th Five-Year Plan". The problem of quality and safety was identified as a priority, and basic research was rapidly developed in conjunction with the legal and interrelated criteria. Moreover, the technology of control was extensively renewed. This study assesses the quality and safety of this sector, in accordance with the standards of quality control and inspection of aquatic products, as well as reviews advances in research and other related areas.

INTRODUCTION

China has a very long history in aquaculture. Thanks to the reform and opening-up policy in 1978, the Chinese aquaculture industry has witnessed growth rates of more than 10 percent every year. Since the late 1980s, the Chinese Government has advocated the policy that the development of aquaculture should be regarded as the central task of fisheries. Guided by the concept that economic benefit should be regarded as the central task, and market as the orientation in the development of aquaculture, seafarmers around China readjusted the aquaculture structure, initially developed the ecological and environmentally friendly aquaculture mode, promoted the safety mode of aquaculture, spared no efforts in industrializing aquaculture and shifted their attention from the output to the quality of the products. At the same time, they have also optimized the aquaculture species and promoted new aquaculture techniques and styles, which helped seafarmers make great achievements in the fast-growing aquaculture sector. According to the statistics issued by the Food and Agriculture Organization of the United Nations (FAO), China's output of aquaculture products (48.15 million tonnes) accounted for 34.1 percent of the world's total aquatic products in 2005 and was 2.97 times more than that of 1995, while the catch of fish was around 90 million tonnes during these ten years. In 2005, the output of aquaculture products (33.93 million tonnes) accounted for 67 percent of the total aquatic products in China

and more than 70 percent of the world total. China has set a good example in fisheries for other countries, especially developing countries, particularly in the development of aquaculture in terms of the sustainable development of fisheries and the guarantee of food safety. The development of aquaculture in China has contributed significantly to the national economy and the increase in fishermen's incomes.

The most encouraging phenomenon is that China's aquaculture products are warmly welcomed in the European Union (EU) and the United States, thanks to their uniform specification and quality, the strict control of the growing period and scale of production, the availability of the quality standard and the convenience in their preservation and shipment. Prawns, salmon, tilapia, eel, catfish and molluscs cultured in China have become major aquatic products in the international market. In 2006, the total value of the aquatic products exported from China reached US$ 89 billion, accounting for 10 percent of the world total. Increased importance has been attached to aquaculture products in the international trade of aquatic products.

Diversification of aquaculture modes

With the advancement of modern technology, the traditional way of aquaculture that was characterized by great consumption of natural resources and other materials has been modified, while modern aquaculture, with its higher degree of human control and automation, has greatly developed. Additionally, more importance is being attached to the sustainable development of aquaculture. Many high-yield modes of aquaculture, such as industrialized aquaculture, cage aquaculture and recirculation aquaculture were used, in which ecological aquaculture was characterized by the integrated use of water and the combination of culture in the sea and on land. Thus highly efficient modes of aquaculture that make full use of energy were extensively adopted.

Continuous diversification of species cultured

There are more than 40 species presently cultured in China, while less than 10 species were farmed only 20 years ago. In freshwater aquaculture, finfishes no longer predominate. Shrimps, crabs and turtles can be commonly seen, although finfish remain the major aquaculture product. In seawater aquaculture, the range of products has been extended to include shrimp, crabs, fish and choice seafood ranging from scallops to algae. Some foreign species such as tilapia, white shrimp and southern flounder have been successfully introduced into China, which has provided a certain economic advantage.

Major expansion of aquaculture throughout China

The geographic distribution of aquaculture in China is that the eastern, central and western areas account for 80, 18 and 2 percent of production, respectively, from which we can clearly see that the eastern area plays a predominant role. Advantageous species like eel, prawn, tilapia and yellow croaker are mainly sea-farmed in the southeastern coastal area, while in the Yellow and Bohai seas, prawn, scallops and fish are the main aquaculture products, most of them being sea-farmed on an industrialized scale.

Responsible fisheries and healthy and sustainable aquaculture are put on the agenda

As the development of public living standards and the citizens' desire to be close to nature increasingly grows, the demand for high-value aquatic products will also greatly increase. To keep pace with this changing situation, we should promote the idea of "ecological aquaculture", readjust the aquaculture structure, enhance the production of hazard-free and organic aquatic products, include fisheries within ecosystem management and promote the sustainable development of aquaculture.

A BRIEF OVERVIEW OF QS (QUALITY SAFETY) FOR AQUACULTURE PRODUCTS IN CHINA

The quality of China's aquaculture products is high compared with that of other countries or previous years. The total volume of trade in aquatic products for both the domestic and export markets grows every year.

According to statistics issued by the Information Office, Ministry of Agriculture during the first regular inspection of 22 cities in China in the first quarter of 2007 for the presence of chloroamphenicol and malachite green, which was organized by the related quality inspection organizations under the mandate of the Ministry of Agriculture, the acceptance rate for the test on chloroamphenicol was 99.8 percent, while the conforming rate for the test on malachite green was 89.5 percent. There are altogether 12 cities where chloroamphenicol and malachite green have not been found: Tianjin, Zhengzhou, Nanchang, Shenzhen, Guangzhou, Qingdao, Fuzhou, Chengdu, Nanning, Shenyang, Dalian and Chongqing.

Analysis of the present situation for QS of aquaculture products

Reasons for the existence of some disqualified and unsafe aquatic products are as follows:

- excessive drug residues are left on aquaculture products because some seafarmers and companies disobey the related regulations and standards;
- problems may occur in all stages of the whole process, including during production, processing, shipment and sale of aquaculture products (for example, some disinfectants and bactericides are used to guarantee survival rate during shipment);
- exaggeration by some media – some subjective and unjust reports on the safety of aquaculture products are not based on scientific evidence (in the case of the news report "Fresh-water Fish Heads Are Inedible Due to Drug Residues" in Beijing, for example, the reporter wanted to attract the reader's attention by quoting the unscientific ideas of some so-called experts; the report, lacking scientific analysis, was not grounded on accurate statistics or confirmed in a scientific way) and
- there are still some imperfect standards for the quality of aquaculture products. (additionally, some examinations fail to offer accurate testing; for instance, some standards for the containment of abio-arsenic in algae and its style of test are to be modified).

Analysis of QS for aquaculture products for exportation

The quality of China's aquaculture products destined for exportation has been increasingly promoted. Excessive drug residues in exported aquaculture products remained the major problem in the international trade in 2006, affecting the exportation of Chinese aquaculture products. The United States Food and Drug Administration (US FDA) and Canada criticized us for the presence of residues of banned drugs such as chloroamphenicol, malachite green and nitrofurazone in exported aquaculture products in March and July 2006.

In September 2006, the US FDA for the first time sent its investigation team to China to inspect the monitoring system for aquatic products. Endosulfan was found in eel exported to Japan in June, 2006, which after investigation turned out to come from fish drugs produced by veterinary medicine factories. At the same time, the "*Scophthalmus maximus* Drug Residues Incident" and the "*Pomacea canaliculata* Spix Incident" occurred, which negatively influenced the exportation of aquaculture products.

Major problems in QS for aquaculture products

China is an important country in terms of aquaculture, and its aquaculture products account for two-thirds of the total volume of the whole world. Aquaculture

enjoyed a "leap-forward" development during the last ten years. Its development is characterized by tendencies of optimization, modernization, industrialization and internationalization. However, some QS problems are emerging due to increasingly deteriorated natural environments and aquaculture modes of higher intensity. The QS situation for aquaculture products is far from optimal, and as aquaculture develops differently from region to region, QS incidents are not uncommon. The major problems are as follows:

- epidemic diseases continuously breakout because of an unchecked chase for high productivity without respect for environmental capacity;
- seafarmers are unable to take control of the sources of pollution;
- the innovative ability of aquaculture is inadequate;
- research on substitute drugs and vaccines for fish is severely limited;
- the coverage of high-priced species is fairly low;
- technology for the development of fish feed is outdated;
- the management tools and manners of fishery departments are not adequate; and
- coordination between the responsible departments is far from desirable.

Responsible departments shoulder heavy responsibilities, so they should make unswerving efforts in QS management of aquaculture products.

QS management for aquaculture products

It's the Chinese Government's responsibility to promote the initial development of aquaculture and at the same time, to strengthen and improve the QS management following the related international standards and conventions, with a view to providing consumers with safe, high-quality aquaculture products and to meeting the demand of the importers in terms of the safety and quality of the exported aquaculture products.

During the "10th Five-Year General Plan", Chinese aquaculture witnessed a sustainable, fast and healthy development enhanced by the readjustment of the aquaculture structure and the "market-oriented" idea. Aquaculture was also guided by the objective of "increase the benefit, upgrade the seafarmers' income and promote the competitiveness of Chinese aquaculture" during that period. To solve the problem of excessive drug residues occurring in exported products, the Ministry of Agriculture initiated specialized inspections for major banned drugs such as chloroamphenicol, enrofloxacin base, malachite green and ronidazol throughout China in order to regulate the fish drug markets, punish the illegal use of banned drugs and improve the order of the fish drug market. Additionally, the QS Standard System and the Examination & Test and Certification System have been improved, and some seafarms meeting national standards and based on hazard-free aquaculture practices have been set up. "Five Systems", namely production logs, scientific use of drugs, monitoring of the aquatic environment, labels for products, and monitoring and control of raw materials have been initiated in some large and medium-size seafarms to assist in producing hazard-free aquaculture products for exportation. As a result of the exploration of effective management mechanisms, the whole-process objective of "from pond to table" is brought forward, the range of monitoring and control over the safety of aquatic products in urban areas is increasingly broadened, and some cities are working on the exploration of new mechanisms for the management of market exit and access.

Improvement of major related laws and regulations

The *Law of Quality Security for Agricultural Product*s was issued on 29 April 2006 and came into effect on 1 November 2006. There were few stipulations concerning QS for agricultural products in the Chinese legal system before the issuance of this law, while there was no clear-cut division of responsibility among governmental departments. Many governmental departments were concerned with this issue; however, when it

came to addressing the detailed problems, there were no specified stipulations to which the law enforcement departments could refer.

The issuance of the *Law of Quality Security for Agricultural Products* for the first time solved the problem of vacuum legis on the QS for agricultural products in China. The law plays an important role in safeguarding the basic needs of the public, which is just one example of its significance. Viewed in terms of the national economy and the development of the rural economy, this law, issued when Chinese agriculture was shifting from a quantity-oriented into a quality-oriented mode, will facilitate the modernization of Chinese agriculture.

Other complementary laws and regulations also play an important role in guaranteeing QS for Chinese agricultural products, and *Regulations on Administration of Veterinary Drugs*, *Stipulations on the Management on Quality Safety for Aquaculture Products*, and *Management Methods of Seed and Fingerling in Aquaculture* are among them.

Gradual improvement of the technique standards system

The technique standards system on aquaculture has been gradually modified and perfected. In the system, the national and industrial standards will be the major parts, coordinated and complemented by the provincial and enterprise standards. The scope of standardized procedure is expanded to include pre-production, production and post-production of the aquaculture products, and more attention is paid to coordination between technique and management standards. The standards concern the production-related environment, feed, drugs, fingerlings, production techniques and quality for aquaculture products. Additionally, standards have been set for infrastructure and facility-concerned fishery engineering, fishing equipment, and materials used in the manufacture of equipment, boats and fishing gear. The range of the standards has been broadened into source environment, species, cost, processing, examination and testing, classification, and packaging and shipment. The drafting of standards for the use of fish drugs, maximum drug residues, safety of feeds and control of hazardous materials in water has experienced a breakthrough, which facilitates the drafting of standards and regulations for aquaculture, its management and the trade in aquaculture products. There are presently 640 items of national and industrial standards, including 65 national and 575 industrial standards. Of these, 224 items are on aquaculture production, 125 are on product processing, 62 are on fishing equipment and material for equipment, 56 are on fishing machines and facilities, 150 are on fishing boats, 23 are on construction of fishing projects and 70 are on hazard-free products. There are 102 compulsory standards and 538 recommended standards.

In terms of certification, recent years have witnessed the issue of certification on "hazard-free, green, and organic aquatic products" based on the standards and regulations of the aquaculture techniques for these types of products. Together with the provincial governments, the General Administration of Quality Supervision/ Inspection and Quarantine of the People's Republic of China (AQSIQ) designed incentives for the construction of model seafarms that meet the national standards.

NEW MEASURES ON QS MANAGEMENT OF AQUACULTURE PRODUCTS

Management of Aquaculture to Meet International Standards

In the 3rd session of the International Conference on Aquaculture held in New Delhi, India, in September 2006, the negative influence of aquaculture on the environment, society and other areas was brought forward; however, experience shows that these kinds of negative influences can be eased by the improvement of management, which can also facilitate the sustainable development of aquaculture. Aquaculture is experiencing fast development that can meet the increasing need for aquatic products

in the future. Therefore, all the related beneficiaries should give top priority to the management of aquaculture. The Chinese Government also attaches great importance to it and some detailed measures have been carried out.

National meeting on the QS management of aquatic products

A National Meeting on the QS Management of Aquatic Products was held in Wujiang, Jiangsu Province, from 26–27 June 2006. The speaker of the meeting pointed out that, with about 20 years' aquaculture development, China has experienced a great transition from being "fishing-oriented" to becoming "aquaculture-oriented", and is now facing another transition that will be more dramatic and difficult. More importance will be attached to QS of aquaculture products in the future. To stick to the principle of "culturing-oriented", we should take good care of QS of aquaculture products. We should also promote the transition from the "high productivity" mode to the "quantity and quality" and "profit and ecology" mode of aquaculture development. We should strengthen our sense of responsibility and take detailed measures to address problems in the QS for aquaculture products, so as to guarantee public health, safeguard the legal rights of seafarmers, and upgrade the exportation of aquaculture products in China.

Drafting of Action Plan on Transformation of Growth Mode of Aquaculture Industry

To implement *Opinions of the Ministry of Agriculture on Carrying out the Nine Major Actions*, and to change the old growth mode of aquaculture, the Ministry of Agriculture issued *Action Plan on Transformation Growth Mode of Aquaculture Industry* in 2006, which is devoted to changing the old growth mode of aquaculture in China, creating new modes, developing the potential, improving the quality of aquaculture products, and promoting the transition from the "high productivity" mode to the "quantity and quality" and "profit and ecology" mode of aquaculture development. In the action plan, it is suggested that 100 model seafarms that are up to the national standard, 20 model counties in the development of beach aquaculture, 10 model seafarms for prevention of aquaculture diseases, and five pilot sites for industrialized recycling seafarms be set up by the Ministry of Agriculture.

Introduction of hazard analysis critical control point (HACCP) into the QS management of aquaculture products

HACCP has been extensively applied to aquaculture all around the world. The United States, Canada, Norway and Thailand have set up their own HACCP operation modes since the 1990s. To apply HACCP to aquaculture is to take complete control of the surrounding environment of the seafarm, the water of the seafarm, the water source, fingerlings, feed and aquaculture drugs during the whole process of parents—egg—rearing of nauplii—maturity—sale. The hazard analysis of every key species should be done at every stage of the whole process and then Critical Control Points (CCPs) should be found and controlled, so as to guarantee that human health cannot be affected by aquaculture products.

Other measures

To guarantee the QS and the sanitation of aquaculture products, the Ministry of Agriculture has published a catalogue of banned drugs and has notified the US FDA of the 11 drugs banned for use in animal-derived food. In addition, the Ministry of Agriculture has also abandoned the related standard for the quality of veterinary drugs; cancelled the drug approval documents; forbidden the production, sale and use of banned drugs; and destroyed all remaining inventory. The related quality standards were modified, and a tracing system for aquaculture products was introduced. Finally, a prescription and medication file system was set up in aquaculture enterprises.

Joo Siang Ng

Vice-Chairman and Managing Director
Pacific Andes Group

Ng Joo Siang, 48, was born in Malacca, Malaysia. He graduated from Louisiana State University in 1980 with a Bachelor of Science degree in International Trade and Finance. Upon graduation, Mr Ng joined the family's timber business in Taiwan POC, before returning to Singapore to manage its grain trading, shipping and fishing businesses. In 1985, he relocated to Hong Kong SAR to help establish the seafood trading and processing businesses. The seafood business, under the name of Pacific Andes International Holdings Limited (the "Group"), was listed on the Hong Kong Stock Exchange in 1994. The Group's resource development and frozen fish supply chain management division, Pacific Andes (Holdings) Ltd, was separately listed on the Singapore Stock Exchange in 1996. In 2004, the Group further diversified upstream into deep-sea industrial fishing. The fishing division, headed by China Fishery Group Ltd, was listed on the Singapore Stock Exchange in 2006. Today, the Pacific Andes Group has a combined market capitalization of over US$2.3 billion and group turnover exceeding US$1 billion. It is a fully integrated group of companies with operations across the entire seafood value chain, which includes harvesting, sourcing, marine reefer transportation, food testing, processing and distribution of frozen fish products, retail-pack products, ready meals and canned products as well as fishmeal and fish oil. Its businesses span the world, with factories located in China, Japan, Thailand, United States and Peru. The Pacific Andes Group currently harvests about 600 000 tonnes and handles nearly 800 000 tonnes of fish annually, and ranks as the world's largest fish fillet producer. Mr Ng is the Vice-chairman and Managing Director of the Pacific Andes Group, overseeing all of the Group's activities, including policy formulation, strategic planning, business development and investment management. He sits on the advisory boards of the Hong Kong Export Credit Insurance Corporation as well as Rabobank's Asia Food and Agribusiness. He is also an Honorary President of the Association of China Small and Medium Enterprises and Vice-President of the International Union of Economists.

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Development of China as the world's largest reprocessing centre of frozen fish products and future challenges for the industry

Joo Siang Ng
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ABSTRACT

As an overseas Chinese operating in China for over 20 years, Mr Ng provides a firsthand account of the development of China's seafood processing industry in the recent decades as the country makes its transition from a planned economy into a market economy. The factors that have shaped China's seafood processing industry are discussed, including its dynamics with other seafood-producing nations, early difficulties and the perception problems faced. The various factors contributing to China's rise as the world's largest reprocessing centre for frozen fish products are also discussed. Against the key trends defining the general landscape of the global seafood industry, the increasingly complex challenges faced by China's frozen fish reprocessing industry are reviewed

INTRODUCTION

I am asked to talk about the development and future challenges of China's seafood reprocessing industry. As there are many distinguished experts from the Food and Agriculture Organization of the United Nations (FAO) and Chinese officials present at this conference, and many statistics have been presented during the last two days, I shall refrain from using too many statistics, which I also believe all of you have already been overwhelmed by. I shall simply speak from my personal perspective and experience. Please therefore pardon me in areas where you may not entirely agree with me.

OVERVIEW OF CHINA'S REPROCESSING INDUSTRY

The scope of China's seafood reprocessing industry is undeniably very wide. Hundreds of factories across China are reprocessing both domestically produced and imported fish into an array of fish products, including but not limited to salted, dried, smoked and various preserved fish products for both domestic and export markets. Just Jilin Province alone, for example, imports about 60 000 tonnes of high-grade (H/G) Alaskan pollock annually for reprocessing into freeze-dried fish for both domestic consumption and export to the Democratic People's Republic of Korea and the Republic of Korea.

Given that the scope is so large and due to the time limitation, I shall focus on the development of the Chinese reprocessing of imported frozen fish for re-export to the international market.

Although China has been exporting processed seafood products to various parts of the world since the 1960s, I would comfortably say, for many years, Japan has been the most important market for Chinese seafood products. Owing to proximity, most of

the seafood species produced in China are those conventionally preferred by Japanese consumers. Japanese conglomerates and seafood companies have also been very active in China. In fact, some of the Japanese companies possess far more in-depth and complete knowledge of the Chinese seafood industry than their Chinese counterparts do. Such knowledge includes market information, quality standards, and the facilities and equipment available at individual Chinese factories. It was the Japanese companies that first realized the low-cost advantage and potential for reprocessing in China.

Towards the end of the 1980s, many Japanese companies were already utilizing Chinese factories along the coast of China to reprocess fish imported from the then-Soviet Union, Europe and North America. Those reprocessed products were then mostly exported to Japan for further processing or repackaging for the Japanese retail market.

Subsequently, several external events that unfolded in the beginning of the 1990s played a determining role in driving the growth of the Chinese seafood reprocessing industry.

First, the Soviet Union began its development towards a market economy. Local fishing companies were all given the right to export their own catches instead of exporting through the Moscow-based Sovrybflot. As a result, huge quantities of fish catch from the Russian Far East were imported into the Chinese market. Qingdao in Shandong Province and Dalian in Liaoning Province, with their proximity to the eastern part of the Russian Federation, formed two important gateways through which Russian fish was imported into China by direct trade. At the same time, supplies also entered China through border trade, taking advantage of the then-preferential Sino-Russia border trade treaty. Some of the fish imported was sold in China's domestic market, while some was reprocessed into fish fillets for export.

Second, around the same time, Newfoundland closed off cod fishing, which created a global shortage in cod supply. Many traditional users of cod products, such as McDonald's and Burger King, as well as some fishfinger producers, were compelled to seek a substitute for cod. Alaskan pollock became the natural choice, and as a result, the United States sea-frozen Alaskan pollock fillet prices skyrocketed.

Seafood processors in China's Shandong and Liaoning provinces saw the opportunities that emerged amidst these developments and began to make use of an abundant supply of low-cost Russian pollock to produce large quantities of twice-frozen fillet to meet market demands.

Back then, the Chinese' recovery rate for producing Alaskan pollock fillet was much lower than that of today. In the early 1990s, every 10 000 tonnes of Alaskan pollock fillet produced by the Chinese plants needed about 20 000 tonnes of H/G pollock as raw material, or equivalent to about 34 000 tonnes of whole round fish. In contrast, the American factories and trawlers then needed about 59 000 tonnes of whole round pollock to produce the same quantity of fillet.

Today the Americans have a much improved yield as compared to 10 years ago. To produce the same amount of fillet, American factories and trawlers would need about 42 000 tonnes of whole round Alaskan pollock. In spite of this, the Chinese' rate of recovery is similarly improving. They now only require about 14 000 tonnes of H/G fish, which is equivalent to about 25 000 tonnes of whole round fish, without the use of any weight enhancing additives. That is a difference of 17 000 tonnes of fish. In other words, the Americans require 69 percent more fish to produce the same quantity of fillet as compared to the Chinese. China's high rate of recovery clearly represents a more effective utilization of valuable ocean resources. For anyone concerned about the long-term sustainability of global fish stocks, that is a very important difference.

Without doubt, significantly lower costs of production have also helped the Chinese to compete in the global market. Depending on product specification and complexity, production cum packaging cost for every kg of fillet is only US$0.30 to 0.50. As compared to producing in Europe or the United States, where costs can easily run up

to more than US$1.50 per kg, it costs only a fraction to produce in China. Moreover, freight costs from China to Europe are only US$0.15 to 0.20 per kg, US$0.20 to 0.30 to the United States and merely US$0.10 to Japan. In fact, inland transportation costs within these markets can sometimes be even more expensive then direct shipping costs from China to the final destination.

Given the low capital outlay and processing costs required in China, the benefit of producing in China was further amplified. Such competitiveness has enabled Chinese reprocessing plants to produce fillets at significantly lower prices.

Producing Alaskan pollock fillets has also lessened the Chinese reprocessing industry's reliance on the Japanese market. The marketing of Chinese twice-frozen Alaskan pollock fillet has helped China to open up and develop new markets, in particular that of North America and Europe.

In order to meet the demands of these new markets, China's reprocessing plants also significantly expanded the range of fish that they processed. Besides fish from the Russian Far East, other species such as northern blue whiting, Atlantic cod, haddock, halibut, herring, mackerel and redfish from the North Atlantic; Pacific cod, black cod, yellowfin sole and flounder from North America; and hake, squid and hoki from the Southern Hemisphere, as well as shrimp and shellfish were also shipped into China for processing into fillets and various other products for re-export.

The above have laid a strong foundation of growth for the Chinese seafood reprocessing industry.

An increasing world population, growing affluence, greater health awareness and a change in dietary habits are factors attributing to rising seafood consumption worldwide. Nevertheless, increasing regulatory control on fishing and lesser illegal fishing activities in the recent years have created pressure on the supply of traditionally favoured commercial species.

At this juncture, I think it is fair to say that the Chinese seafood reprocessing industry has made the following contributions to the global food supply chain:

- increased the availability of fillet and fish products to the world market through its higher recovery rates on production;
- lowered the cost of fish products to consumers worldwide;
- provided better utilization of some previously underutilized fish species for human consumption. (Take northern blue whiting as an example. Found in the North Atlantic, it is one of the world's most abundant species, but was previously only suitable as a raw material for fishmeal because its size was simply too small to go through an automated Baader processing line. In the last few years, this fish is increasingly being imported into China to be reprocessed into fillets and re-exported to Japan, Europe and Russia); and
- provided more varieties of product form to the retail and foodservice industries. Unlike the highly automated plants of the West, Chinese plants undertake processing manually and are capable of taking on small-scale production without much loss of efficiencies. They are also able to adapt to changes in customer requirements with much flexibility.

Higher fish prices worldwide in combination with the above mentioned advantages provided by the Chinese reprocessing plants have shaped China as the world's largest seafood reprocessing centre today. Benefiting from its geographical proximity to the Republic of Korea, Japan and Russia, as well as excellent port and coldstorage infrastructure, Qingdao has become the hub of China's seafood reprocessing industry.

Since the turn of the century, there have been an increasing number of mergers and acquisitions within the global food supply industry. Consolidation of upstream fishing companies has concentrated fishery resources in fewer hands, hence enabling them to achieve the much-needed economies of scale. It has also given them stronger bargaining power in demanding higher selling prices for their fish.

Consolidation on the downstream side of the supply chain, on the other hand, has enabled supermarket retailers and foodservice companies to exert greater pressure on their suppliers for more stable supply and lower prices. In fact, the retail chains are now so powerful that they dictate the terms of supply and frequently do not accept price increments. It is of no surprise that Chinese reprocessors and their customers, who are mostly secondary processors and/or distributors supplying to these retailers, are increasingly facing margin compression. In fact, some of the larger retail chains have already established direct sourcing policy from first producers. Although today they are still with little success, the trend is nevertheless inevitable. In order to fulfill the retailers' demand for lower-price products and to remain competitive, more and more products that are less time-sensitive and have less advantage of producing in the West are gradually being processed here in China.

ISSUES AND CHALLENGES

Although China's seafood reprocessing industry is presented with many opportunities and has bright growth prospects, it is also confronted with an increasing number of issues and challenges both externally and internally.

First, despite having only evolved in the last 20 years, China's seafood reprocessing industry is the world's largest today. Along with this rapid rise have come numerous criticisms and misperceptions. It is believed that China is able to produce such low-cost products, not only because it has cheap abundant labour, but also because it has enjoyed unfair trade advantages, and that local enterprises receive generous subsidies from the government.

According to *Seafood International* magazine, in the recent North Atlantic Seafood Conference, it was pointed out that the value of frozen cod and whitefish fillet block exports from China to Europe has increased 74 percent in the first ten months of 2006. Fillet exports were also up 41 percent to US$741 million. Piecing this together with the common knowledge that fish resources are limited, Aker Seafoods and some Norwegian participants openly alleged that such export value growth could only have been achieved because a large part, or as much as 130 000 tonnes, of cod and whitefish being reprocessed in China was illegally caught.

This is a grave and – in my personal opinion – largely unfounded accusation. Those who have been importing seafood into China would know that Country of Origin and Veterinary Certificates issued by relevant authorities of the exporting nations must be presented to the CIQ for the issuance of an import clearance permit. It is only with this permit that goods can be cleared by the Chinese customs for import into China. To a large extent, I believe such accusations arise as a result of a lack of understanding or even unwillingness to understand China. I am not saying that there have never been businesses in China that might be involved in any unacceptable behaviour; but the same could be said for most of the countries represented here today. Our governments oversee our business sacredly, and the large majority of reprocessors in China, including Pacific Andes, strive to match and better global best practices, not just in legal sourcing, but also in efficiency, hygiene, food safety etc.

China will have to grapple with a serious perception problem internationally. There is a propensity to point a blaming finger at China, and not helping matters are sensationalized overseas media reports that often cast China's food supply industry in an unfavourable light. I remain hopeful that given time, other countries will come to achieve a better understanding of China.

Then, some of these issues are regulatory in nature. For example, since the mid-1990s, HACCP certification has been made mandatory for all processing plants supplying to the United States; the European Union (EU) also requires all processing plants supplying into the region to possess EU registration numbers. In recent years, an increasing number of British and European retailers also demand that processing plants

must possess the British Retail Consortium (BRC) and EFSIS accreditation before they can supply their products.

In addition, customers' requirements are becoming stricter. Besides product quality, they are also paying more attention to environmental and social issues in satisfying increasingly complex consumer demands. Sustainability, food miles and ethical trading are some of the key issues currently receiving attention. Customers now require product traceability and complete documentation trace from raw material import to inventory and throughout the whole production process. Increasingly, they also demand social and ethical compliance from their suppliers.

While these requirements are stringent, the industry in fact benefits from having to comply with these standards. They have driven the Chinese reprocessors to sharpen their quality of management and facilities, thus bringing the overall standards of the industry to higher levels.

However, when these requirements become unrealistically difficult to meet, the industry has to deal with the high level of costs and intensive management effort that go into satisfying them. For instance, last year Japan set maximum residual limits (MRLs) for a list of more than 810 chemicals, including veterinary drugs and pesticides, many of which they have yet to establish clear commercially practical methodologies for. Likewise, the EU has also set MRLs for over 340 chemicals. Complicating matters is the fact that there exist many inconsistencies between the regulations of different countries. While full compliance is achievable, these have nevertheless created extremely high barriers of entry to the respective markets.

Food safety is now a major issue of the 21st century. Consumers are becoming increasingly aware and there is pressure across the global food supply chain to deliver safe food products. Historically, we have witnessed several blanket bans that arose as a result of problems in singular products. To illustrate, in 2002, when chloramphenicol was found present in some Chinese products, the EU banned the import of all products of animal origin from China. The ban was subsequently lifted, but only very slowly, and only species by species. More recently, Louisiana State in the United States banned sales of all Chinese seafood products when some farm-raised catfish from China tested for fluoroquinolones. As we can see, problems in a single product can now easily escalate into an industry-wide problem.

Clearly, the individual enterprise is no longer a one-man isle. Every player's survival is now intertwined with its peers, and while pursuing individual objectives, each enterprise must also bear in mind its responsibility towards the rest of the industry. It is only by sharing a common vision and working hand in hand that we are able to bring our industry to greater heights and ensure its long-term sustainability.

With this I end my presentation. Thank you.

Session 5: Progress – the future

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Aquaculture and fisheries: complement or competition

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ABSTRACT

The growth of the aquaculture sector has both positive and negative impacts on the traditional fisheries sector. In the ecosystem some aquaculture has: a) directly influenced fish stocks through its use of wild fish stocks for inputs such as feed; b) influenced fish stocks through intentional releases (salmon stock enhancement) or through unintentional escapes; c) displaced wild fish through its use of habitat and, in some cases, enhanced fisheries habitat (e.g. some oyster operations); and d) influenced both wild and farmed fish stocks through disease transmission and related interactions. However, aquaculture also has a tremendous influence on wild fisheries through international trade and the market. It has: a) influenced prices negatively through increased supply and positively through the development of new markets (e.g. catfish); b) changed consumer behaviour, c) accelerated globalization (e.g. salmon, shrimp and tilapia); d) increased concentration and vertical integration in the seafood sector; e) resulted in the introduction of new product forms; and f) significantly changed the way seafood providers conduct business. The growth of aquaculture has stimulated the traditional wild fisheries sector to improve quality and, in some cases, attempt to become more efficient. Growth in aquaculture has created a backlash of criticism from the wild fisheries sector (and environmental groups) through the media and, in several cases, has been met with increasingly restrictive international trade barriers (e.g. salmon, shrimp and catfish). These interactions and changes are explored and implications for the future of the wild and farmed seafood sectors are discussed.

INTRODUCTION

The growth of the aquaculture sector has both positive and negative impacts on the traditional fisheries sector. There has been considerable discussion regarding whether aquaculture and fisheries are competitive or complementary. The objective of this paper is to address this issue and its implications for the future of the seafood sector. First, is competition positive or negative? Are complements negative or positive?

Competition can be positive if it results in improved efficiency and/or increases in innovation. However, it may be considered negative if it results in bankruptcy and displaces the existing industry, community and heritage. A complementary activity may be considered positive if it expands demand or revitalizes growth. However, a complement can be considered negative if it enables inefficiency or stifles innovation. Whether something is negative or positive depends on one's perspective: aquaculturist, fishermen, fisheries manager, trader, consumer or environmentalist.

Let's remember the simple reality. Poor fisheries management and increasing demand are the stimuli for aquaculture and innovation. The aquaculture sector has

emerged to avoid mismanagement, minimize environmental shocks, control fish stock and fish growth rates, and manage to meet the market demand. Aquaculturists want to take control of production and marketing. They tend to do this through ownership, information and technology.

The emerging aquaculture sector tends to be more forward looking, rapidly growing, innovative, international and control oriented. It is shaping the future seafood sector through market, trade, production and environmental interactions.

AQUACULTURE AND FISHERIES INTERACTION IN THE ENVIRONMENT

Aquaculture and fisheries interact in several ways in the ecosystem:

- aquaculture can influence fish stocks through its use of wild fish stocks for inputs, such as feed, broodstock or juveniles;
- aquaculture and wild fish stocks can influence each other through disease transmission and other related interactions;
- aquaculture can influence wild fish stocks through intentional releases (e.g. salmon enhancement) or through unintentional escapes; and
- aquaculture can displace wild fish through its use of habitat (shrimp farms) or, in some cases, it can enhance fisheries habitat (e.g. some oyster operations build oyster reefs).

The following examples illustrate each of these interactions individually. Aquaculture can influence fish stocks through its use of wild fish stocks for inputs. Probably the most controversial example today is the use small pelagic fishes for fishmeal and fish oil. The growth of aquaculture and in particular, the culture of carnivorous fishes, has had a direct impact on the demand for fishmeal and fish oil. Fishmeal prices have traditionally traded in a range two to three times the price of soy meal. Recently, fishmeal has traded at levels more than six times the price of soy meal. The traditional relationship between fishmeal and soy meal has changed substantially. The empirical evidence indicates that the increased relative price of fishmeal and fish oil represents an important structural shift (Kristofersson and Anderson 2006). If fisheries are well managed, this implies an opportunity for the wild fisheries sector to increase net revenue. On the other hand, if fisheries are poorly managed, this implies increased risk of overfishing. In either case, the increased relative price for fishmeal and fish oil presents an incentive for innovation. We see this occurring in declining feed conversion ratios, especially in the case of salmon and the rapid development of new feed formulations.

Another way aquaculture uses wild fish stocks for inputs is when aquaculture uses wild juveniles for growout. For example, tuna farmers in Australia, Mexico and the Mediterranean capture wild juveniles and then fatten them in aquaculture cage systems. When the farmed shrimp industry started, it was heavily dependent on postlarval shrimp from the wild fisheries for stocking shrimp ponds. The farmed oyster and mussel industries depend heavily on wild seed. If not managed correctly, the use of wild stocks could have negative effects on wild fish stocks. On the other hand, the use of wild seed for oyster and mussel farming may actually help increase the stock of oysters and mussels because of increased survivability.

Aquaculture and wild fisheries have also interacted through the transmission of disease and by facilitating invasions of nonnative species. Here are some examples (See NRC (2004) for more detail related to oysters). The oyster disease MSX was introduced from Asia, and it contributed significantly to the decline of oysters in the Chesapeake Bay and elsewhere on the United States East Coast. Bonamiosis was introduced into France by oysters imported from North America. This introduction contributed considerably to the rapid decline of the French oyster farming industry in the 1970s. In both cases, part of the solution was introduction of oysters from Asia that were naturally resistant to the disease. Today the French industry is dependent upon *Crassostrea gigas,* an oyster from Asia, and officials are considering introducing farmed

Asian oyster, *C. ariakensis,* into the Chesapeake Bay. In both cases, the unfortunate invasions of introduced diseases have resulted in the use of farmed nonnative organisms to mitigate the problem.

Despite media attention to concerns related to the introduction of nonnative species, the introduction of nonnative species is common. White shrimp from South America have been introduced into Asia because they are resistant to white spot disease and are easier to grow than the native black tiger shrimp. Salmon have been introduced into Chile, New Zealand and Australia and have resulted in substantial industries in these countries. Channel catfish has been introduced from the United States to China. Tilapia, originally from Africa, has been introduced almost everywhere that has tropical climate.

Aquaculture has also been used to replenish or enhance fisheries through purposeful release of juvenile or adult fish. For example, the Japanese chum salmon fishery is almost exclusively dependent upon hatchery-based salmon. In Alaska, approximately 40 percent of the state's salmon harvest is dependent upon hatchery-based fisheries (Knapp, Roheim and Anderson 2007). However, although hatchery (aquaculture)-based capture fisheries may result in increased harvest, they also may facilitate inefficient harvest practices and create problems with genetic diversity and the integrity of truly wild stocks.

Hatchery fish do not face the same selective pressure as wild fish stocks and can compete directly with wild stocks for food and habitat. Wild salmon must swim up river and compete for a mate. In the hatchery, the eggs, fry and fingerlings face little selective pressure compared to their counterparts in the wild. Over the long run, this tends to result in declining wild fish stocks if the hatchery-enhanced fisheries are not carefully managed. Consider pink salmon in Prince William Sound (PWS), Alaska. In 1979, wild pink salmon accounted for over 90 percent of the total PWS harvest. However by 2004, the wild salmon harvest has declined to less than 10 percent of total harvest (ADFG 2007).

Aquaculture practices have had some extensive influence on habitat. For example, shrimp farms have had negative effects on mangroves and estuaries. Excessive finfish cage culture has resulted in the destruction of benthic habitat and in some cases has caused considerable pollution. On the other hand, there have been positive examples of aquaculture influence on habitat. Oyster culture has contributed positively to reef development that increases the diversity of fish in the area. Profitable fish farming has helped re-establish ecosystems, for example, mangrove replacement.

AQUACULTURE, FISHERIES, MARKETS AND TRADE

The aforementioned aquaculture/fisheries interactions indirectly influence the seafood market by changing the health of wild fish stocks and wild fish harvest. However, aquaculture also has a considerable direct influence through its impact on the market and international trade. For example, aquaculture has:

- influenced prices through increased supply;
- changed consumer behaviour, which has resulted in development of new markets;
- accelerated globalization;
- increased concentration and vertical integration in the seafood sector;
- resulted in the introduction of new product forms and improved quality and consistency;
- influenced the sector to become more forward thinking and market driven; and
- reduced price uncertainty and risk.

Evidence of price declines related to aquaculture can readily be seen by examining real price trends of aquaculture species. The real price trend for farmed fish species is going down. Competitive pressures in the last few years have led the prices of salmon, catfish and cod to converge (Urner Barry Publications 1990–2005).

An examination of seafood consumption in the United States will illustrate the influence of the aquaculture sector on seafood availability, changes in consumer behaviour and increasing concentration in fewer species. First, per-capita consumption of aquaculture species has increased remarkably over the last two decades. Consumption of shrimp (mostly farmed), the number one seafood, increased over 75 percent between 1987 and 2005. Consumption of salmon (mostly farmed), third in the ranking, went up 400 percent over the same time period. Consumption of farmed catfish (fifth on the list) increased by more than 90 percent, while tilapia (farmed), a species virtually unknown in 1987, is now number six. It is obvious that growth in seafood consumption is being fueled by aquaculture, while consumption of certain wild-caught species, such as cod, is declining. Thus, United States seafood consumption is currently dominated by imported aquaculture products. Second, seafood consumption in the United States is becoming concentrated on fewer species. The top five species accounted for 75 percent of consumption in 2004; in comparison, they accounted for only 56 percent of consumption just two decades ago. The top ten species comprised 71 percent of consumption in 1987; they now represent 93 percent. Why are we seeing the industry getting less complicated and more concentrated, at least in the United States and probably in many developed countries?

The explanation of the decline in prices and increasing concentration lies in the fact that growing markets and growing trade will come to those who can consistently deliver a high-quality product at stable or declining costs. In the seafood sector, this is what aquaculture producers have been doing for the past few decades. It can also be argued that sector diversity in the future is going to come from the "sauce" (i.e. the value-added component of the fish) and from image issues such as ecolabelling, rather than being created through the production of a large number of species. Thus, despite the fact that hundreds of different species are harvested – and will continue to be harvested – around the planet, in proportional terms more and more of the supply is going to be concentrated in fewer and fewer species. Likewise, more and more of the diversity is going to come from the marketers because, as you take control of and manage the fish, you can market it better and start selling additional attributes. By contrast, the traditional fisheries sector is going to experience many more difficulties in this category. Aquaculture operations tend to be managed for production and marketing control. Conversely, the wild sector is managed towards restricting access and harvesting the "right" amount to meet conservation goals. However, they are still failing to manage for quality and the market, yet it is clear that the sector that manages for these two factors will attain greater success in the market.

Another key point in this discussion has to do with the structure of costs. In the traditional fisheries, the primary costs are labour, fuel and maintenance of the boats. In the aquaculture sector, the primary costs are feed and fingerlings. This is an important difference, as aquaculture has immense opportunities to reduce costs through genetics research and feed substitutions. In contrast, fisheries have less room for cost improvement unless a move is made towards more efficient management, e.g. rights-based fishing. This is really a question of better management, biotechnology and related factors. The most impressive achievements have been attained in salmon aquaculture, but there is still much room for improvement with regard to production of tilapia and other new species.

This report will briefly touch on two species (salmon and tilapia) to emphasize the points made above. Farmed salmon production already accounts for over 70 percent of world supply, while the capture sector's harvest has remained relatively stable. Regarding United States imports of salmon, most of the growth in recent years has come in the form of boneless, skinless fillets produced primarily in nations with significant aquaculture industries. A natural consequence of having an industry where production systems are more highly controlled is that more value-added processing

activities can occur. The industry is currently dominated by portion-control, value-added products. The negative media campaign against salmon aquaculture appears to have had some limited impact on demand. However, an analysis of these recent developments is beyond the scope of this report. For the purposes of this discussion, the point that must be emphasized is that salmon aquaculture has moved forward and gained market share despite the negative media, and yet there is still room for wild salmon – both the low-end (pink and chum salmon) and in the specialty/premium (chinook, coho and sockeye) segments

Tilapia also supports strong aquaculture industries in developing countries (Egypt, Philippines, Indonesia, China). As observed previously with salmon, United States imports of tilapia are experiencing a shift from whole to processed fish. Tilapia is seen as a substitute for flounder, snapper and all kinds of white fish. In addition, many environmental groups actually favour tilapia.

CONCLUSIONS

- Aquaculture enters when fisheries have failed to meet market demands.
- Growth in the seafood industry will be fueled by aquaculture imports.
- Aquaculture is forcing change in fisheries:
  - through competition (supply);
  - by developing new technology (hatchery-based fisheries);
  - by example (quality control); and
  - by creating new demand – both for inputs (fishmeal) and outputs (seafood).
- There will be increases in per-capita seafood consumption; however, consumption will be concentrated on fewer species, with diversity coming in the "sauce" and with labelling issues, such as organic and ecolabelling.
- Growth of aquaculture parallels a shift in the market towards value-added products.
- Technology, innovations, better nutrition and disease management will continue to reduce costs in aquaculture. Lower production costs will increase supply from aquaculture and hold prices down for all fish. The trend towards value-added creation will drive processing to countries where labour costs are low.
- Despite criticism from environmental organizations, aquaculture will not go away. The potential constraints for aquaculture development, in particular the fishmeal, will be circumvented by new technology and substitution.
- Aquaculture will dominate the commodity market, but there will be increasing opportunities for wild-market products in the upper-end segments, especially the niche market.
- In the long run, all significant commercial seafood supplies will come from one of three sources:
  - fish farms/aquaculture;
  - aquaculture-enhanced fisheries; and
  - fisheries that adopt systems of management that are more like aquaculture management; clearly define rights and responsibilities; incorporate principles of husbandry, range management, forestry and farming; and are more market and quality driven.

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Gunnar Knapp is a Professor of Economics at the University of Alaska Anchorage Institute of Social and Economic Research, where he has worked since receiving his PhD in Economics from Yale University in 1981. Dr Knapp has researched a wide variety of topics on the economy of Alaska and the management of markets for Alaska natural resources. Since 1991, much of his research has focused on markets for Alaska salmon and how they have been affected by the competition from farmed salmon and other factors. He has also studied the changes in the Alaska salmon industry over this time, and how fishermen, processors, fishery managers and politicians have responded to change. In connection with his research, Dr. Knapp has traveled widely within Alaska and other wild and farmed salmon producing regions. Together with Professors Cathy Wessells and Jim Anderson of the University of Rhode Island, Dr Knapp wrote the recently released report *The Great Salmon Run: Competition Between Wild and Farmed Salmon*, which was published in February 2007 by TRAFFIC North America (www.traffic.org).

Implications of aquaculture for wild fisheries: the case of Alaska wild salmon

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ABSTRACT

Worldwide aquaculture production is growing rapidly. The experience of Alaska wild salmon suggests that aquaculture may have significant and wide-ranging potential implications for wild fisheries. Salmon farming exposed wild salmon's natural monopoly to competition, expanding supply and driving down prices. Wild salmon has faced both inherent as well as self-inflicted challenges in competing with farmed salmon. The economic pressures caused by competition from farmed salmon have been painful and difficult for the wild salmon industry, fishermen and communities, but these pressures have contributed to changes that have helped make the salmon industry more economically viable. Farmed salmon has greatly expanded the market and created new market opportunities for wild salmon. Farmed salmon has benefited consumers by lowering prices, expanding supply, developing new products and improving quality of both farmed and wild salmon. Salmon farming has had no apparent direct effects on Alaska wild salmon resources, but could have indirect effects on wild salmon resources that might be positive or negative. The experience of Alaska wild salmon suggests that anyone interested in wild fisheries should pay close attention to what is happening in aquaculture. No wild fishery market – especially for higher-valued species – should be taken for granted.

INTRODUCTION

An aquaculture revolution is happening in the world seafood industry. Aquaculture accounts for an ever-growing share of world seafood production. One of the most important questions facing wild fisheries is how they will be affected by the development of aquaculture.

Salmon is one of the species for which the growth in aquaculture production has been most dramatic. Alaska is the world's largest producer of wild salmon. Between 1980 and 2004, farmed salmon's share of world salmon supply grew from 2 percent to 65 percent, and Alaska's share fell from 42 percent to 15 percent. The experience of the Alaska wild salmon industry during this time provides insights into how aquaculture may affect wild fisheries.

A BRIEF OVERVIEW OF THE ALASKA WILD SALMON INDUSTRY

In recent years, Alaska salmon harvests have averaged about 350 000 tonnes (Figure 1). Over the past two decades harvests in most Alaska salmon fisheries have been very strong. Alaska wild salmon fisheries are certified as sustainable by the Marine Stewardship Council.

FIGURE 1
World supply of wild and farmed salmon

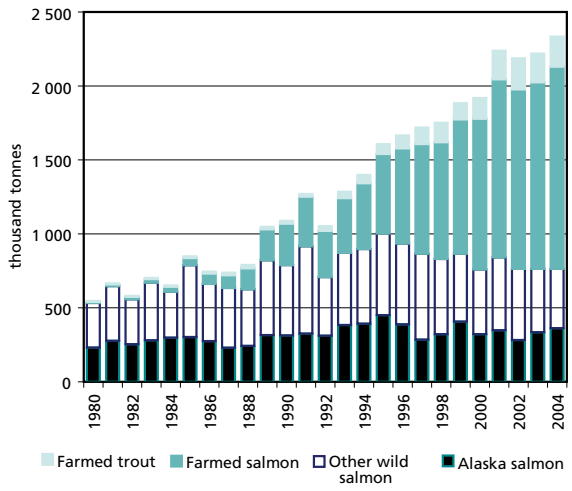


FIGURE 2
Alaska Seafood Marketing Institute advertisement for Alaska wild salmon

Five species of Pacific salmon are harvested in Alaska. Pink salmon accounts for the largest share of volume, followed by sockeye, chum, coho and chinook. Sockeye salmon – which commands much higher prices than pink or chum – accounts for the largest share of ex-vessel value.

Alaska wild salmon are processed into four major primary products, including frozen salmon, canned salmon, fresh salmon and salmon roe. These products are sold in markets all over the world (Figure 2). In recent decades, the most valuable markets have been the Japanese frozen salmon market (for sockeye salmon), the European and the United States canned salmon markets (for sockeye and pink salmon), the United States market for fresh and frozen salmon, and the Japanese market for salmon roe.

Alaska wild salmon are harvested in 26 gear and area-specific fisheries by small boats utilizing four major types of fishing gear (seine, drift gill net, set gill net and troll). Participation is restricted by a limited entry management system. About 20 000 fishermen work seasonally in Alaska salmon fishing. Alaska's coastal communities are heavily dependent on salmon fishing for fishing and processing jobs and for tax revenues.

There is no salmon farming in Alaska. Salmon farming – and all finfish farming – is banned in Alaska. It was banned partly to protect wild salmon resources and partly to protect fishermen from economic competition from farmed salmon.[1]

For many or most Alaska salmon fishermen, salmon fishing is more than just a job. They love salmon fishing in part because it allows them the chance to work and live independently in remote places of great beauty. In the late 1980s, Alaska salmon fishermen enjoyed not only these benefits but also unprecedented higher prices and incomes.

TEN LESSONS FROM THE EXPERIENCE OF ALASKA WILD SALMON

I would like to suggest ten lessons from the experience of Alaska's wild salmon industry about the implications of aquaculture for wild fisheries.

1. Aquaculture can have rapid and dramatic negative effects on markets for wild fisheries

Competition from farmed salmon was the most important cause of a dramatic decline in Alaska salmon prices from the late 1980s to 2002. By 2002, real (inflation-adjusted)

[1] Although salmon farming is banned, Alaska does have a large-scale salmon hatchery programme. Hatchery releases account for about one-third of Alaska salmon harvests.

ex-vessel prices for most Alaska salmon species had fallen to about one-third of average prices during the 1980s (Figure 3). [2]

For example, during the 1990s, farmed salmon rapidly replaced wild sockeye as the dominant product in the Japanese market. As the total supply of salmon to the Japanese market increased, the Japanese wholesale price of Alaska sockeye salmon declined dramatically (Figures 4 and 5). As the wholesale price in Japan declined, the price to the Alaska fisherman also declined.

2. Changes caused by competition from aquaculture may be painful and difficult for those who depend on wild fisheries

There were many difficult adjustments for Alaska fishermen as they experienced increasing competition from farmed salmon. As salmon prices declined, their incomes declined, as did the value of their boats and limited entry permits. Many fishermen lost their markets as declining profits resulted in the closing of many processing plants. Fishing communities experienced a loss in fishing taxes and population as processing plants closed and fishermen moved away, and through social stresses such as alcohol abuse. The political influence of the salmon fishing industry declined, and pressures grew to reallocate salmon from commercial fisheries to other uses such as sport fishing.

Many Alaska salmon fishermen blamed these problems upon competition from farmed salmon. They view farmed salmon as an inferior product that has harmed them. They believe that salmon farming in other places is harmful to the environment and unfairly subsidized. Car bumper

FIGURE 3
Indexes of real Alaska salmon ex-vessel prices, 1980–2002

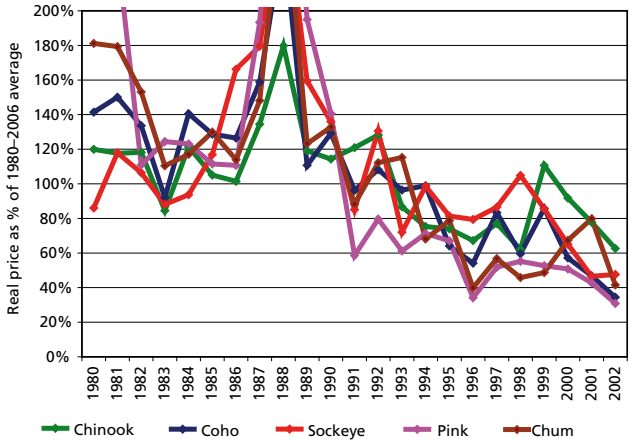


FIGURE 4
Japanese "red-fleshed" frozen salmon imports and wild sockeye wholesale price, 1986/87 to 2004/05

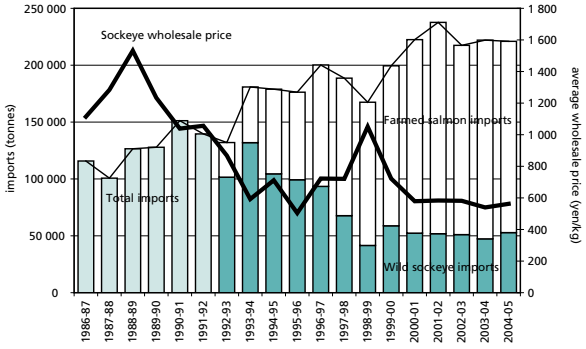
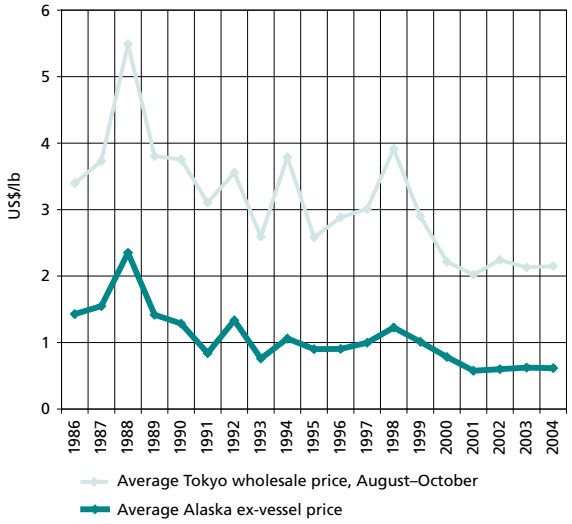


FIGURE 5
Japanese wholesale prices and Alaska ex-vessel prices for sockeye salmon, 1986–2004



[2] Farmed salmon was not the only cause of the decline in prices for wild Alaska salmon. Many other factors also contributed to the decline, including large Alaska salmon harvests, growing exports of Russian salmon, a recession in the Japanese economy and stagnant consumer demand for canned salmon.

FIGURE 6
Two examples of car bumper stickers

FIGURE 7
Alaska sockeye salmon harvests: projected and actual, 1980–2006

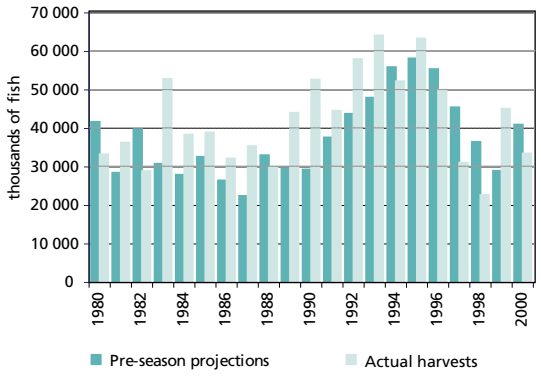


FIGURE 8
Idle fishing boats

The fact that many Alaska fishing boats and processing plants are idle for much of the year is a huge cost disadvantage.

stickers such as those shown in Figure 6 are commonly seen.

I think it is typical and natural for people who are suffering economic harm from competition to look for someone to blame – and to ask their government to help and protect them. However, when you are facing competition I think that the only real long-term solution is to understand better what your customers want and to work even harder to provide them what they want.

3. In an increasingly globalized economy, the market effects of aquaculture on wild fisheries occur regardless of where the aquaculture is happening

Alaska wild salmon are sold in global markets. The decline in Alaska sockeye salmon prices was caused by farmed salmon production in a foreign country for export to another foreign country (Chilean and Norwegian exports of farmed salmon and trout to Japan). Banning salmon farming in Alaska did not keep it from happening. Banning United States farmed salmon imports would not have kept it from happening.

4. Wild fisheries may face significant inherent challenges in competing with aquaculture. These challenges derive from the fact that aquaculture producers have much greater control over production

Inconsistent and unpredictable supply makes it much more difficult for wild salmon producers than for farmed salmon producers to meet buyers' supply needs and to plan for marketing. Alaska wild salmon catches vary widely from year to year, and often vary widely from the preseason catch predictions (Figure 7). In contrast, salmon farmers know exactly how many fish they will have to process and to market – and who can choose when to process and market them.

The seasonality of wild salmon fisheries increases production costs relative to farmed salmon, and makes it relatively more difficult to market wild salmon (Figure 8). Sometimes so many salmon are harvested in a day that there is no practical processing option other than canning. There are not enough planes to fly the salmon to a fresh market, and there are not enough freezers to freeze them.

Wide variation in sizes and quality increases costs of processing and marketing wild salmon.

FIGURE 9
Bruising may occur as salmon are "picked" from gillnets

5. Competition with aquaculture exposes not only inherent but also "self-inflicted" challenges in wild fisheries

There are significant quality problems in many Alaska salmon fisheries resulting from practices at many different stages of fishing, tendering and processing. These include, for example, bruising that occurs as fish are removed from gillnets (Figure 9), poor handling as fishermen focus on working fast rather than handling fish carefully, long delivery times between when fish are caught and when they are processed, and lack of refrigeration or icing on fishing boats.

In some Alaska salmon fisheries there are many more boats fishing than are needed to catch the fish (Figure 10).

Competition with aquaculture exposes these problems. When customers for Alaska salmon have alternative sources of supply, they are less willing to accept quality problems with Alaska wild salmon. When prices fall, it is harder to ignore how traditional ways of fishing add to costs.

6. Economic pressures caused by aquaculture may contribute to changes that make wild fisheries more economically viable

In the Alaska salmon industry, as fishermen and processors have left the industry, costs have fallen and efficiency has increased. Quality has improved in many fisheries. Marketing efforts have expanded. The salmon industry has worked harder to understand and meet the needs of customers.

7. Over the longer term, aquaculture may benefit markets for wild fisheries by expanding markets and creating new market niches for wild fisheries

As salmon farmers have expanded world supply of salmon, they have also greatly expanded world demand for salmon. Salmon farming has made salmon much more widely

FIGURE 10
Crowding in Alaska's highly competitive Bristol Bay drift net fishery

Photographs by Bart Easton

FIGURE 11
Indexes of real Alaska salmon ex-vessel prices, 1980–2006

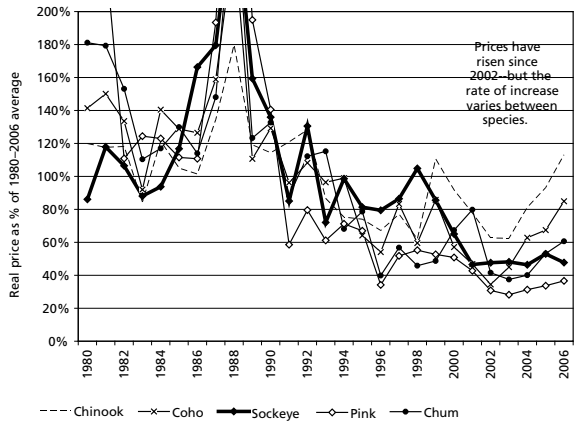
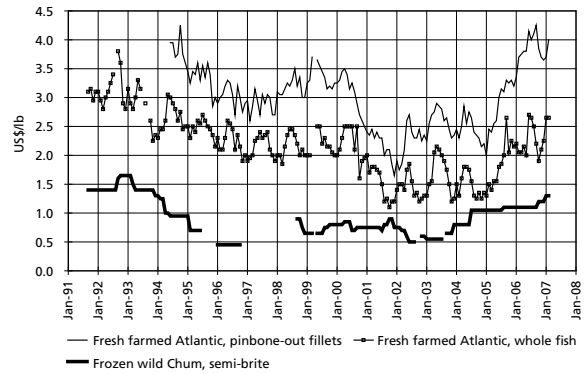


FIGURE 12
US wholesale prices for selected wild and farmed salmon products, January 1991 – January 2007



available – in more countries and more stores, throughout the year. Salmon farming has created new salmon consumers and new product forms. Growing demand is creating growing niche market opportunities for high-quality wild salmon. Since 2002, strong demand has contributed to a rebound in prices for both farmed salmon and Alaska wild salmon (Figure 11).

8. Aquaculture benefits consumers by lowering prices, expanding supply, developing new products and improving quality of both farmed and wild fish

Since the development of salmon farming, both farmed and wild salmon have become cheaper and available more consistently, over a far larger geographic region, in more stores and restaurants and in more product forms (Figure 12).

9. Aquaculture may have both direct and indirect effects on wild fishery resources, which may be either positive or negative

The experience of Alaska wild salmon suggests that aquaculture may affect wild fishery resources in several different ways. Salmon farming critics have pointed out the potential for salmon farming to introduce diseases among wild salmon populations or for escaped salmon to introduce non-native salmon species or to affect wild salmon genetic diversity. However, because there is no salmon farming in Alaska, none of these direct effects have occurred in Alaska.

Aquaculture proponents have suggested that fish farming may benefit wild fishery resources by lowering prices and thus fishermen's incentives to overexploit wild fishery resources. However, because Alaska salmon fisheries are well-managed, they are not over-exploited, and there is little evidence that lower prices have significantly reduced fishing catches or benefited salmon resources.

A potential indirect effect of competition from salmon farming is that lower salmon prices may reduce economic and political incentives to protect salmon resources and the environment on which they depend. When Alaska wild salmon were very valuable, there was a very strong commitment protecting salmon resources and the environment upon which salmon depend. But as the economic value of salmon has fallen, funding for salmon management and research has fallen, and there is greater support for proposed mining and oil development projects in salmon-producing regions.

10. The experience of Alaska wild salmon suggests that anyone interested in wild fisheries should pay close attention to what is happening in aquaculture. No wild fishery market – especially for higher-valued species – should be taken for granted

Aquaculture will continue to grow rapidly because it can meet market demands for

predictable, year-round and growing supply of high-quality seafood. The challenges to wild fisheries posed by aquaculture will increase over time.

EFFECTS OF SALMON FARMING ON THE ALASKA SALMON INDUSTRY: TWO CONTRASTING PERSPECTIVES

I will close by contrasting two different perspectives about how the Alaska wild salmon industry has been affected by salmon farming. The first perspective, which I call the "popular/green/Alaskan" perspective, is often reflected in the press and is commonly heard in Alaska:

Unfairly subsidized and inferior farmed salmon harmed the environment and wild stocks in producing nations, and flooded world markets, depressing wild salmon prices and significantly harming Alaska fishermen and fishing communities.

My own perspective, which I call the "economic perspective," is different:

Salmon farming exposed a "natural" monopoly to competition, benefiting consumers by expanding availability, lowering prices, spurring innovation and market development, and leading to a more efficient wild salmon industry more focused on meeting market demands.

I do not mean to imply that competition from salmon farming has been easy for the Alaska salmon industry. It has not. It has been very difficult. But in the end, I think the Alaska salmon industry can and will change, survive and compete successfully in the very different world salmon market that salmon farming is creating – and will better serve the world's consumers.

Jonathan Shepherd

Director General
International Fishmeal and Fish Oil Organisation

Jonathan Shepherd is a qualified veterinarian with a doctorate in aquaculture economics. He has held general management posts associated with aquaculture, including for the British Petroleum, Unilever and Norsk Hydro groups. Jonathan was Group Managing Director of the Danish fish feed company BioMar until appointed Director General of the International Fishmeal and Fish Oil Organisation in 2004. He is married and lives in London.

The lessons from intensive livestock development for aquaculture

Jonathan Shepherd
International Fishmeal and Fish Oil Organisation

ABSTRACT

Aquaculture production has some inherent biological advantages over land animal production in terms of efficiency. However, the difficulty of providing a truly controlled environment for aquaculture also brings some disadvantages. The developmental steps in conventional livestock production are being now recapitulated by the aquaculture industry but at a much faster rate. From the first step of simply producing enough food for the population, these include modernization (from backyard to farm-scale), the emergence of concern issues (e.g. biodiversity; environmental pollution), through to the growth of added-value products based on quality, convenience etc. The developments in modern poultry production are briefly considered, including key improvements in nutrition, genetics and breeding, health care and management. Lessons are drawn for future development in aquaculture production. Finally attention is paid to the big issues currently affecting the value chains for meat and aquaculture production.

INTRODUCTION

Commercial agriculture has developed over millennia, whereas modern aquaculture has largely developed over the past 30 years. Modern intensive poultry production only started to develop in the 1950s, but at that stage there was little, if any, interest in environmental, welfare and food safety issues, whereas modern aquaculture has been faced with these challenges from the outset. The fact is that aquaculture is the fastest growing food sector, even if it may be struggling a little with its image in some quarters.

Fish farming was probably first practiced as long ago as 2000 BC here in China, and in 475 Fan Lai produced his Chinese treatise on carp culture. China has led the world in aquaculture, and the more extensive systems will continue to play an important role in some countries. However, I have been asked to speak about the lessons from intensive livestock development of land animals for aquatic animals, and I will therefore restrict myself to modern intensive systems of aquaculture. That is not to say there won't be a continuing role for traditional more extensive systems of aquaculture under certain circumstances, but with economic development it becomes more difficult to justify in terms of resource allocation and utilization.

How does one define modern intensive livestock development? The factors usually taken into account include stocking and production intensity, closed life cycle, compounded diets, environmentally controlled housing etc. to enable optimized growth via control of inputs resulting in controlled and marketed output. This approach also lends itself to continuous improvement. Note that the different inputs to the cost of production (Figure 1) apply to both intensive fish and intensive poultry production.

FIGURE 1
Inputs to the cost of production

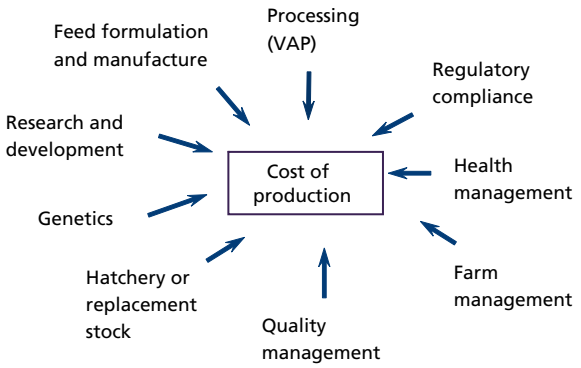
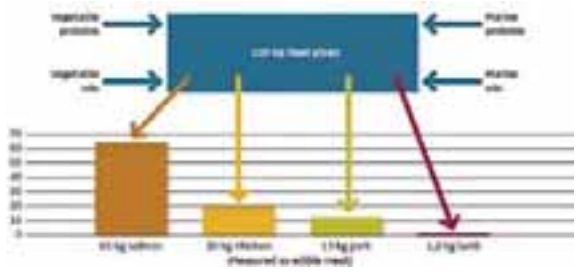


FIGURE 2
Efficient production of proteins



Source: Kontali

The consumption of poultry meat has outstripped the rising trend of animal protein consumption, which in turn was a result of animal protein becoming more universally affordable. Worldwide pork consumption currently stands at 100 million tonnes, poultry at 80 million tonnes, beef at a little over 60 million tonnes and eggs close to 60 million tonnes. By comparison, according to FAO (2006a), global aquaculture production in 2005 was 48.8 million tonnes compared with a total fishery capture figure of 93.8 million tonnes, with aquaculture representing 34 percent of total world fisheries in 2005.

HOW DOES AQUACULTURE DIFFER FROM LAND ANIMAL HUSBANDRY?

Compared with land animal farming, fish farming is a much more varied activity with many more species farmed, each having different characteristics. At the same time, fish and invertebrates alike recapitulate their evolutionary history in the water instead of *in ovo* or *in utero* as do warm-blooded animals, so growing fish requires attention to larval survival and larval feeding, which imposes constraints on successful rearing from egg

Fish are inherently more efficient converters due to being cold-blooded. Fish do not waste energy counteracting gravity or moving about on land. Fish catabolism and reproduction are also more efficient than that of land animals. Figure 2 illustrates how efficient farmed salmon are as protein converters compared with farmed land animals. The amount of dietary protein and energy retained by farmed salmon is approximately twice that retained in chicken and pigs, which are the most efficient terrestrial converters (Aasgaard and Austreng 1995).

The yield of edible meat is often higher in fish. Losses from removal of the viscera at processing depend on species, with carnivorous fish having shorter intestines and lower gut-out (e.g. 10 percent in salmon) than herbivores. But of course fish do not need heavy bones to bear weight or walk about on land so their bones are lighter. Carcass yields vary but typical values are: poultry 0.7–0.8, pigs 0.7–0.8, cattle 0.5–0.6, sheep 0.5 and fish 0.7–0.8. On the other hand, it is more difficult and costly to maintain a controlled environment for fish and hence to maintain biosecurity, control escapes of fish stock and waste material etc. The use of onshore tanks is largely impractical for marine fish due to extra investment and pumping costs, although exceptions occur (e.g. farmed flatfish). Also, postharvest preservation and distribution can be more challenging than that of warm-blooded livestock.

THE FOUR DEVELOPMENT STAGES OF ANIMAL HUSBANDRY

The development of animal husbandry can be simplified to cover four different steps: producing enough food to feed the population, modernization, the emergence of concern issues and adding value.

For example, producing enough food was the immediate priority in parts of Europe straight after World War II and remains so today in many poorer parts of the developing world where subsistence agriculture is often the norm.

The first step in modernization typically occurs when there is a transition from small family farms to large farming enterprises. A greater proportion of feed inputs and replacement stock are bought-in, and farmers start to specialize in specific aspects of production. Also there is increased mechanization and use of fossil fuel energy. Demand and production of livestock products are increasing rapidly in developing countries, which have outpaced developed countries. This increasing demand is associated with important structural changes in countries' livestock sectors, such as intensification of production, vertical integration, geographic concentration and up-scaling of production units.

In developed economies, issues such as antibiotics/chemicals, biodiversity, pollution, animal welfare etc. have come to the fore. In recent years, the scare over bovine spongiform encephalitis (BSE) or "mad cow disease" has shown the dramatic consequences of ill-considered recycling of agro-industrial byproducts (meat and bone meal) as animal feed. The incident and its media coverage have also brought new livestock feeding practices to general public attention. This and similar events, such as dioxin contamination of broiler meat in some European Union (EU) countries, have created widespread consumer distrust in the industrial livestock sector. In China, livestock production is starting to modernize and already these concern issues are important (e.g. antibiotic residues; melamine contamination), especially for those food companies exporting to western countries.

Powered by large food retailers, factors such as convenience, quality, safety assurance, the use of non-genetically modified ingredients, and even taste etc are now important as means to add value to food products. Large food processing and retailing firms are becoming dominant in the meat and dairy trade, achieving economies of size and scope, integrating vertically and securing market ownership. As a result, the requirements of integrated food chains in terms of volume, quality, safety etc. are becoming pervasive throughout the livestock sector.

In summary the livestock sector has been transformed by technology, including:

- by the effect on productivity of the widespread application of advanced breeding and feeding;
- by irrigation, fertilization and plant breeding, which have meant much higher yields and improved nutritional properties in fodder crops used for feed;
- by increased use of fossil fuel, which has helped to improve productivity; and
- by modern information technology and other technical changes, which are improving post-harvest, distribution and marketing of animal products.

AQUACULTURE FOLLOWING SAME STEPS BUT MUCH FASTER

The hunting of fish and the problem of static or declining fish stocks represent an uncertain and erratic way to meet demand consistently on a long-term basis. This helped to encourage pioneering investment in Atlantic salmon farming salmon in the 1960s, and the industry took off in the 1980s as retailers and restaurant chains became able to place contracts for a year-round supply of consistent product. In the same way, tilapia farming is now being powered by the demand for bland white fillet in order to make prepared dishes in the United States. Aquaculture growth is now focusing more on higher-value species reared for profit on a capital-intensive basis in purpose-built facilities.

The recent history of this expansion is characterized by industrialization and commoditization. The dramatic change in supply of farmed salmon and the decline in farm gate price and decline in production costs are shown in Figure 3. I may add that the consumer has seen a rather smaller drop in the retail price.

At the same time, concerns have arisen about threats to the environment from aquaculture. These include pollution, escaped fish, damage to mangroves, sustainability questions etc. In summary, aquaculture has gone through the same development steps

FIGURE 3
Farmed salmon: production volume, cost and farm-gate price

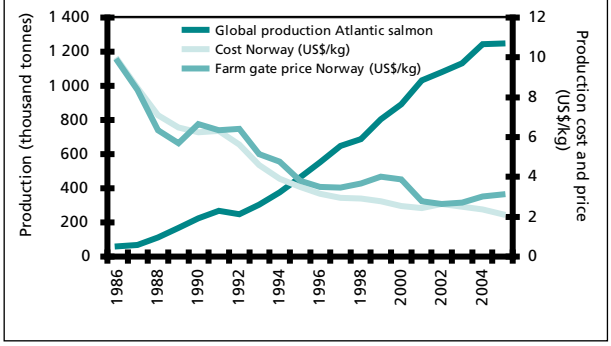
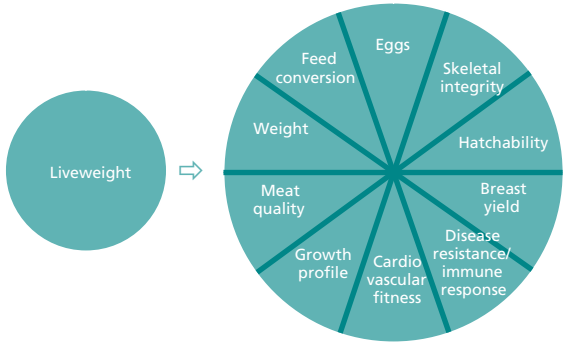
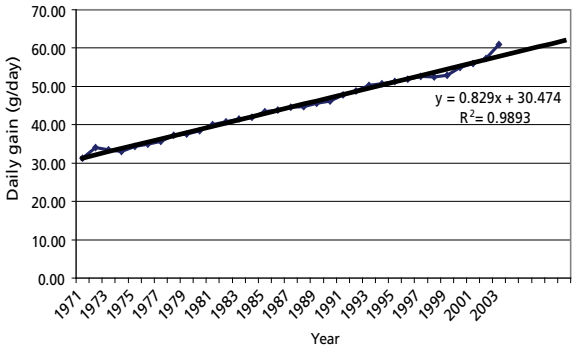


FIGURE 4
Evolution in broiler breeding genetics



After Laughlin (2007); courtesy of Aviagen

FIGURE 5
Change in poultry LWG over time



Laughlin (2007) based on NFU Broiler Bulletins

as land animal husbandry but has done so in a few decades instead of many centuries.

KEY DEVELOPMENT TRENDS IN POULTRY PRODUCTION

An example of the many improvement trends from among land animal species is given by milk production from cows (which has improved by 45 percent in last 20 years), and there have indeed been centuries of observational selection for better livestock. However, I will now focus on poultry, where the changes have been the most dramatic and where it is perhaps easiest to make comparisons and draw parallels with intensive aquaculture.

Nutrition

How much of the performance gains over the past 50 years have been due to genetics and how much is attributable to improvements in feed formulation, environmental control and husbandry systems? Havenstein, Ferket and Qureshi (2003) compared modern strains of broilers with a control strain established in 1957. By using also 1957 and 2001 feed specifications, they concluded that for growth rate, carcass and parts yield, the genetic selection brought about by commercial breeding companies had contributed 85 to 90 percent of the change over 45 years, while nutrition had provided 10 to 15 percent of the change. For feed conversion and mortality, this estimate was more difficult since age and weight must be allowed for, but the modern strain required 15 percent less feed for each unit of gain on the modern diet than the 1957 diet. Combining genetic and nutritional influences, the modern strain grew to an identical weight in one third of the time with a three times better food conversion ratio (FCR).

Genetics and breeding

In the last 40 years the genetic selection programmes for poultry have become increasingly sophisticated, achieving rapid balanced progress. Since the 1960s where live-weight was almost the only trait selected for, the number of traits has greatly increased, covering not only production traits but also traits related to the physical and metabolic support, survival and health of the selected bird. Figure 4 shows development of trait inclusion in a modern poultry-breeding programme. In the same paper in which this figure appeared, Laughlin (2007) also re-looked at United Kingdom's poultry performance data since 1971 based on the

breeds used across the industry at any time. The production data (Figure 5) reflect a remarkably consistent linear improvement in both daily liveweight gain (LWG) and FCR. The regression line ($R^2 = 0.99$) indicates an annual improvement (in the field) of 0.83 g per day per year – equivalent to 37.5 g per day to 42 days.

FCR data represent a major contribution to the profitability of the industry in terms of reduced feed inputs, as well as in waste output. Overall it seems that breeding companies have effectively dominated much of poultry industry development by their strategic choices regarding directed genetic selection of commercial traits.

Health

Breeding for disease resistance has played a major role in overcoming infectious poultry diseases (e.g. salmonellosis) as well as metabolic diseases. A good example of the latter is tibial dyschondroplasia causing lameness in fast-growing broilers, which has been shown to be heritable and successfully reduced by selection. As specific poultry vaccines have replaced the need for routine medication, use of antibiotics has fallen and many flocks do not even receive antimicrobial growth promoters.

Management

None of the above developments would have been possible without good housing and husbandry practices. For example, at the same time as the developments in genetic science were occurring, various reproductive technologies were developed (e.g. artificial incubation and hatching, lighting programmes to enable year-round production, and artificial insemination). These techniques were essential to enable the development of the production industry.

Due to close control and continuous improvement, the financial implications and performance variations of only 1 or 2 percent are measurable, known and acted upon. In this regard, the poultry industry is significantly ahead of other agricultural livestock sectors. Also, willingness to supply and share data – anonymously – for benchmarking has been shown to be of considerable value to cost reduction in the United States poultry industry (c.f. salmon farming industry in Norway).

WHAT CAN WE LEARN FROM LAND ANIMAL PRODUCTION?

Technology is the key to intensification and to industrialization

Breeding and genetics have been the key to cost-efficiency in poultry, and these tools are now being applied to farmed fish. For example, Gjedrem (1997) estimated that the time taken to reach a harvest weight of 3.5 kg had been shortened by 1 month per generation as a result of the Norwegian salmon-farming programme. Although initial focus has been on improved LWG, FCR, disease resistance and delayed maturation, attention has moved to aspects of flesh quality that help to determine appearance, presentation, texture and taste (R. Alderson, personal communication). By comparison with poultry, the longer generation time of salmon means that selection work takes longer, albeit much faster with tilapia than salmon. But as things stand, much of aquaculture largely depends on wild strains of fish.

Nutrition is, of course, vital and there are still a lot of gaps in our knowledge of the requirements of most aquaculture species. But once again we have gained a lot of knowledge and technology from land-based agriculture, particularly poultry, in many different areas, including basic nutritional knowledge (e.g. amino acid requirements), milling technology and nutritional technology (e.g. best-cost feed formulation, reduction in antinutritional factors etc).

However, there are a number of major differences when it comes to aquaculture diets compared with agricultural diets, including the importance of protein and fats in the energy requirements of most fish and the poor use they make of carbohydrates,

the problems of pellet stability and nutrient leaching in water, and the environmental problems produced from wasted feed.

With the intensification of aquaculture, there has been a steady move away from extensive feeding systems relying on the fertilization of the water and the consequent primary production, as well as from the feeding of moist feeds consisting of milled plant material and trash fish. Intensive aquaculture relies instead on formulated, pelleted diets that give better biological performance and biosecurity (quality control, hygiene, stability, storage etc.) as well as less environmental pollution. This global trend is likely to continue.

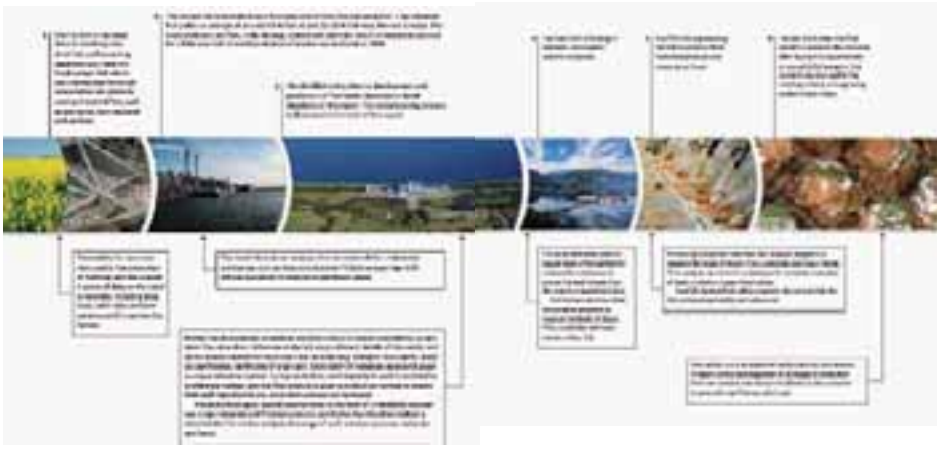
As with land animals, good husbandry is the paramount consideration in fish health management, including preventive medicine to keep pathogens out and boosting the immune status of fish. However, there are special challenges, depending on species. For example, shrimp have a more primitive immune system than finfish, and different approaches to vaccination are therefore needed. Lessons have been learnt from BSE and laws introduced in Europe to prevent intra-species recycling of disease by feeding back to farmed fish processed offals derived from the same species. The importance of biosecurity cannot be over-emphasized, as much in fish as in poultry.

In the early days of salmon farming in Europe, health problems threatened to kill off the industry. The answer was a combination of vaccines (injecting each smolt prior to seawater transfer using poultry multi-dose equipment) and good husbandry. This involved the use of single-year-class sites, fallowing periods after harvesting and site rotation, with the added benefit that antibiotic use fell dramatically. Unfortunately it seems that some of these hard-won lessons are being forgotten as salmon farming has expanded elsewhere.

Supply chain management

Just like poultry, successful industrial fish farming is all about management of the supply chain to provide continuity of supply for the customer. The key steps include raw material procurement, farm management, processing and distribution, while at the same time other supply chain issues, including quality assurance and verification that procedures are being followed (e.g. HACCP and ISO standards). Figure 6 illustrates how a major fish feed supplier (BioMar Group) views food safety and traceability in the aquaculture value chain.

FIGURE 6
Food safety and traceability in the aquaculture value chain



Source: Biomar annual report 2006

Avoiding food scares

Managing quality and risks and avoiding food scares is crucial, whether from disease (e.g. the effects on consumer demand from BSE of cattle and avian flu) or from contaminants (e.g. dioxin in poultry). International food scares are part of the price of globalization and occur with depressing regularity followed often by catastrophic falls in market demand, sometimes for long periods. This is linked to supply chain management via auditing of raw materials and of their suppliers, as well as full chain traceability. Note that new EU rules ensure a foodstuff can be tracked from either soil to table or from water to table – and back again. The problem is that one rogue farmer, supplier or distributor can wreck the market for an entire industry that is otherwise doing a good job using best management practices.

Marketing

On the industrial scale, producers need to forge strong relationships with food processors, distributors and retailers, i.e. form partnerships along the value chain. Aquaculture needs to think value chains and to understand the drivers on food habits and consumer acceptance (e.g. price, convenience etc). They must also bear in mind that supermarkets are fighting aggressively among themselves for market share, which includes altering the perceptions of their customers on various issues. Following food scares, at least in Europe, the public may appear to trust supermarkets more than they trust governments.

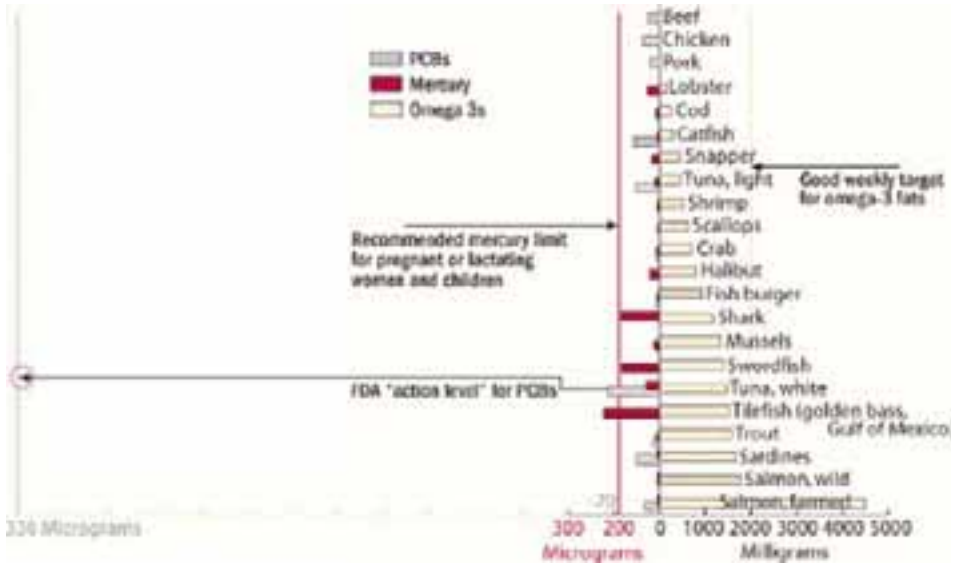
On the more local scale, there is a wide range of opportunities due to the diverse range of aquatic species. In the future, it's likely that over 80 percent of products will be from less than 10 aquaculture species. However, the many other "minor" species could well continue to be exploited on a more local level from outlets offering "niche products" (e.g. organic fish akin to free range chicken products; premium fish via restaurant/catering channels etc.).

AQUACULTURE AND HEALTHY EATING

We must remember that intensive aquaculture is a very recent phenomenon and has come a tremendously long way in a short time. Of course problems have arisen and mistakes have occurred, while laws and codes of practice were put in place to cope with all this. Not surprisingly there have been institutional problems and a lack of organizational support – while FAO has been at the forefront in addressing this (the Network of Aquaculture Centres in Asia-Pacific (NACA) is the only regional intergovernmental organization that promotes aquaculture and the Committee on Fisheries (COFI) Subcommittee on Aquaculture is the only global intergovernmental forum that discusses aquaculture exclusively). Also aquaculture has a mixed image partly due to the time of its birth (agriculture would never have gotten off the ground if started in the twentieth century!), partly due to the learning curve and partly due to sheer misinformation. For example, scientific focus on the minute levels of chemicals arising from marine contaminants despite their being generally well within legal levels, to my mind, unfairly undermines the aquaculture industry and misses the main point, which relates to consumer health.

As incomes grow, expenditure on meat grows rapidly – and on fish even more so – due to high income elasticity of demand for livestock products. So with higher disposable incomes and urbanization, people move away from relatively monotonous diets of varying nutritional quality (e.g. indigenous grains or roots) towards more preprocessed food, more foods of animal origin, more added sugar and fat etc. This is accompanied by reduced physical activity leading to a rapid increase in overweight and obesity. Worldwide, the number of overweight people (about 1 billion) has now surpassed the number of undernourished people (about 800 million) and the World Health Organization (WHO) estimate there are 300 million obese adults and 115

FIGURE 7
Omega 3's, PCB's and mercury in fish and meat



Harvard Medical School 2007 : Harvard Heart Letter February 2007

million suffering from obesity-related conditions in the developing world (see FAO 2006b). This is leading to a growing interest in healthy eating.

Figure 7 helps to explain why an important part of the solution to this problem lies in greater fish consumption. Saturated and omega-6 fats mean poultry and red meat are a mixed blessing, whereas fish (especially marine fish) are very much a 'Good News' story due to their containing high levels of long chain omega-3 fatty acids (EPA & DHA) with well attested benefits to the cardiovascular system. Referring to the epidemic in diabetes and consumption of junk food, Wout Dekker of Nutreco has recently described fish as "living swimming functional food". Increasingly demographics favour older rich consumers wanting lean high protein, easily digestible food that helps them to live longer.

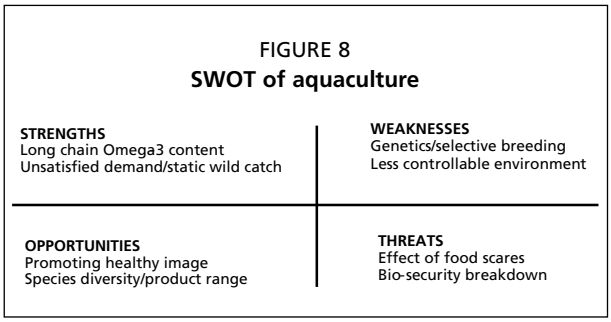
But for fish to take market share from land animals, it needs both the organization of supply chains and changes in consumer preferences. This message of fish health is not being sufficiently coordinated and promoted globally to consumers. At the same time, aquaculture must take care to maintain its healthy image, avoid contaminant scares, ensure sufficiently high levels of these long chain omega-3 oils remain in its products for consumer health purposes and avoid excessive substitution with vegetable oil feed ingredients.

CONCLUSIONS

Aquaculture is replicating the development steps seen in intensive livestock production, albeit at a much faster pace. This mirrors the focus on intensive production and industrialization with the resulting characteristics of commoditization, concentration, scale, price cycles etc. The immense diversity of aquaculture offers many mainline and niche products. But seafood distribution is fragmented compared with meat supply, and industry restructuring will occur. In this connection, there are large supply-demand gaps that need closing (e.g. 90 percent of United States seafood is imported). As with intensive land animal production, there is an ever-present threat of food scares due to quality and safety errors. This can wipe out a whole industry overnight and is linked to the question of biosecurity controls, not just on the farm but also along the value chain and at government level.

We have seen how closely breeding, genetics and health management are interlinked and hugely important in poultry production; this competence gap will constrain aquaculture without stronger public and private investment. However, aquaculture has the great advantage over red meat and poultry production of enhancing health and well-being, and the benefits of greater fish consumption need to be exploited more vigorously.

FIGURE 8
SWOT of aquaculture



The implications of these concluding points are summarized (Figure 8) in the form of a 'SWOT' analysis of aquaculture's strengths, weaknesses, opportunities and threats.

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The blue revolution – feed alternatives for aquaculture

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ABSTRACT

Rapid growth in aquaculture has led to a drastic rise in demand for feed. It is becoming increasingly apparent that because the traditional raw materials for feed production (fishmeal and fish oil) are limited, this is going to curb growth and slow down further developments. How can the aquaculture industry get around the "fishmeal trap"? The search for alternative feed resources is showing the first signs of success. A number of agricultural products, in particular, seem well suited to at least partially replacing fishmeal and fish oil. There has been remarkable progress in the development of weaning feed that could replace complicated live feed regimes for young fish and shrimp larvae. It is still not possible to do fully without rotifers and *Artemia* nauplii, but the day is drawing nearer when a starter feed will be available that can be given from the first day. This would make the farming of a lot of marine fish species, in particular, easier and give mariculture an important growth impulse.

INTRODUCTION

Aquaculture is developing and expanding in many countries throughout the world. The industry is diversifying and new species are coming up. This exciting development calls for renewal or at least slight modification of well-tried systems and practices. Consumers worldwide are paying attention to sustainability and environmental aspects of farming processes. Animal welfare on farms is a hot topic today. Society expects aquaculture to treat the fish with care and respect. If modern aquaculture is to retain its license to operate from society, it must meet the public's expectations and show itself to be a responsible industry. That requires, at least partly, new farming methods and improved technologies. This need for adaptation and renewal makes aquaculture a truly innovation engine.

One of the biggest problems is aquaculture's high dependence on fishmeal and fish oil for feed production. Demand for high-quality, suitable feed is growing, and the question as to how fishmeal and fish oil, which are both of limited supply, can be replaced is becoming increasingly urgent. The search for alternatives is one of the most important preconditions for the future growth of aquaculture. Carnivorous species like salmon and shrimp are aquaculture's main consumers of fishmeal and oil. Both give the best production results when they are fed high-quality fishmeal with minor additions of other protein sources.

Farming fish in aquaculture requires balanced feeds that supply them with all the nutrients they require. The choice of raw materials influences both the fishes' growth and health and also the flesh quality and flavour. In order to grow optimally, fish need certain amounts of proteins and, although the quantity required varies from species to species, it is usually over 30 percent even in the case of omnivorous species such

as catfish. In such cases, however, it is possible to satisfy protein requirements almost completely with plant raw materials, for example, soybeans. Carnivorous species such as salmon and other salmonids also have few special demands as regards the origin of the raw materials – as long as the feed contains ten essential amino acids (arginine, histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine) in a good balance plus fatty acids, minerals, vitamins and pigments. (Amino acids that cannot be synthesized in animal bodies are classified as "essential.") Here lies an important chance for the feed industry, in that basically other raw materials can replace fishmeal in fish feed as long as they fulfil the special dietary requirements of the fishes!

RISING FISHMEAL PRICES INCREASE THE PRESSURE

Although the big breakthrough has still not come in the quest for alternatives for fishmeal and fish oil, fishmeal can already be replaced in part in salmonid diets by plant protein sources – usually wheat, soy meal or corn gluten meal. This is not without forfeiting protein digestibility and absorption of amino acids, however. Optimized mixtures in which plant raw materials are mixed into the feed or sometimes even "pre-digested" achieve better results, but even these often do not come up to those obtained with high-quality fishmeal. While digestibility of proteins in fishmeal is over 95 percent, it varies between 75 and 96 percent in the case of plant proteins, depending on the plant species. Added to this is the fact that fish are often less willing to eat the feed when it contains a proportion of plant raw materials. Presumably it is the different content of glutamine acid (which influences flavour) that is responsible for this. Against this background, it can be viewed as a considerable success that the industry has succeeded in reducing the share of fishmeal in salmon feed from 50 to 30 percent by replacing it with plant protein sources.

The pressure exerted on feed producers is increasing because fishmeal and fish oil prices on the world market are rising. Prices of about US$ 1 000 per tonne of fishmeal are forcing feed costs up and could become an obstacle to the growth of aquaculture. An even greater problem is the supply of fish oil. Lipid digestibility, feed utilization and the quality of the produced fishes are strongly dependent on the fat content and fatty acid profile of the fish feed. Both mono- and poly-unsaturated fatty acids (PUFAs) are important for fish growth and health. Feed producers are trying to use plant oils to partially replace fish oils with a high share of PUFAs. The suitability of plant oils with a high content of monoenes and less n-3 fatty acids is also being examined. Experiments are also being carried out with rapeseed and other plant oils – which are often, however, even more expensive than fish oil. In order to limit feed prices, completely new feed formulas will thus have to be developed. The requirements are extremely high: the new feeds have to fully satisfy the fishes' nutritional needs and must not change the health value and flavour of the final product.

Meals from marine products like krill, crabs or shrimp would also serve as alternatives to fishmeal in salmon and trout feed. Crab meal would have the advantage that it already contains the pigment astaxanthin that gives the salmon flesh its red colouring. The disadvantages of such meals, however, are that they rarely contain more than 50 percent protein and that they are only available in small quantities, usually as waste products in the processing industry.

Other animal proteins from meat, bone and blood meals would be conceivable as alternatives to fishmeal. They are inexpensive and rich in amino acids, but their digestibility and nutritional value vary considerably. About one quarter of the fishmeal in feed could be replaced, for example, by meat and bone meals (higher proportions can lead to growth depressions). However, these animal proteins are hardly freely available on the market because they are almost fully used up in the production of animal and pet feeds.

AMINO ACID SPECTRUM OF PLANT PROTEINS OFTEN INSUFFICIENT

Plant-based proteins are usually not as digestible as fishmeal. Their inclusion in the diet often results in depressed growth rates and feed intake. The main plant alternatives to fishmeal are oil seeds and cereals, which are produced worldwide in large quantities. Although the raw protein content of oil seeds (about 30 percent) is below that of fishmeal (about 65 percent), the amino acid spectrum is largely in accordance with a fish's nutritional requirements. Hopes are particularly high in soybean products, but sunflowers and lupines are also interesting. Cereal products are attractive as regards price but their raw protein content (12 to 15 percent) is considerably lower, which makes usage difficult.

Soybean meal (SBM), in particular, is currently seen to be a very promising alternative. By mixing in a SBM share, it would be possible to reduce the price of fish feed by a third, perhaps even by half. Soy grows quickly and is available in large quantities. The amino acid spectrum of SBM is, however, less suited to a fish's diet than that of fishmeal. Soybeans are a good source of lysine and tryptophan but contain a relatively small amount of methionine and cysteine. Added to this is the fact that soybeans contain some antinutritional factors. Antinutritional factors are compounds that influence nutrient digestion, uptake or other metabolic activities, and they can also even be toxic. For example, a naturally occurring antinutritional factor in uncooked soybeans is the Kunitz trypsin inhibitor that prevents the enzyme trypsin from breaking down dietary proteins in animals' intestines. For this reason, the soy share in fish feed should not exceed a certain level. If the share is too high, the fish react with reduced growth and weakened immune defence, sometimes even leading to serious health problems. While some carnivorous species can tolerate 20 percent soybean meal replacement, most fish can handle only 10–15 percent.

Pulses like peas that have a raw protein content of 22 percent would also be a possible alternative. Peas also contain antinutritional factors, however, that make their usage difficult. On the other hand, peas can be processed to protein concentrates (protein content over 50 percent) that are more easily digestible – but also more expensive. Apart from that, there is also the problem that the amino acid profile of grain and other plant concentrates does not correspond fully to a fish's needs, particularly as regards the essential amino acids methionine and lysine that are lacking in these products. Corn meal contains sufficient methionine and could replace 25 to 40 percent of the fishmeal, but it gives the fish fillet a yellow colouring that makes marketing more difficult.

Despite extensive efforts, scientists have so far been unable to replace more than 40 percent of fishmeal. A perfect alternative to fishmeal has yet to be found. Other possible protein substitutes have turned out to be in short supply, impractical or even the cause of nutritional problems.

FISH OIL ALREADY PARTIALLY SUBSTITUTED BY VEGETABLE FATS

The search for alternatives for fish oil is even harder. Apart from plant oils, some marine oils such as krill oil come into consideration. Krill oil is particularly rich in omega-3 fatty acids. The available quantities are low, however, and apart from that, krill oil is expensive. The price level is about the same as that of fish oil…so that really only leaves plant oils but – compared to fish oil – their share of the important fatty acids EPA and DHA is often too low. Researchers have already highlighted the possibility of using plant oils during the fishes' growing phase and only using fish oil in the last farming phase to re-establish the natural composition of human health promoting omega-3 fatty acids in fish flesh. At least in salmonids, a substitution of plant oils to levels of 50 percent will generally not result in growth reductions or increased mortalities.

WEANING FEED AND GREEN WATER TECHNIQUE

Another significant problem that aquaculture has to solve is the development of weaning feeds to simplify offspring production. Today, live foods such as rotifers or *Artemia* are used for rearing fish and shrimp larvae. While suitable starter feeds have long been available for young salmonids, cod, halibut and turbot larvae still have to be fed initially on live feed. Live feeds are costly, variable in quality and constitute a potential source of disease contamination. A weaning feed to replace live feed organisms would therefore be an important contribution to accelerate the further development of aquaculture. A formulated larval feed would mean less work for larvae producers, would be easier to use and would result in lower costs for larvae production.

The nutritional demands of marine fish larvae can currently only be met by live feed. The demands placed on weaning feeds are extremely high. Firstly, like any artificial diet, weaning feeds have to deliver a balanced nutrient profile in a cost-effective and biosecure manner. Secondly, the nutrients must be highly digestible in order to safeguard an adequate supply of larvae. Thirdly, the weaning diet also needs to be palatable and must be offered attractively to the larvae in order to ensure a good uptake of the feed particles.

In order to raise larvae of marine coldwater species like cod and halibut or warmwater species like seabass, dorade, sole and turbot, single-cell marine microalgae, rotifers (often *Brachionus plicatilis*) and *Artemia* nauplii have to be cultivated at the same time. In a lot of hatcheries that have specialized in the breeding of marine fish species, the fish channels and tanks only account for about half of the building area. The other half is reserved for departments in which the necessary live feed – algae, rotifers, *Artemia*, etc. – are produced. In spite of this effort, live feed only rarely really fulfils the demands of the larvae. For example, it is relatively lacking in nutrients or does not supply them in the required quantities. A simple tried and tested method of correcting this lack is to enrich the rotifers and nauplii with the missing substances, e.g. HUFAs (highly unsaturated fatty acids), amino acids or vitamins.

Progress has been made in the farming of marine fish larvae in the form of the green water technique, which basically involves enriching the water with algae. While this kind of green water was previously only used for feeding rotifers, it is today added to the water in which the fish larvae are contained. Scientific findings indicate that these microalgae have numerous positive effects. They are said to have an antibacterial effect, for example. Some polysaccharides that are contained in the cell walls of the algae stimulate the larvae's immune systems. Apart from that, the algae function as a biological filter because they remove potentially dangerous nitrogenous compounds from the water and produce oxygen to make up. Because they dim and diffuse the light, they enable homogeneous living conditions within the tank so that the larvae are distributed evenly throughout the water column. Due to their limited vision in green water, the larvae are also less diverted from their search for food: their prey stands out more against the murky background and they are more successful in picking out their food. It is also assumed that algae encourage the production of certain digestive enzymes and vitalize the larvae.

The mortality of marine fish larvae reaches its highest when the fish are taken off live feed and put onto dry feed. How strongly mortality rises depends on a large number of factors, including the quality of the dry feed that is given during this phase. It has to suit the larvae's requirements in size and composition and has to be sufficiently attractive to make sure it is chosen over live feed. Although it will presumably still be some time before a weaning feed that can completely replace live feed comes onto the market, the progress made so far is encouraging. Step by step, researchers are bringing forward the point at which fish larvae are given dry feed for the first time.

DEMANDS ON WEANING FEED ARE EXTREMELY HIGH

One of the problems is the size of the feed particles. The particles of the finest weaning feed are hardly bigger than the diameter of a hair. Despite this, their nutritional value has to be as similar as possible to that of live natural feed. Every feed granule has to contain everything the fish needs for its development: high-quality proteins with essential amino acids in a balanced ratio, carbohydrates and fats that are rich in poly-unsaturated fatty acids… plus micronutrients, minerals, vitamins and trace elements, and all of it has to be in a highly digestible form. Some ingredients are present in the feed particles in such inconceivably small quantities that we are almost talking about individual molecules. Added to this is the fact that some substances are soluble in water and have to be specially protected so that they really do get into the alimentary canal of the fish and are not lost in the water. Apart from that, the microfeed has to taste good too, if the larvae are to eat it at all, and it has to be soft so that it does not injure their delicate intestines. Digestibility can be controlled through the use of "native" proteins and the inclusion of hydrolyzed proteins such as peptides and free amino acids. Another challenge in replacing live feed has been the difference in feeding styles. While fish larvae swallow whole feed particles, crustaceans chew their food. This means that every feed particle – and they often have a diameter of only 50 µm – must contain all the necessary nutrients that the crustacean larvae need to grow.

HIGH-TECH FEED PRODUCTION

Already these few examples make it easy to guess that this kind of feed cannot be produced using conventional methods. Completely new techniques had to be developed. Two of the most important are microencapsulation and agglomeration. In general, two factors are the key to larval feed quality: leaching and digestibility. Leaching can be controlled by encapsulation of particles smaller than 300 µm and by coating particles larger than 300 µm.

Microencapsulation is a modern technique in which tiny quantities of substances are surrounded by a protective coating and at the same time enclosed in a microcapsule. This, on the one hand, serves to keep feed components together in the desired ratio and on the other hand, to protect water-soluble components and bind them in the feed particle. Various methods can be used for microencapsulation. For example, the feed components can be enclosed in tiny fat droplets or sprayed with microscopically fine lipid pearls that form a kind of net around the granule. It is also possible to make coatings of gelatine or protein. For the production of a protein coating, a polypeptide thread is wrapped around the feed granule like a strand of wool. Because the molecular building blocks of this thread then form cross-links, a stable coating is produced that on the one hand has a high nutritional value and is itself digestible and on the other hand has gaps that enable the digestive enzymes in the fish larvae's intestine to make a direct attack on the substances inside the feed particle.

Agglomeration really means accumulation and comes from the Latin word "agglomerare", to connect firmly. It is a special principle in which tiny microparticles practically "voluntarily" form larger particles. More and more particles connect up with a relatively coarse structure so that the construction gradually becomes larger. This process is called coalescing or in pharmacy, wet granulation. Agglomeration is currently the only technique for producing water-stable feed particles in the micro range. In contrast to traditional techniques that are all destructive (large feed particles are broken down through grinding), agglomeration is a constructive process in which the particles are built up as required. It is important that the agglomeration process takes place without the impact of heat that could damage the microcapsules and denaturalize individual feed components, i.e. reduce their nutritional value. At its most

simple, agglomeration can be achieved by slightly moistening a powdery substance and then drying it again. The powder-fine particles clump together and form a kind of granulate.

Homogeneous feed particles in the range of 250-700 µm are produced in a particle agglomeration device called a "marumerizer". "Micro-extrusion marumerization" represents a remarkable progress in microfeed technology. The technology can also be used to apply liquid or powder coatings to the particles.

The feed particles produced using agglomeration (also called clusters) look like tiny raspberries when viewed using a microscope. This structure has the advantage that tiny air bubbles remain between the feed globules that reduce the specific weight of the mini feed granules. They float in the water or sink very slowly to the bottom, so that the larvae have sufficient time to pick them up. The longer a particle floats in the water the more likely it is that the larvae will mistake it for rotifers or nauplii and eat it.

Although so far no feed producer has succeeded in fully replacing rotifers, *Artemia* nauplii or other live feed for farming marine fish larvae, the phase of live feeding is constantly being shortened by high-quality dry feed, and feeding regimes are becoming more economical.

CONSUMER RESERVATIONS PREVENT GENETIC MANIPULATION SOLUTIONS

One of the conceivable options for at least partially solving the feed problem in aquaculture and escaping the fishmeal trap would be genetic manipulation. In general, transgenic technology has the potential to enhance fish production to meet the rising demand for fish and could also have other benefits for humans. Strictly speaking, genetic techniques could even approach the problem from two sides at the same time. On the one hand, via modification of the produced species so that they take up and utilize feed that they could not do previously, and on the other hand, via genetic influencing of the feed raw materials, for example by adapting the fatty acid spectrum or amino acid composition of agricultural products more strongly to the requirements of the fish.

A lot of the plants that are produced using agricultural methods are already in some way genetically manipulated, usually through selective farming. A simple method: from generation to generation only the largest, best or those that are the most useful for a particular purpose are selected. These are then used as the next generation of parents. However, so called genetic engineering or gene technology has nothing to do with conventional breeding and selection. Its basis is a transfer of genes from one organism to the gene set of another, even unrelated, organism. The foreign DNA is inserted into the nucleus so that it participates in chromosomal replication and becomes part of the hereditary material of the cell. This results in quite new varieties of organisms. Primarily, targets for genetic manipulation could be faster growth, better feed conversion and improved disease resistance, but the technology can also be used to insert additional beneficial genes that would provide stress resistance, hypo-allergens and enhance taste, colour, reproduction and sex change.

However, transgenic fish has unknown biological properties, and gene expression does not always alter performance. The mechanisms that control genome expression are so complex that some of the biological effects cannot be predicted with certainty. That is one of the main reasons why consumers reject and thereby prevent the use of this technology. It is feared that transgenic fish might pose some serious risks, including threats to ecological integrity and biodiversity. Transgenic fish could escape and become part of the gene pool of wild fish populations. This could add genetic diversity to the population, lower or raise fitness, or have no recognizable effect (some of the possible effects might be temporary, because transgenes are – like any other genetic material – the object of natural selection processes). Therefore before the

production of any transgenic fish is initiated, their possible impact on the ecosystem and environment must be studied very carefully.

Transgenic technology has been controversial, as it is a new concept and poorly understood. Lack of information on the potential ecological and socio-economic impacts of transgenic fish has contributed to a growing debate on biosafety problems of transgenic fish.

Closing of the conference

Closing remarks

Ichiro Nomura
Assistant Director-General
Fisheries and Aquaculture Department
Food and Agriculture Organization of the United Nations

Dear Participants and Colleagues,

It gives me great pleasure to preside over the closing ceremony of the Conference on Global Trade in Aquaculture. On behalf of the Director General of the Food and Agricultural Organization, I would like to thank all of you for your valuable contribution to the success of this Conference. In fact I am tempted to call it the First (or the Qingdao) Conference on Global Trade in Aquaculture, because I am sure all of you will agree with me that with this conference we have initiated a much needed forum to discuss important issues of aquaculture and global trade. I am certain that all of you will be awaiting the 2nd conference with great expectations because all of us feel that we have learned a great deal from each other, that we have touched upon very interesting issues of aquaculture in international trade and that we have developed valuable contacts that future conferences will nurture and enrich further.

Indeed, the Conference enabled us to listen to over 30 eminent speakers who addressed around 400 participants from over 30 countries, companies and organizations for which aquaculture and trade in aquaculture products are extremely important. I would like to take this opportunity to thank on behalf of FAO and on your behalf all the speakers who despite their very busy schedule took the time to come and share their experiences and thoughts with us.

I would also like to extend my sincere thanks to INFOFISH, INFOYU, the Bureau of Fisheries of the Ministry of Agriculture of China, the Chinese steering Committee, the organizing and advisory Committees of the Conference and to my professional and general staff from FAO, who have spent many hours of hard work to plan, coordinate, prepare and arrange for this conference; and I am sure all of you will agree with me that the result is a success.

I would also like to thank the Ministry of Agriculture for its nice hospitality, the various sponsors for their financial support and last but not least, the interpreters who worked very hard during the lengthy sessions of this Conference. I wish you a safe journey home. Thank you and Good bye. See you at the next conference on Global Trade in Aquaculture.

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