ASEM WORKSHOP

Aquaculture Challenges in Asia
After the Bangkok Declaration on Sustainable Aquaculture
The next step

Proceedings of Workshop held in
Beijing, China
27 - 30 April 2002

IMBC

Confirming the International Role of Community Research

This volume contains the manuscripts and abstracts of the papers presented at the AQUACHALLENGE Workshop held in Beijing, China, from April 27 - April 30 2002.

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FOREWORD

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Early experiences of human societies in culturing aquatic organisms date back millennia, both in Asia and Europe. Since then, socio-economic systems, geographical and ecological conditions have led to diverse approaches and pathways towards improved control of aquatic production.

Modern-day aquaculture faces many opportunities, but also challenges and high expectations in the context of growing global demand for its products coupled with ever more stringent requirements on environmental and product quality and safety, not least as a result of labelling and traceability obligations. In the face of shrinking capture fisheries, much of today's fish supplies already originates from aquaculture. However, many earlier culture fisheries practices are now understood to be themselves unsustainable.

Advances in broodstock management, protection of genetic diversity and understanding the biology of cultured species need to be pushed further in order to achieve greater energy efficiency with concomitant reduction of environment consumption. 'Farming down aquatic foodwebs' on the one hand and better use of the natural productivity of aquatic ecosystems for carnivores on the other are complementary aspects to meet quantitative and qualitative demand.

Research and innovation, knowledge and learning are amongst the most critical factors in ensuring continued progress towards safe and sustainable production, marketing and distribution. Sharing and comparing knowledge across boundaries is in the best tradition of Asia and Europe and this ASEM workshop made a significant contribution in this direction. In so doing, it built on already existing scientific and technological cooperation between Asia and Europe. But primarily it is expected to instill fresh impetus and direction into future cooperation supported by continued dialogue.

Questions were asked as to how best to deliver this intensified cooperation towards sustainable aquaculture, how to mobilise the combined expertise and operational capacity of many institutions and individual actors. These concerns will continue to be pursued on future occasions, but participants in this ASEM workshop provided at least some answers on how to move from knowledge to action, as can be seen from the Executive Summary which follows.

FINAL AGREED STATEMENT

Statement drawn up, discussed and agreed by all participants

Beijing, April 30 - 2002

The aquatic frontier - managing aquatic culture environments for sustainable food production and other goods and services

An ASEM framework for scientific co-operation

1. INTRODUCTION

In the light of the rapid growth of the aquaculture industry, and bearing in mind its concomitantly growing problems (environmental conservation and safety, feed quantity and quality, animal and food health and marketing) which pose significant challenges but also present major opportunities for the future, the Ministers of science and technology of the ASEM countries[1] (10 Asian, 15 European Union members) and the European Commission selected aquaculture as one of the priority thematic areas for future scientific co-operation at their meeting in October 1999 in Beijing.

The ASEM workshop on the challenges in today's aquaculture and research co-operation addressing the knowledge development and management necessary to meet these challenges (Beijing on 27-30 April 2002) was one of the follow-up activities to this decision, convened under the auspices of the EU's international scientific cooperation programme and through the partnership of Greece's General Secretariat for Research and Technology and the Chinese Society of Fisheries. It built on a range of successful research collaborations at bi-regional and bi-lateral levels, which mobilise intra-European and intra-Asian cooperation. It also took inspiration from the Bangkok Declaration on sustainable aquaculture adopted in 2000 in the occasion of the international conference on 'Aquaculture in the Third Millennium'.

The objective of the workshop was to develop an action-oriented agenda for ASEM scientific co-operation and to develop a platform for multi-stakeholder dialogue, networking and continued coordination.

2. THE CHALLENGES AND OPPORTUNITIES

The Workshop discussions highlighted a range of driving forces which affect societies in Asia and Europe, though in somewhat different ways. Three broad inter-related areas of societal concerns were identified which must be addressed as a matter of priority in the context of ASEM cooperation in aquaculture and for which realistic actions for effective progress need to be identified:

1. Trade, food safety, nutritional security and quality standards
    - Trade opportunities, constraints and risks (inputs, outputs and services)
    - Maintenance/establishment of markets, market stability
    - Consumer nutrition, consumer perception of industry
    - Traceability, certification, labelling

1. Austria, Belgium, Brunei Darussalam, China, Denmark, Finland, France, Germany, Greece, Indonesia, Ireland, Italy, Japan, Korea (Republic of), Luxembourg, Malaysia, Netherlands, Philippines, Portugal, Singapore, Thailand, Spain, Sweden, United Kingdom, Vietnam.

2. Environmental sustainability
   - Biological and technical issues (husbandry, grow-out systems, health of cultured organisms, feeds and feeding technology)
   - Identification and calibration of sustainability indicators
   - Integrated assessment of production systems (monoculture, polyculture, various combinations of aquaculture with agriculture and forestry, coastal zone management, etc.)
   - Genetics, breeding, genomics and stock improvement
3. Social equitability
   - Support to social cohesion with particular emphasis on smallholder and barriers to entry
   - Recognition of gender issues in sustainable aquaculture
   - Explore and use consultative and participatory approaches to research and management.

In order to meet these societal objectives, and to organise ways to address them effectively, new partnerships involving societal stakeholders, public and private bodies and representatives of civil society are required. These must be supported by transparent scientific knowledge.

3. DEVELOPING AN ASEM SUSTAINABLE AQUACULTURE PLATFORM

These opportunities and challenges require mobilisation and organisation of knowledge, learning and action on a broad front which will address concurrently the three main concerns listed in para. 2 above and which will:

- combine the environmental, socio-cultural and economic dimensions
- construct inter-disciplinary networking around the principal themes identified, but also incorporating existing networks
- build bridges between the different types of partnerships involved.

The setting up of a platform of ASEM partners from research, private sector, administration and civil society is recommended as the most suitable mechanism to mobilise the strengths of these different partners synergistically.

3.1. Concept and design of the ASEM Sustainable Aquaculture Platform

The Platform for exchange, voluntary co-ordination and joint action is an open and permanent dialogue space, where all partners interested in ASEM sustainable aquaculture can be members. This Platform is not in itself a funding instrument for scientific cooperation but an enabling mechanism for equal partners.

Singapore had laid some of the foundations by providing an issues paper to the Ministerial meeting in 1999. China and Greece have so far provided the initial co-ordination with the support of the European Commission and could continue to act as interim facilitators on the Asian and European sides, by preparing a concrete proposal for such a Platform. The role of the Platform's facilitators will be to promote the ASEM S&T Aquaculture Co-operation by initiating networks, projects, workshops, promoting private/public partnerships and supporting investment in human resources and exchange of experience, training and information.

Platform activities will be reported to a small Steering Committee consisting of leading personalities from 3-5 ASEM partner countries who will represent the diversity of the societal actors involved in sustainable aquaculture.

3.2. Funding

A clear and foreseeable action plan for the ASEM Sustainable Aquaculture Platform should be prepared in the near future by the interim facilitators with support from the Steering Group, in order to secure the necessary funding for activities. The Platform will have some fixed costs (Secretariat, offices, etc) which will be borne by the coordinators from each region, to be identified in the afore-mentioned action plan. Improved coordination among different stakeholders on the platform will lead to multiple sources of funding for various forms of ASEM Aquaculture co-operation, with particular emphasis on research and learning under the EU 6th Framework Programme, as well as sources such as national, multilateral and bilateral funds (Global Environment Facility (GEF), Asian Development Bank (ADB), World Bank (WB), European Investment Bank (EIB), etc).

3.3. Next step

As the next step, the Platform content and structure will be presented at the ASEM IV Summit in Copenhagen in the second half of 2002.

Aquaculture in Greece: Production, Research and Future Programmes

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It was in Beijing, in October 1999, that the first ASEM Ministerial Meeting for Research and Technological Development took place. During that Meeting, Aquaculture was identified as a one of the priority areas for Euro - Asian S & T Cooperation. Professor A.Tsaftaris, Secretary General for Research and Technology at the time, and head of the Greek delegation, proposed that Greece could hold a coordinating role in exchanging information about the current activities in this field in the ASEM member countries.

At the same meeting, Professor Tilak Viegas, European Commission's scientific officer for International Cooperation, over the course of several unofficial discussions, encouraged the Greek delegation to exploit the opportunities offered by the INCO-Dev Programme to support this initiative. However, Professor Eleftheriou of the Institute of Marine Biology of Crete, one of the Greek delegation, took up the idea with some enthusiasm and, in collaboration with world-class scientists from Europe and Asia and with the full support of the European Commission, set up the present Workshop. Once again the Chinese government is hosting an ASEM meeting in Beijing, the capital of China, the most important aquaculture producer in the world.

Over the last fifteen years, Greece has become the most important producer of euryhaline finfish species (mainly sea - bass and sea - bream) in Europe and the larger Mediterranean area. Favourable climatic and environmental conditions, alongside with several incentives provided by national and European community investment policies and the growing demand for fresh fish products, played a critical role in this development.

But despite the progress achieved, this flourishing industry in Greece, as elsewhere in the world, is facing problems such as for example, severe fluctuations in prices: periodically prices decline dramatically and as a result many medium and small size enterprises do not manage to survive.

In Greece, aquaculture production was not based solely on in-house scientific and technological development, but also on a degree of technology transfer from Northern European countries and subsequent adaptation to the local conditions and requirements of the cultured Mediterranean species. Many active research teams are presently working in Greek Universities and public research centres. At the same time, the largest production companies have established their own RTD departments with competent staff and modern equipment (see Fig. 1).

Furthermore, a sectoral company aiming at facilitating liaisons between industry and academia has been created by the Greek government.

In the past five years, financing of RTD projects in the field of aquaculture, through the Operational Programme for Research and Technology, the main funding instrument for RTD in Greece, reached around 5,5 million Euros (see Figure 1).

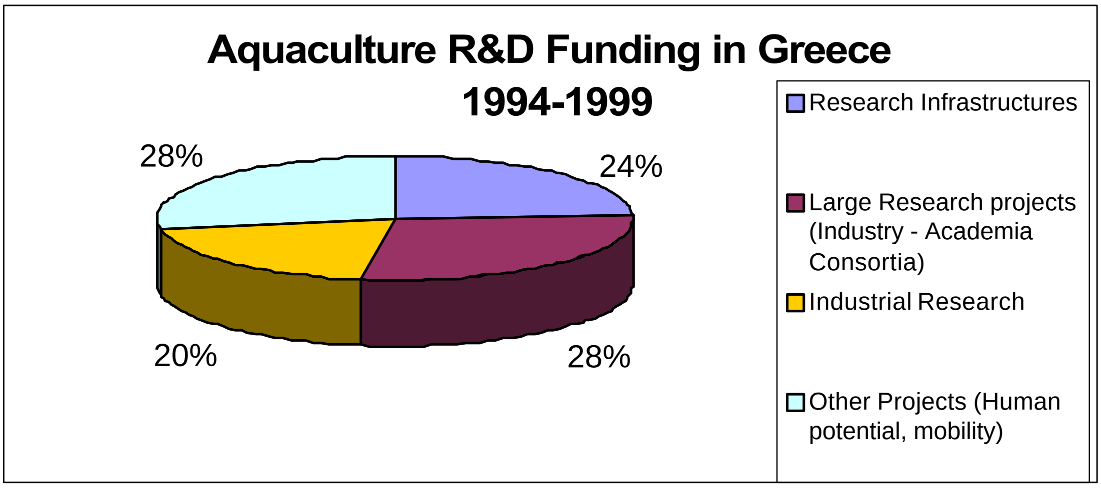

Figure 1: Aquaculture R & D funding in Grecce 1994-1999

Greek institutions and companies have also participated in several European projects under the various EU Framework Programmes. In the context of bilateral cooperation, offering mostly mobility grants, our more active partner countries in the field of aquaculture are Italy, Spain, the United Kingdom and China.

According to the Bangkok declaration, "There is a need to increase investment in aquaculture research and development, whilst making efficient use of research resources"… A mechanism identified towards this end is trans-regional co-operation. Events such as the present AQUACHALLENGE Workshop, promoting the exchange of ideas and experiences between world-class scientists, both from Europe and Asia, could significantly contribute in providing the solid scientific knowledge for guaranteeing the sustainability of the sector. Furthermore, it could act as a catalyst for trans-regional cooperation enhancing the establishment of scientific consortia able to take advantage of the possibilities offered by several national and international funding schemes.

Greece has undertaken the role of joint facilitator, along with China, in the present ASEM initiative, in promoting an aquaculture cooperation platform through the mobilisation and organisation of knowledge, learning and action on the broad front of the issues presented as part of the AQUACHALLENGE Workshop, to be joined in this role by Belgium, in the proposed future networking platform.

As a further earnest of our intent towards the building up of the ASEM aquaculture platform, I would like to give a brief description of the "Focused RTD Programme" for "Agriculture, Food and Aquaculture" that will soon be launched. This Programme offers opportunities for participation to foreign scientists. A special bonus in the evaluation of proposals is foreseen for projects including international cooperation activities. Even though direct funding of foreign institutions is not allowed within the framework of this Programme, it can nevertheless provide travel and consultant grants to foreign experts visiting Greece, in order to participate in a project. Furthermore, it foresees financial support for the organization of joint events in Greece.

The general objective of the Programme is to promote partnerships between industry and academia, to help industry to take advantage of scientific and technological achievements and to support integration of innovative technologies in the production process, quality control and marketing.

The specific Action Lines of the Programme in the field of Aquaculture are:

- Diversification of the production with new species for aquaculture
- Optimisation and modernization of the aquaculture techniques and methodologies in use - Introduction of innovative techniques and methodologies
- Coastal zone management - management of inland waters suitable for aquaculture
- Genetic improvement of cultured species
- Environmental impact of aquaculture
- Nutrition of cultured species
- Pathology of cultured species

The overall budget of the Programme is around 22 million Euros (of which 50% will be covered from public funds) and it will support around 40 projects of an average budget of 550.000 Euros each.

The call for proposals will be published both in Greek and in English in order to encourage international cooperation. The submitted proposals will be evaluated by committees consisting of Greek and foreign experts.

WORKSHOP OVERVIEW

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1. INTRODUCTION

1.1. ASEM background information

A new Asia-Europe partnership was set up in 1996,with its inaugural meeting in Bangkok. The Asia-Europe Meeting, otherwise known as ASEM, is a process of dialogue and cooperation set up with the aim of bringing together the fifteen EU Member States and the European Commission, together with ten Asian countries[1]. Summit meetings are held every two years (Bangkok 1996, London 1998, Seoul 2000, Copenhagen 2002). This unique bi-regional dialogue process is carried forward through a series of Ministerial and working-level meetings, in which the dialogue addresses political, economic and cultural issues, with the objective of strengthening and enhancing the relationship between the two regions, in a spirit of mutual respect and equal partnership.

1.2. ASEM joint research agenda

The ASEM process is built around the "three pillar" framework (political, economic and social aspects) within which there is considerable potential to achieve positive results in identified priority areas, i.e., sustainable aquaculture, along with forestry, water, food safety and clean industrial production, was chosen at the meeting of Science and Technology Ministers (Beijing, October 1999). It was felt that the organisation of thematic workshops was a useful way of carrying forward the ASEM agenda and so the present Workshop, funded by the EU International Cooperation Programme (INCO), is a direct outcome of that strategic plan of action.

1.3. The AQUACHALLENGE Workshop

The challenge is to develop sustainable aquaculture in the new millennium in relation to the stated aims of the INCO Programme within the context of the current social, economic and environmental situation. The workshop brought together participants from ASEM partner countries, scientists, technologists and industrialists of differing experiences, but with similar needs. A main objective was to develop an action-oriented agenda for ASEM scientific co-operation and, by means of well-prepared discussion sessions, in which specially invited panel members participated, to develop a platform for multi-stakeholder dialogue, networking and continued coordination.

A small steering group prepared the ground for a wide-ranging exchange of ideas by outlining a series of six thematic areas around which discussions could flow naturally. Core areas and principal themes that direct scientific aquaculture research priorities were:

- Environmentally responsible grow-out systems
- Integrated management systems, incorporating ecosystem health and biodiversity considerations
- Nutrition/feeding strategies taking account of sustainability and consumer concerns
- Adaptive and appropriate use of biotechnology and genetics
- Appreciation of global economics, supply and demand, marketing and distribution
- Development and application of BEPs, Codes and self-regulatory mechanisms.

1. Brunei, China, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore, Thailand, and Vietnam.

2. NEED FOR TECHNOLOGY TRANSFER

2.1. Global Aquaculture production

There has been a considerable increase in aquaculture production on a worldwide scale over the past twenty years, with Asia continuing to dominate production, and within Asia, China remains the leading aquaculture producer, making up 85.3% of Asian production and 77.6% of global production. Chinese aquaculture production in 2000 was 25. million tons, of which 15.2 million tons came from freshwater culture and 10.6 million tons from mariculture. However, in the past, most aquaculture production was for the purpose of food security, with culture systems far removed from the industrial production systems in operation in the developed world. Asian production, though it dominates global aquaculture, and offers great variety in cultured species, technologies and farming systems, can nevertheless benefit from new approaches in order to meet the combined challenge of growing demand and pressure on production models and the environment. There is a perceived need in the Far East for the transfer and adaptation of know-how in the optimisation of feed management strategies, in broodstock management to ensure good egg and larval quality and also to preserve genetic diversity.
At the same time there is worldwide focus on the need for sustainable aquaculture, to ensure the production of quality products of high market value and at the same time to protect the environment and promote ethical approaches.

2.2. Quality assurance issue and environmental standards

Aquaculture has changed its role very dramatically with a huge increase in production, mainly of high value species. Great financial rewards have been one result, stemming from the acceptance of the latest scientific and technical advances. Knowledge of these developments in the Far East could provide an interface between science and society and could pave the way towards making better investment decisions which could benefit all stakeholders. Because quality assurance depends to a large extent on the maintenance of strict environmental regulations, these are more readily accepted by stakeholders in a spirit of enlightened self-interest.

2.3. Need to accept environmental standards

With one in four fish eaten coming from cultured stock (thus emphasising its popularity as a food item), marine aquaculture nevertheless suffers worldwide from negative perceptions concerning its impacts on the environment. Recently, producers have begun to realise that:

a) a high quality product cannot be produced in poor environmental conditions

b) the maintenance of fish health is of paramount importance for high quality production

c) the movement of fish can cause the spread of fish disease, with subsequent catastrophic financial losses and persistent loss of water quality.

d) consumers want a high quality product that is also environmentally friendly

e) negative perception stemming from the above points will ultimately harm the market.

2.4. Role of EU

These issues are emerging as of genuine concern, because of their perceived links with human health, the protection of the environment, and not least, their relevance to the future of the aquaculture industry itself. The EU has maintained a high level of R & D support towards the scientific and technological advances being made in the aquaculture industry. These advances have however brought in their wake a corresponding increase in certain kinds of difficulties now being experienced on a worldwide scale. At the same time, patterns of production in some parts of Asia are also changing rapidly from semi-intensive farming towards intensive methods for high-value species. Some significant advances in many sectors are being made and accumulated know-how in EU countries and elsewhere is beginning to provide solutions to some of these problems. It is therefore important to make an attempt to bridge the scientific and technological gap, to be aware of both differences and similarities between the different geographic areas, production methods and species/ sectors. Hence the background and the rationale behind the choice of thematic areas in the present Workshop.

3. WORKSHOP CONTRIBUTIONS

3.1. Keynote presentation

The Workshop opened with a review of the R& D priorities as perceived by aquaculture farmers as well as scientists, which made its first impact at Bangkok, in the AquaMillennium Conference organized by NACA and FAO in 2000. Main topics concerned environmental issues, genetics, nutrition, and disease control. The conclusions were that risks of major environmental and human health problems need to be weighed against achieving a more cautious rise in production which is, in the longer term, sustainable.

3.2. Thematic area contributions

3.2.1. Environmentally sound grow-out systems

The urgent issue of how to make grow-out systems more environmentally sound was tackled with experts from Asia and Europe offering a). information (on the European scale and the national scale(Vietnam); b). insights into closed recirculation systems in Europe and biological filters in Southeast Asia and c). recommendations concerning the rehabilitation of degraded mangrove sites utilising the Polluter Pays principle, to methods of improving traditional polyculture of Chinese carps, to the reduction of fishmeal and fish oil inputs in feeds. Changes such as these require a paradigm shift from the short-sighted 'commons' exploitation of water, mangroves and other resources to the ecological footprint approach that incorporates not only inputs, but also outputs such as facilities to treat effluents.

3.2.2. Integrated management, ecosystem health and biodiversity

The session addressed the interactions (negative and positive) of the most important resource users, such as tourism, shipping and fisheries as well as aquaculture, in the opening contribution. The need for cooperation in developing management strategies that protect the resource while optimizing its utility for all users was exemplified in a case study from the Richibucto waters in Canada where developing a thorough and integrated investigation of the economic carrying capacity of the Richibucto estuary for shellfish aquaculture.investigation was seen as a major tool in participatory coastal zone management. This approach was echoed in a presentation made concerning several Chinese government projects, which also focused on the importance of models to predict the potentiality of new sites for mariculture based on their ecological carrying capacity as well as their mariculture carrying capacity. However, it was also recommended that for structure optimization of a single culture system, cultured species among or between which there is mutualism in niche or in food resource utilization should be selected. Integrated systems which optimize the utilization of nutrients derived from aquaculture for agriculture use were also recommended.

3.2.3. Adaptive and appropriate use of biotechnology and genetics

The objective in this session was to obtain a better understanding of the potential of biotechnology to enhance aquaculture productivity. Developments in the following areas were shown: transgenesis whereby fish with enhanced performance such as fast growth and increased disease resistance are produced; molecular diagnostics and vaccines of pathogens; molecular genetics and selection; microbial/microalgal genetic engineering for water quality management or as probiotics/feed supplements; reproductive and sex control. However, issues were also raised such as risks to human health and the environment (Genetically Modified Organism issues), and ownership (Intellectual Property issues), the latter of particular concern in Asia, with the very real possibility of the marginalization of small-holders in rural areas, who are unable to keep up with such biotechnology advances. Another important issue was highlighted: the need for genetic assessments of the degree of population structuring and gene flow, not only to preserve the existing biodiversity, but also to keep valuable adaptive resources. In a ongoing project, SEFABAR, which concerns the future use of genetics, one main option for aquaculture was seen as follows: to redefine breeding goals for fish into a wider perspective by a). producing animals with a economic productive life without giving signs of disturbed health and welfare in a specific environment and b). by optimizing input/output and feed efficiency with sustainable feed resources.

3.2.4. Nutrition and feeding

The aims of this session were a). to stress the importance of sound nutrition and feeding on most issues facing the aquaculture such as productivity, environmental and product quality and food safety; b). to illustrate the functional role of nutrition in ensuring complete domestication including reproductive success and larval development and c). to discuss on how far existing know-how can be extended to other species and situations d). to evaluate the potential for alternative protein/oil sources for fishmeal and fish oil.

3.2.5. World economics, marketing and distribution

The challenge of aquaculture in the present and near future is to balance the local social goals of equity and more even distribution of income and employment with the global development of markets. The opening contribution emphasized that it is not enough to implement present knowledge, but it is essential to be able to read the signs of markets and politics as well. The transition period includes the risk of destabilisation of prices, incomes, employment and settlement patterns, which means that the liberalization of fish trade might therefore create new market imperfections and anomalies. Key topics raised: sustainability and management regime; multiple services and joint production; market development; social implications of policy; international policy (FAO, WTO, OECD).

3.2.6. Best Environment Practice, health, monitoring, regulations, Codes of Conduct

Improved techniques and methodology arising from BEP can lead to a reduction in environmental impacts. By identifying the effects of aquaculture production on the water column and the sediments, either by traditional techniques or by whole system monitoring and assessment which looks to the carrying capacity of an area, it may be possible to achieve a system compatible with the interests of all the stakeholders involved. Good environmental practice, linked to a realistic set of regulatory measures, could make sustainable aquaculture a real possibility because of the demonstrable benefits to all the players in the different conflicting interest groups. This could in turn lead to the establishment of a code of conduct which might also provide a measure of quality control and thus lead to penetration of the global market. The distinction between Codes of Conduct and Codes of practice was clearly made.

4. PANEL-LED DISCUSSIONS

A main feature of the Workshop was the lively discussion from the floor, led by a specially invited panel. These discussions were both wide-ranging and well-informed.

4.1. Day 1 Panel Discussions

4.1.1. General

The first day's Panel discussion session concerned bi-regional scientific and societal cooperation. To support the transition towards sustainable aquaculture, the differences between Europe and Asia, cultural, economic and social, must be recognized if its ambitions are to be realised.

4.1.2. Sustainability

Points raised concerning the sustainability issue were i). societal and operational types of partnerships which can find common goals should be involved and therefore the participation of community/farmers/local decision-makers is essential for progress; ii). new sustainable technologies must get down to the small farmer and iii). the role of women in sustainable aquaculture can be of great importance.

4.1.3. Food safety-consumer security

Food safety as related to consumer security issues was also prominent in the panel discussion. It was pointed out that in aquaculture market forces were much influenced by consumer avoidance of poor quality. If there is high production of poor quality fish, then this leads inevitably to low prices. One possible solution is the involvement or the establishment of producer associations, building on existing networks where possible. It was also stated firmly that research should anticipate trends and possible problems by means of risk assessment studies and modelling.

4.1.4. Policy environment and social issues

Policy environment and social issues which were raised concerned the major issue of social equitability. However, the need for better communication pathways, leading to more public awareness of options, meant that education (perhaps even starting at government level) was a vital element in this process.

4.1.5. Last words from the floor

- *Most presentations seem to be concerned with intensive aquaculture, i.e., monoculture, but in Asia a great deal of aquaculture is semi-intensive and uses polyculture methods, i.e., mixture of species (carnivorous species as well as filter feeders which help to balance the ecosystem).*
- *There are lower yields from integrated systems: if costs are steady, this can be accommodated, but in developing countries costs are rising. Lower yield per unit hectare can also mean less exposure to risk.*
- *In coastal zone management, aquaculture is only one relatively small part. The whole socio-economic aspect needs to be better defined. Stakeholder participation, industry participation, academic participation: do we in Asia have the tools to carry this out?*

4.2. Day 2 Panel Discussions

4.2.1. ASEM Platform

The ASEM should develop a platform for effective cooperation and networking on sustainable aquaculture. Networking objectives should be long term, avoiding the "quick solution" and be based on full stakeholder involvement and using vertical and horizontal integration measures for complete and effective cooperation.

4.2.2. Trade and finance

The driving forces for action were seen first of all in terms of trade opportunities in products, equipment and services. Consumer perception of seafood products remained an important focus of discussion. Problems of quality assurance and freedom from disease can be met by introducing labelling, though the cost of certification is seen as too high. However, labelling and certification are seen as critical for the international market, and regulations will have to be complied with, for entire product range. Financial issues relating to the establishment and the maintenance of markets were concerned with market stability and how to reduce investment risk. Intellectual ownership matters, particularly relating to biotechnology, were also of some concern insofar as they may have a cumulative effect upon the small farmer.

4.2.3. Sustainability

On Day 2, the Panel discussion focused on technical and biological issues with regard to Genetically Modified Organisms (GMOs) from the point of view of the consumer as well as of the researcher. Recent developments in feeds and feed components also figured largely in the discussion. Social equity remained an important issue, with stress on support for smallholder production and market access. There also should be, at this level, the identification of environmental/management options.

4.2.4. Last words from the floor

- *Genetically Modified Organisms(GMOs) were the subject of lively exchanges. In the developed countries, the mere mention of the word "genetic" raises problems of consumer acceptability. Public perceptions have to be changed and that takes sustained educational efforts. As a result of recent widespread animal disease, there is equally widespread distrust of scientists. There has to be open discussion about what is taking place, then pathways will be found to change perceptions.*
- *The structure of breeding programmes is very important, otherwise in the years aquaculture could resemble poultry farming where there are now only 6 species.*

4.3. Day 3 Panel Discussion

4.3.1. ASEM new partnership opportunities

The opportunities presented by the ASEM process are multiple but clear and realistic actions for effective progress need to be identified. New partnerships involving societal stakeholders, public and private bodies and representatives of civil society, are required and these must be supported by transparent scientific knowledge. The extension and expansion of existing regional research, knowledge and learning networks will be particularly effective in stimulating the dynamic multiplier effects required for the achievement of sustainable aquaculture.

The building and mobilisation of research capacity in both Regions, taking advantage of synergistic actions within other programmes, will provide a framework that will underpin policy decisions, public/private partnerships and local and Regional initiatives for the implementation of a sustainable aquaculture strategy.

4.3.2. Capacity building

Capacity building should be encouraged in all areas of the food supply chain and associated sectoral inputs. Encouragement for self-governance, through the development of specific Codes of Conduct and Practice, must be accompanied by a reinforcement of Associative structures for aquaculture production. Such strengthening would lead to small-scale producers raising their potential for participation in the decision-making process. Carrying these actions through to the Regional level would provide coherent partners for governments and create a stronger position for facilitating the sustainable development of Asian aquaculture.

4.3.3. Last words from the floor

- *The ultimate aim being marketability and profitability, perhaps one answer is to search for new markets. Organic farming now is seen as an important new market and Asian-grown fish would qualify for entry into this new and growing market. There is a need to analyse developing markets, to predict future changes, and to develop guidelines for quality assurance.*
- *We need to mediate between the need for profitability and sustainability. In aquaculture, habitat conservation is must more than a green issue, for without a clean environment, there will be no future profitability.*
- *The achievement of the cooperative and networking actions required should be through the creation of an ASEM Aquaculture Platform that would provide the focal point for ASEM partners to mobilise their strengths and to facilitate the actions required to achieve the goals identified.*

The Bangkok Declaration 2000: aquaculture R&D priorities in the new millennium

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1. INTRODUCTION

I would like to thank the organizers for inviting me to present the keynote talk which I prepared for the AquaMillennium Conference organized by NACA and FAO in 2000.

I was able to prepare this review thanks to the input from a large number of colleagues and friends from all over the world.

I am sure that many of the subjects which I will raise here are treated in too superficial a manner and at times my approach might be considered rather provocative. However, the intention is that these issues can be taken up in the discussions of the respective thematic areas.

It is necessary to raise an important and critical issue at the start of this presentation. In many reports it is proposed that in the decades to come aquaculture should bridge the gap between market demand for aquatic products and supply from capture fisheries. I want to underline that there is great consensus in the research community that, following present-day aquaculture approaches, this is a very simplistic goal; in fact, it might not even be the right decision to try to achieve this goal by applying current technology and business methods. Risks of major environmental and human health problems need to be weighed against achieving a more cautious rise in production which is, in the longer term, sustainable. We should all see this not only as a challenge to do it well and responsibly but also as a commercial opportunity for the industry.

Aquaculture is clearly at a crossroads and can come, in fact, should come of age, in the 21st century. However, this will require more responsible researchers and more integrated R&D approaches than we apply at present.

2. TWO TYPES OF AQUACULTURE

Allow me to simplify things by classifying present-day aquaculture into two types: traditional food aquaculture, mainly practised in Asia with a few species of freshwater and brackish water fish, shellfish and sea weeds, and the more recent business aquaculture of shrimp, catfish, salmon, just to list the key groups.

2.1. Aquaculture for food security

Although food aquaculture still represents the dominant output, this type of aquaculture has evolved along with minimal research inputs. Trial-and-error practices, developed over several decades, even centuries, have resulted in well-balanced extensive production systems. Continuous expansion of production areas and further improvements in culture systems have been responsible for the rapid growth over the last decades. Many agree, however, that productions cannot continue to increase at the same pace simply because of the limitations of suitable water resources. Furthermore, the recent interest in 'modernizing', which in fact means to intensify freshwater fish production, will imply very serious threats to sustainability.

2.2. Aquaculture for profitability

Fast progress in business aquaculture has benefited most from R&D inputs, especially in Western countries, although we need to admit that it has often followed very empirical approaches. Short-term oriented research had to find ways:

- to grow the animal,
- how to maximize profitability, and
- how to assure long-term sustainability.

This 3-step process has been accelerated by high profits, abuses in some regions (although at the start often committed in ignorance) and vocal opposition to these types of industrial farming in some sectors of the NGO community. Still, in other words, the approach has been to develop monocultures, and to apply intensification which has brought about diseases. The treatment of disease often resulted in more problems (e.g., bacterial resistance, not to speak of the environmental problems) until it was realized that disease prevention was the new procedure to adopt.

2.3. Duplication of approach

It is interesting to see how both types of aquaculture have begun to duplicate some of the other's approaches: business aquaculture has started to adopt the principle of polyculture widely applied in food aquaculture, whereas China is intensifying its traditional freshwater pond cultures and is using formulated feeds. Such approaches open up very interesting opportunities, but also bring serious constraints as well.

2.4. Shared goal of sustainable aquaculture

2.4.1. Holistic approach

Further development of the aquaculture industry must take a holistic approach to culturing technologies, socio-economics, natural resources and environment so that sustainability can be achieved. The momentum of the sustainability dialogue in aquaculture has increased dramatically in recent years.

2.4.2 Need for objective approach

Despite increasing institutional focus the amorphous nature of the sustainability concept continues to constrain progress towards objective definitions and applications. It is here that researchers need to fill in by developing criteria and documenting test cases. At present "codes of conduct" and "development criteria" often lead to over-generalizations and to qualitative goals with little or no specific means of measure or application.

2.4.3. Ecological footprint

Different new concepts have been proposed; one of these is the "ecological footprint" which reflects the land and water areas necessary to sustain current levels of resource consumption and waste discharge by a given aquaculture practice. Cultures that combine species from different trophic levels, both terrestrial and aquatic, application of ecocyclic production, generation of multiple services and outputs, all can reduce the ecological footprint substantially.

All agree that since freshwater resources are limited, the priority is thus to increase production in the presently available volumes of water, not necessarily by further intensification but, rather, by polyculture and integration with terrestrial productions.

With regard to the coastal and marine environment, we are beginning to realize that these ecosystems must be managed as a whole and that we need to model these systems for nutrient-carrying capacities of the different water systems involved, for the various human activities and the different ecological conditions at any one location.

2.4.4. Aquaculture and Integrated Coastal Zone Management

2.4.4.1. Need to consider socio-economic and regulatory aspects
Various funding agencies are finally giving high research priority to "integrated coastal zone management studies", which are not restricted to ecosystem studies involving biologists, oceanographers and aquaculturists but consider the socio- economical and legal aspects as well. Our Asian colleagues, for example, have identified the need for more socio-economic studies for integrated farming systems in poor coastal communities, for example by developing sustainable coastal production systems that integrate aquaculture and fisheries under community management. Conclusions from the research results of these studies in developing as well as developed countries may well be straightforward. However, it is clear that special motivation will be required to see proper implementation of the true cost of certain farming practices. New tax systems or - even better - a system of incentives could be considered here.

2.4.4.2. Extractive aquaculture
In the case of aquaculture activities in the coastal zone the purpose is to reach a balance between "extractive" aquaculture and "fed" aquaculture. Extractive aquaculture refers to sea weed and mollusc farming which can play a significant role in nutrient recycling, in fact of any waste nitrogen and phosphorus, and not only from aquaculture farms. R&D projects in Europe are currently exploring the potential of extensive mariculture for 'anthropogenic nutrient recycling'. Sea weeds are efficient nutrient scrubbers that could assist in the management of nitrification of coastal waters. Other ideas are based on the fact that the cost of mussel farming, if used only for nitrogen removal, is about the same as in a conventional purification plant.

2.4.4.3. Fed aquaculture
Fed aquaculture systems are, for example, the cage farming of carnivorous marine fish such as salmon, bream and grouper. These systems might have to be removed from the more sensitive inshore waters to systems further offshore, and eventually integrated with further nutrient trapping by sea weeds and molluscs. Shrimp farming is another example of such "fed" aquaculture systems, the impact of which on coastal ecosystems needs to be better remedied by integration with proper nutrient trapping and/or recirculation.

3. RESEARCH PRIORITIES

3.1. Diversification of farmed species

3.1.1. Eel, blue fin tuna, milkfish

The next level to explore in the research priorities are the farmed species. There is general consensus that species diversification, especially of carnivorous types, is not a research priority. Broad species diversification leads to an exponential growth of research requirements which are not easy to meet because of limited resources, though clear exceptions have been made for a few key species such as the genus Anguilla and the blue fin tuna, for which controlled breeding would mean a major breakthrough. In the case of eel it would alleviate the pressure on wild stocks of glass eel in Asia as well as in Europe. Hatchery availability of blue fin tuna would reduce pressure on tuna fisheries and thus reduce the by-catch problem significantly. Still, little effort is devoted to search for and cultivate more species of shellfish, sea urchins, sea cucumbers and especially herbivorous fish species, those primary consumers able to utilize primary productivity most efficiently. They have been listed on many occasions as a priority to improve overall energy budgets. It is clear that for several species market demands, consumer preferences or restrictions are the main driving forces. A good example here is the milkfish which is considered a staple in the Philippines, but is not appreciated at all in many other SE Asian countries. Market researchers claim that there is room for improvement here and this research challenge should be taken up very seriously, especially in Asia.

3.1.2. Mussels

The same applies to the molluscs where there are still further handicaps, in the form of health risks arising from the consumption of contaminated product, as a result of which interest has declined in several species and regions (e.g., mussels in the Philippines). Suggestions are being made to consider new approaches that will increase the value of low-in-the-food-chain products: if not as food products, then perhaps as dietary ingredients.

3.1.3. Air-breathing fish

Freshwater becoming more and more a limited resource, air-breathing fish (clarid catfish and snake head) are proposed as a valuable extension to the species list of freshwater fishes. Among the primary producers, seaweeds are clearly identified as still having a very important potential, not least because their domestication is still at the early pioneering stages.

3.1.4. Seaweeds

As mentioned earlier several research groups, such as the Maricult project in Norway, are exploring the possible role of seaweeds in large-scale nutrient recycling and even in increasing the capacity of the sea as a carbon dioxide sink. However, the search for and development of new utilizations of seaweeds either as a source of fine chemicals and/or as an ingredient in formulated feeds will be crucial here.

3.2. Genetics

3.2.1. Comparison with agriculture

Let us turn now to research in genetics. It is widely believed that for the next decade the real challenge will be to get the aquaculture industries to introduce effective genetic improvement programmes using selective breeding. The aquaculture industry is decades behind developments in the agricultural sector where genetic research has resulted in huge gains in productivity. In recent times milk production is up 150%, daily weight gains in pigs has doubled, the time needed to produce marketable broilers cut in half.

3.2.2. Productivity levels constant

The Norwegian salmon industry, where a great deal of research money has been targeted in the past, has seen overall gains of 60 to 70 per cent.

Productivity of most other farmed species has remained almost constant, close to that of the wild founder stocks. Research is proceeding with several species of fish (carp, tilapia, trout, bream, bass) and molluscs (oysters, clams, abalone) though with others, such as shrimp, work has barely begun as very few species can be regarded as domesticated.

3.2.3. Strategy for selective breeding programmes

3.2.3.1. Sound basis for good selection

The technical challenge here is to close complex life cycles, not only with empirical culture techniques but especially to understand how the nervous and the endocrine systems coordinate with the changing external environment. Once fully-domesticated breeds are available and all the factors for good genetic management of brood stock are fulfilled, the selection work can start. The importance of such a strategy of selective breeding is two-fold. First, it provides a sound population within which incremental improvements can be begun. Second, much of this work is practical and the sooner the industry people are involved the better the technology transfer and the closer is the return on investment. Another point is that no other genetic approach offers continuing incremental improvement. The formation of improved selected lines provides a base population upon which, sooner or later, the additional advantage of other genetic approaches can be applied, on top of the incremental change. The first priority is thus to develop domesticated brood stock (still an art with some key species such as the Penaeid shrimp) to be followed by selective breeding schemes, allowing the production of certified seed.

3.2.3.2. Faster Selection of advantageous traits
The ability to use techniques in molecular biology to mark and identify stock by genetic fingerprinting will enable a much faster selection of advantageous traits. The highest priority in selective breeding programmes is given to disease-related aspects where two approaches are considered: disease-free as well as disease-resistant lines. Although no miracles are to be expected either, as good farming practices, optimal health management, appropriate measures of quarantine should not be neglected. Other factors of interest in selective breeding programs are growth rate, market size and quality, food conversion ratios, fecundity and ease of domestication. Although selection on a wide genetic base will give continued improvement, the development of monosex and polyploid strains can yield large gains, already the equivalent of several questions of selection.

The logical approach is to work for a combination of gains as has been done successfully with genetically-male tilapia (GMT) and genetically-improved farmed tilapia (GIFT). Several of these strains have already proven their benefits; however, their impacts on the environment are not yet satisfactorily documented.

3.2.3.3. Genetically modified organisms
Finally to consider the transgenics or genetically modified organisms (GMOs). This is a very sensitive issue indeed, especially since opinions are so extreme, with ongoing work supported in some countries, but completely halted in some others. On one hand public concern is at such a level, at least in the Western world, that the products will have to be proved safe for consumption and for the environment three times over. Let me warn you, however, that public perceptions of safety are every bit as important as safety itself. Proper testing is essential here. It seems likely that public debate will increase on this issue and that the well-publicized precautionary approach, with strict application of "Performance Standards" developed as a guide for researchers, will be adopted with absolute priority. The main danger seen is not so much that of health but rather that of the maintenance of biodiversity through the effects of escapes into the wild. In this respect the often-proposed need for the gene-banking of aquatic organisms should receive a higher priority.

In any case the development of transgenic aquaculture organisms is not expected to proceed as fast as some are claiming. The utility of any transgenic work is dependent upon inserting genes into individuals and having the insertion stable so that it is inherited. The expression of genes is dependent upon the genetic background into which they are inserted. That, and their continuance in a breeding population means that there has to be a sound domesticated population into which they can be introduced for them to be effective. This is another reason for ensuring that industries should establish sound selective improvement programmes first.

3.3. Culture systems and Techniques

3.3.1. Pond Culture

Let us now turn to research priorities in culture systems and techniques. Although pond cultures make up by far the most dominant form of aquaculture, still very little is understood about pond ecosystem functioning. It is time to plan more studies on nutrient dynamics in the water, the soil and their interactions as well as the role of microbes in these processes. One could explore the potential to increase primary and secondary productivity, for example by providing extra substrate as in the new idea of aquamats used in fish and shrimp farming; in fact a very similar approach has been applied for decades in some traditional estuarine and coastal fisheries: the acadjas in Cote d'Ivoire and the katha fisheries in Bangladesh and India where extra substrate suitable for colonization by periphytic flora and fauna results in increased food supplies.

It is very likely that more research on pond culture systems could improve the economics of the production and especially ensure better environmental sustainability.

3.3.2. Open-sea cage farming

In view of the need to move mariculture further off-shore, extra research is needed on open-sea cage farming: equipment and materials, knowledge of fish behaviour, use of submersible lights to adjust photoperiod to control cycles of growth and maturation; integration with seaweed and mollusc farming, as practised for example in Chile.

3.3.3. Recirculation technology

Recirculation technology will receive much more attention as it offers lots of opportunities for captive markets and for safe applications with GMOs as absolute guarantees can be provided to prevent escapees. Systems need to be further improved in order to make the production more efficient to be able to deliver competitive products for the market.

3.3.4. Restocking and stock enhancement

Consider restocking and stock enhancement: its beneficial effects are well documented in confined areas such as lakes and reservoirs and in respect of benthic organisms. However, more research is needed with pelagic species in the marine environment. There needs to be more emphasis on how to make fish juveniles more fit for life in the wild, on releasing strategies and their possible impact on wild populations. Needed most of all are validation studies, which can be better planned, now that appropriate tagging and genetic marking techniques have become available. In addition, the issues of artificial reefs and off-shore drifting nets require more attention. Can we better document increased primary productivity or is it the sole effect of an aggregation of the fishable stocks?

3.4. Feeds

3.4.1. Fish meal, fish oil and alternatives

As aquaculture feeds often make up 50 % and more of the production cost it is clear that research in this field will remain a priority. The nutritionist has to develop economic feeds and here the concerns about the availability of fish meal and especially fish oil are paramount. Although some claim that there are no difficulties for the present and for another one to two decades, many others are not so optimistic. Who can guarantee that global fish meal production will remain high? What about the sudden increase of fish meal consumption in aquafeeds in China? As stated earlier, a gradual conversion is taking place in China of extensive freshwater fish production to semi-intensive systems making use of pelleted feeds. The search is on for alternative protein and lipid sources. Plant-based protein sources come highest on the list, but rendered products could also be valuable, although the human health concern will require careful study. Single-cell proteins and by no means least the recovery proteins from the waste of seafood processing and from fisheries by-catch are also on this list. Any disease issues that might be involved with this approach also need to be understood. Of course these substitutions will require supplementation to fulfil the essential aminoacid balance and essential fatty acid requirements.

3.4.2. Microbial products

Microbial products might alleviate demands for selected amino acids and fatty acids of the n-3 and n-6 series. Before this can become a reality, production must be increased, supplies must be stable and prices must fall to a competitive level. Improved nutrient availability should optimize the digestible protein to energy balance, but should also be effective for maintaining good health and improving disease resistance.

3.4.3. Eco-friendly feeds

Finally, the so-called eco-friendly feeds, the more nutrient-dense diets that allow for reductions in phosphorus and nitrogen waste output will further gain in importance. Progress in diet formulation is essential, but improved feed management is yet another field where research could contribute to more environmentally-friendly productions: development of regimes that lead to reduction in losses from unconsumed feed and use of interactive feeding systems, to mention a few approaches. Consumer preferences will have to be better considered as diet and feeding practices influence attributes of the farmed fish: their nutritional quality, texture and flavour.

3.4.4. Starter feeds

Further progress is also required with the starter feeds: use of less live food could be further improved and made more predictable. One could consider better selected and eventually manipulated strains of algae, rotifers, and Artemia. Another need is more diversity in Artemia resources. Also required are improved formulations and manufacturing of micro-diets for use in co-feeding and full substitution of live food.

3.5. Diseases control

With annual losses of several billion US dollars caused by diseases in aquaculture it is clear that this is another area of high research priority. However, first of all we should realize that we need to leave behind us the past decade of disease treatment with all its attendant negative environmental and other consequences, and move forward to a future of disease prevention. Disease control in aquaculture should focus first on preventive measures related to good management practices which maintain good water quality, with better/certified seed, less stress, high-quality feeds, etc.

In many, perhaps most farming practices, there is still plenty of room for improvement on many of these counts. More applied research should better document these effects. We still need to acquire a good deal more basic knowledge of the microbial, viral and parasitic diseases and their epidemiology in aquatic organisms. Access to a large arsenal of molecular techniques will certainly assist quick progress in this area.

Development and validation of appropriate diagnostics has a high priority. However, whilst PCR-based kits are very sensitive and can detect very small quantities of organisms, in the wrong hands they can be very dangerous as false positives and negatives are common from non-standardization of techniques, contamination, etc. Lack of time does not allow me to elaborate further on research needs for vaccine development, quarantine systems, basic immunology research especially in invertebrates.

Because of my laboratory's preliminary research experience with microbial manipulation in larviculture systems I would like to mention here that I expect important progress in the study of microbial processes and their regulation in many aquaculture systems: competitive exclusion is one of the ecological processes that allows manipulation of the bacterial species composition in the water, the sediment and the animal digestive tracts.

4. RESEARCH EXTENSION

I mentioned earlier that extension and dissemination of research results has to be better considered as there are too many failures in technology transfer. We need more adaptive research: partnerships between the farmers and various service providers. Researchers need to realize that we have a responsibility to prove the validity of our research findings. Furthermore, researchers often might not realize that, depending on specific circumstances, social and economic factors may be more important than technological factors. More interdisciplinary interaction will pay off, as is illustrated by recent aquaculture progress in the Mediterranean, through various schemes of support by the European Union for joint initiatives between the private sector and the research community. Furthermore North-South and especially South-South R&D interactions and networking should be much more stimulated.

Today, we live in a small world with unique opportunities for communication and interaction. I am also convinced that, in the field of aquaculture, humanity has an opportunity to benefit considerably from the historical differences: the diversity of our cultures and ways of thinking (for example with regard to identifying research priorities and performing research and extension), the diversity in aquaculture farming practices, the differences in consumer interests, all of these can help us to better understand aquaculture principles and consider more carefully the challenges for the century to come.

THEMATIC AREA I

Environmentally responsible grow-out systems in Aquaculture

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ABSTRACT: Aquatic plants, molluscs, crustaceans and fish are grown out in a variety of ponds, pens, cages, trays, and rafts from low-density, extensive systems to high-density farms with artificial feeding and water circulation. Asian aquaculture, mainly in the tropics and subtropics, contributed around 90% of global output, and freshwater fish (44%) and macroalgae (22%) comprised the bulk of production in 1999. But increasing focus on high-value carnivores like shrimp and salmon and their culture in intensive ponds and pens/cages has caused negative ecological impacts associated with resource utilization (e.g., mangrove conversion) and waste production (causing eutrophication, sedimentation and salinization). Grow-out systems need to reduce and mitigate such impacts and become more environmentally responsible through the development and/or wider dissemination of available onfarm technologies (e.g., recycling), integration of aquatic species, and of aquaculture with agriculture/mangroves. All these require a paradigm shift from the short-sighted 'commons' exploitation of water, mangroves and other resources to the ecological footprint approach incorporating not only inputs such as feed and seed, but also outputs, e.g., effluent treatment facilities.

1. INTRODUCTION

1.1. Global aquaculture production

Global aquaculture production in 1999 totalled 42.8 million mt valued at US$53.6 million (FAO, 2001). Asia, the cradle of aquaculture, contributed 90.9% of total volume and 82.3% of total value compared to 4.9% and 8.6%, respectively, from Europe (Table 1), a relative newcomer to the field. Eleven of the top fifteen aquaculture-producing countries are in Asia, among them China (with 9.4 million mt) and India (2 million mt) compared to only four countries from Europe.

	Asia	Europe	Total (incl. others)
Fish Crustaceans Mollusks	29,481,961 mt US$ 38,441,232	2,091,866 mt US$ 4,605,737	33,310,349 mt US$ 47,874,991
Aquatic Plants	9,404,996 mt US$ 5,658,947	6,060 mt US$ 7,475	9,460,629 mt US$ 5,687,592
TOTAL	38,886,957 mt (90.9%) US$ 44,100,179 (82.3%)	2,097,926 mt (4.9% US$ 4,613,212 (8.6%)	42,770,975 mt US$ 53,562,583

Table 1. 1999 aquaculture production of animals and plants in Asia and Europe by volume and value (FAO, 2001).

1.2. Grow-out systems in Asia

Grow-out systems in Asia for plants (beds, rafts) and molluscs (rafts, stakes, longlines) are predominantly extensive, but crustaceans and fish are reared in extensive, semi-intensive and intensive land-based ponds, and water-based pens and cages (Table 2). As in Asia, molluscs in Europe are farmed in trays, rafts and ropes, but fish are raised only in intensive tanks, cages and pens.

	Asia	**Europe**
Aquatic plants	extensive: beds, stakes, rafts	--
Molluscs	extensive: beds, stakes, rafts	extensive: bottom (trays) + suspended (rafts, ropes) system
Crustaceans	extensive, semi-intensive, intensive ponds	--
Finfish	extensive, semi-intensive ponds (land-based) intensive cages, pens (water-based)	intensive tanks (land-based) + cages (water-based)

Table 2. Dominant aquaculture production systems (modified from Beveridge et al, 1996) in Europe and Asia.

1.3. Major aquaculture crops in Asia

The major aquaculture crops from Asia are freshwater fish, seaweeds, crustaceans, marine fish and mollusks, and from Europe diadromous fish (salmon) and molluscs. Converting aquaculture production to a pyramid based on species group and feeding habit (Fig. 1) shows interesting trends. Carnivorous fish and crustaceans comprise only 14.7% of production volume but their value more than doubles to 35.2% of total due to high market price of these commodities. In contrast, plants and lower trophic level molluscs and herbivorous fish contribute up to 45.8% of total production by volume but only 27.5% by value. All over Asia and elsewhere, there is a shift towards more high-value (and therefore more profitable) carnivores.

2. ECOLOGICAL IMPACTS

2.1. Effects of changes in farming practices and farmed species

The growth of aquaculture in recent years has been associated with a variety of negative ecological effects, in part due to intensification of traditional farming practices and a shift to high-value carnivores. These impacts have been discussed in various review papers (e.g., Wu, 1995; Naylor et al., 2000) and will not be detailed here. It will suffice, for the purpose of the present discussion, to draw from two examples from Southeast Asian aquaculture - the milkfish *Chanos chanos* and the giant tiger prawn *Penaeus monodon.*

2.1. Two examples: the milkfish *Chanos chanos* and the giant tiger prawn *Penaeus monodon*

Traditional low-density farming of both species in earthen ponds in the Philippines has depended on wild fry, natural food (the microbenthic complex called lablab), and tidal water exchange. Increased production of milkfish came from expansion of brackishwater pond area, mainly in mangroves in the 1950s and 1960s (Primavera, 1995), and more recently in high-density pens and cages deployed in rivers, coves and other protected coastlines (Bagarinao, 1999).

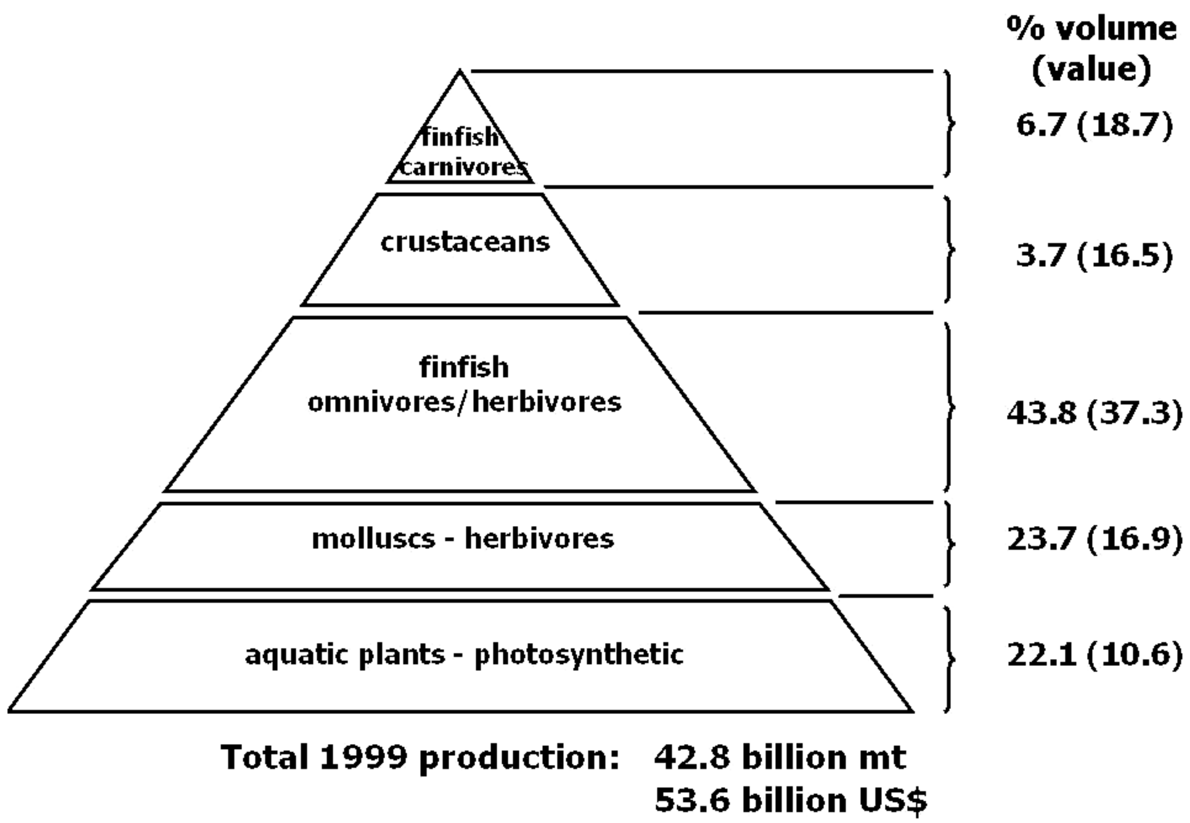

Fig. 1. Ecological pyramid of 1999 global aquaculture production (from FAO, 2001) according to taxonomic group and trophic level.

Increasing harvests of tiger prawn were due to intensification of pond culture with the availability of hatchery seed and commercial feeds (Primavera, 1993). Shrimp farming has been linked to the (mis)use of antibiotics and other chemicals, the salinization of soil and water, and the introduction of exotic species, e.g., *Penaeus vannamei* from tropical America via Taiwan (Primavera, 1998).The major impacts from expanded and intensified milkfish and prawn culture in the Philippines are the loss of hundreds of thousands of hectares of mangroves (and their goods and services), eutrophication and organic loading in coastal waters, and pollution from effluents. Reports of milkfish kills due to overstocking, excessive feeding and deteriorating water quality in pens and cages date back to the mid-1990s. But these mass mortalities have progressively worsened to such an extent that in February 2002 alone, the town of Bolinao, Pangasinan in northern Philippines lost 200 million mt of fish worth PhP800 million (~US$ 16 million).

3. RECOMMENDATIONS

Thematic Session One of this workshop addresses the urgent issue of how to make grow-out systems more environmentally sound. Aquaculture experts and scientists from Asia and Europe offer information, insights and recommendations below some of which require a paradigm shift from the short-sighted 'commons' exploitation of water, mangroves and other resources to the ecological footprint approach that incorporates not only inputs, but also outputs such as facilities to treat effluents (Kautsky et al., 1997).

1) *Reduction of fish meal and fish oil inputs in aquaculture feeds* - M.B. New discusses the challenges created by the use of these marine ingredients in aquafeeds
2) *Water and effluent management* - Closed recirculating aquaculture systems or RAS (based on 15 years commercial experience in Europe) and a verification project in Southeast Asia involving biological filters are described by J.H. Verreth and R.R. Platon, respectively.
3) *Integrated production systems* - J.-Y. Ye suggests ways to improve traditional polyculture of Chinese carps in the face of problems such as genetic deterioration and environmental pollution. R.R. Platon and the former author report the results of trials utilizing mangrove flora to treat effluents from brackishwater shrimp ponds.
4) *Rehabilitation of degraded sites* - Collection of green taxes based on the Polluter Pays principle can provide funds to mitigate aquaculture impacts through mangrove replanting projects, rehabilitation of damaged coastal systems, and correcting water quality problems.
5) *Vietnamese aquaculture* - T.T. Nghia provides insights on how Vietnamese aquaculture can be both sustainable and profitable
6) *Overview of European aquaculture* -Y. Harache's historical overview of European aquaculture, current environmental concerns and the innovative technologies that confer strategic advantages to Europe.

REFERENCES

Bagarinao T.U.B. 1999. Ecology and Farming of Milkfish. SEAFDEC Aquaculture department, Iloilo, Philippines. 171 pp.

FAO. 2001. Aquaculture Production 1999. FAO Yearbook - Fisheries Statistics vol. 88/2. 178 pp.

Kautsky N., Berg, H., Folke, C., Larsson, J. and Troell, M. 1997. Ecological footprint for assessment of resource use and development limitations in shrimp and tilapia aquaculture. Aquacult. Res. 28: 753-766.

Naylor R.N., Goldberg R.J., Primavera J.H., Kautsky N. Beveridge M., Clay J., Folke C., Lubchenco J., Mooney H., and Troell M. 2000. Effect of aquaculture on world fish supplies. Nature 405: 1017-1024.

Primavera J.H. 1993. A critical review of shrimp pond culture in the Philippines. Rev. Fish. Sci. 1: 151-201.

Primavera J.H. 1995. Mangroves and brackishwater pond culture in the Philippines. Hydrobiologia 295: 303-309.

Primavera J.H. 1998. Tropical shrimp farming and its sustainability. In: Tropical Mariculture (S. de Silva, ed.), pp. 257-289. Academic Press, London.

Wu R.S.S. 1995. The environmental impact of marine fish culture: towards a sustainable future. Mar. Poll. Bull.

Carp Polyculture System in China:
Challenges and Future Trends

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ABSTRACT: China has long been known for manure-based integrated multiple species fish farming technology. The traditional Chinese system of polyculture, stocking fish with fingerlings of different species of fish with different food habits, at a ratio determined by the quantity and quality of natural food available in the pond, has been practiced with a view to utilizing all the natural food available, thus maximizing fish production per unit area of pond surface. The Chinese major carps, such as silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Arigtichthys nobilis*), grass carp (*Ctenopharyngodon idella*), black carp (*Mylopharyngodon piceus*), mud carp (*Cirrhina molitorella*), Crucian carp (*Cyprinus carpio*) and common carp (*Cyprinus carpio*), are widely cultured in these ponds wherever traditional markets exist. The challenges faced by the Chinese system of polyculture include genetic degeneration of the Chinese major carps, deterioration of pond eco-systems, frequent occurrences of fish diseases, poor quality feeds, poor growth performance, environmental pollution and serious market competition. Aquaculture production technologies are experiencing a revolution, rapidly expanding and undergoing change to higher valued species and higher technology levels, due to pressures on the Chinese government and producers for improved economic and resource efficiency and for environmental concerns. In the 21st century, profitable and sustainable aquaculture will become the major concern for fish producers in China.

KEY WORDS: Chinese major carps, traditional polyculture system, profitable and sustainable aquaculture.

1. FISH PRODUCTION BY AQUACULTURE IN CHINA

Presently, fish and shellfish production in China is growing at an annual rate of approximately 10.5%, while production from capture fisheries is slowly declining because of over fishing and pollution (Yang et al., 2000). Since 1990, China has become the leading fish and shellfish producer in the world. Available statistics indicated the annual production of aquatic products was 31.3 kg per capita in 1998 (Yang et al., 2000). This ranks China above the average level in the world.

Aquaculture has developed rapidly in China, which accounts for approximately 67% of the total world aquaculture production. Figure 1 shows the production of fish and shellfish for the world and China, 1988-1997 (FAO, 1998). Figure 2 shows fish and shellfish culture as a percentage of total world aquaculture, 1988-1997 (FAO, 1998). In 1996, aquaculture contributed 18.61 million tons, or 56.6% of the total fish and shellfish production (Tu, 1998). Since then, China has become the first country for which aquaculture achieved a higher production than capture fisheries. The aquaculture growth in China is mainly driven by two factors: (1) increasing population (2) dwindling returns from marine capture fisheries.

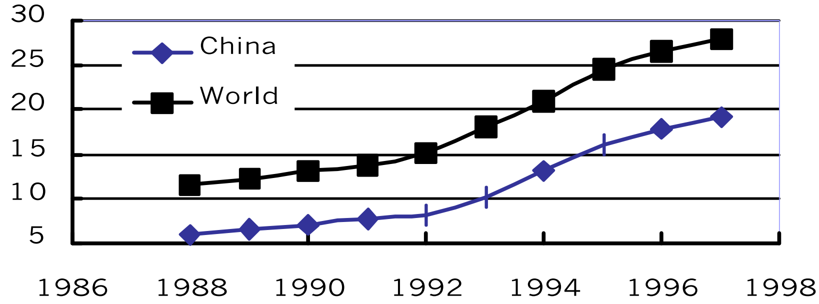

Figure 1. Production of fish and shellfish, World and China,1988-1997 (FAO)

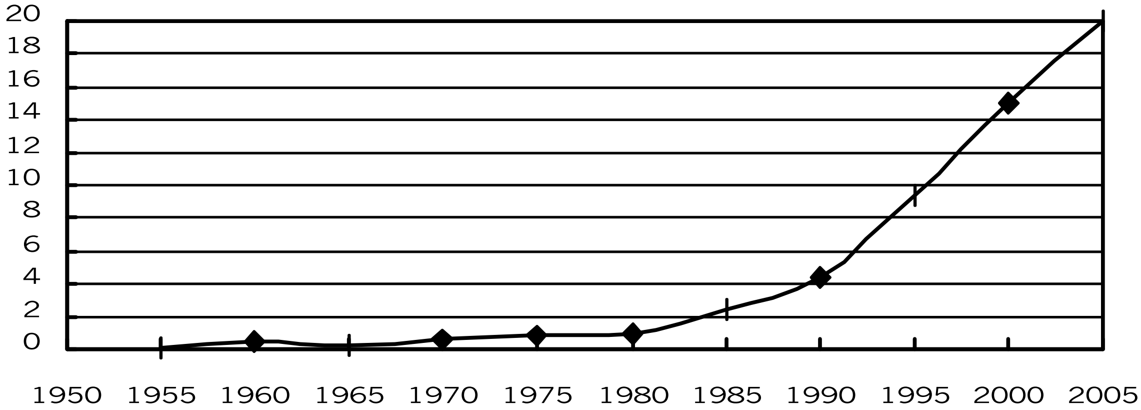

Figure 2. Fish and shellfish cultured in China as a percent of world aquaculture, 1988-1997 (FAO,1998)

China has a long history of freshwater aquaculture. The earliest record of freshwater aquaculture dates back to as early as 3000 years ago. The earliest monograph on fish culture, "Treatise on Pisciculture", was written by Fan Li in 473 B. C. Aquaculture techniques continued to improve and to increase in complexity through the centuries (Li, 1990), and the polyculture of fish first started in China in 618 A. D. In 1950, the total production from freshwater fisheries in the People's Republic of China was 360,000 tonnes from 380,000 ha, of which freshwater aquaculture represented 18%, or 64,800 tonnes. The success of artificial reproduction of Chinese carps in 1958-1960 greatly increased the availability of carp fry (Li, 1990). In 1959, total production from freshwater fisheries increased to 1.23 million tons, in which the contribution from aquaculture was 590.400 tons, or 48%. As a result of the emphasis placed on fish production through aquaculture by the Chinese government, production increased steadily through the 1960s and 1970s.

A dynamic upturn in freshwater fish production began around 1980, as a result of the open policy promoted by the Chinese government and a change in nutrient input bases, from manures to agricultural by-products. The earliest trials on grass carp (*Ctenopharyngodon idella*) culture, using nutritionally incomplete compound feeds, were first conducted in 1972, but with the same mixed species as in the traditional polyculture technologies (Shi et al., 1998). Studies on the nutrient requirements and feed technology of the Chinese major carps were begun in 1981. In 1982, approximately 3 million ha were brought under freshwater aquaculture production, yielding 1.1 million metric tons. Polyculture in freshwater ponds, with a combined area of 910,000 ha, contributed 863,590 tons, or 78.5% of the total freshwater aquaculture production.

Profitability of the traditional polyculture system rapidly declined after 1986, when the Chinese government effectively conducted reform away from a centrally planned economy to a market-driven economy. Since then, demand increase for aquaculture products has been primarily for higher value, fed species - in contrast to the low value, filter species that dominated the traditional Chinese polyculture systems. Recently, farmers with foresight have realized that to be more competitive, they need to change the species composition of their polyculture systems, from six to nine species with low market value, to one or two select species with high value and market demand. Figure 3 shows the actual growth of freshwater aquaculture production in China, 1955-1996, and projected through 2000. (Schmittou et al., 1998).

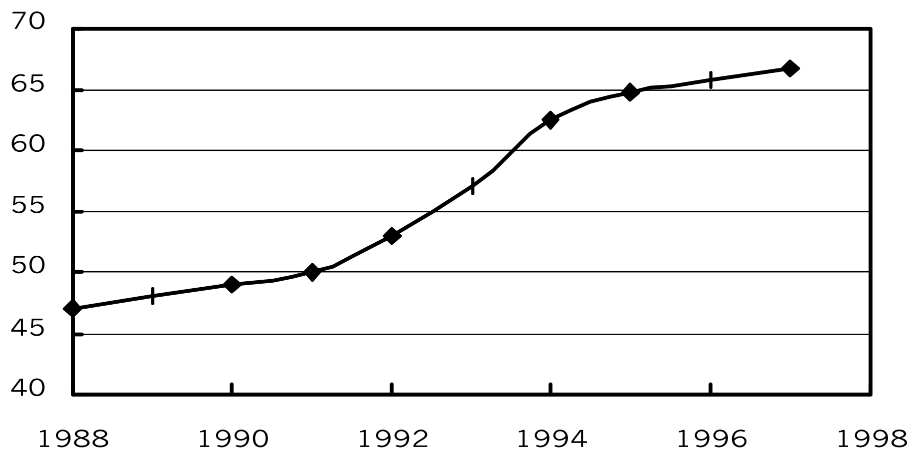

Figure 3. Growth of freshwater aquaculture production in China, 1955-1996, and projected through 2005 (H.R. Schmittou, 1998)

2. STATUS OF CARP CULTURE

The Chinese major carps, such as silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Arigtichthys nobilis*), grass carp, black carp (*Mylopharyngodon piceus*), mud carp (*Cirrhina molitorella*) and crucian carp (*Cyprinus carpio*), etc., have long been cultivated as the major species in freshwater ponds, lakes, and reservoirs (Li, 2001). In spite of rapid progress made in the culture of higher valued species over the last ten years, carp culture still plays a very important role in Chinese aquaculture. Pond polyculture makes substantial contributions to the overall fish production from the freshwater fisheries. Nearly 80% of the total freshwater fish production comes from carp (particularly silver carp, grass carp, and bighead carp) polyculture ponds (Li, 2001).

Pond fish culture characterized by polyculture and integrated fish farming systems represents the typical traditional and productive fishery conducted in China (Li, 1990). In traditional Chinese pond polyculture, the silver carp feeds on phytoplankton in the water column, the bighead consumes zooplankton, the grass carp eats supplemental vegetation, the black carp eats molluscs, and the mud carp and common carp (*Cyprinus carpio*) eat benthos/ detritus. The major carps are cultured together at a ratio determined by the quantity and quality of natural food available in the pond. Other species, such as crucian carp, wuchan fish (*Megalobrama amblycephala*) and tilapia (*Tilapia* spp.), etc., are also considered for pond cultivation. The embankments of the ponds are used for the production of vegetation. Some land is also reserved for the establishment of piggeries and duckeries, to integrate the culture of pigs and ducks with fish farming. Manure from pigs and ducks is used to fertilize the ponds to generate high quantities of natural food for fish, thus making it possible to increase fish production per unit area of pond without much additional cost. Agricultural by-products, such as rapeseed cakes, rice and wheat bran; by-products of beer and wine industries, and the vegetation grown on the banks of the ponds are also used as fish feed. Figure 4 shows schematically the traditional Chinese system of polyculture.

China produces more than 480 billion freshwater fish fry (mainly Chinese carps) annually, of which at least 80% are hatchery produced (Li, 2001). Encouraged by the success of pond fish culture, the Chinese government,

in its bid to improve the nutritional status of the increasing population and adjust the structure of agriculture, has turned to aquaculture, and in particular, to pond aquaculture. A policy has been drawn up to promote aquaculture development within the next five years in China.

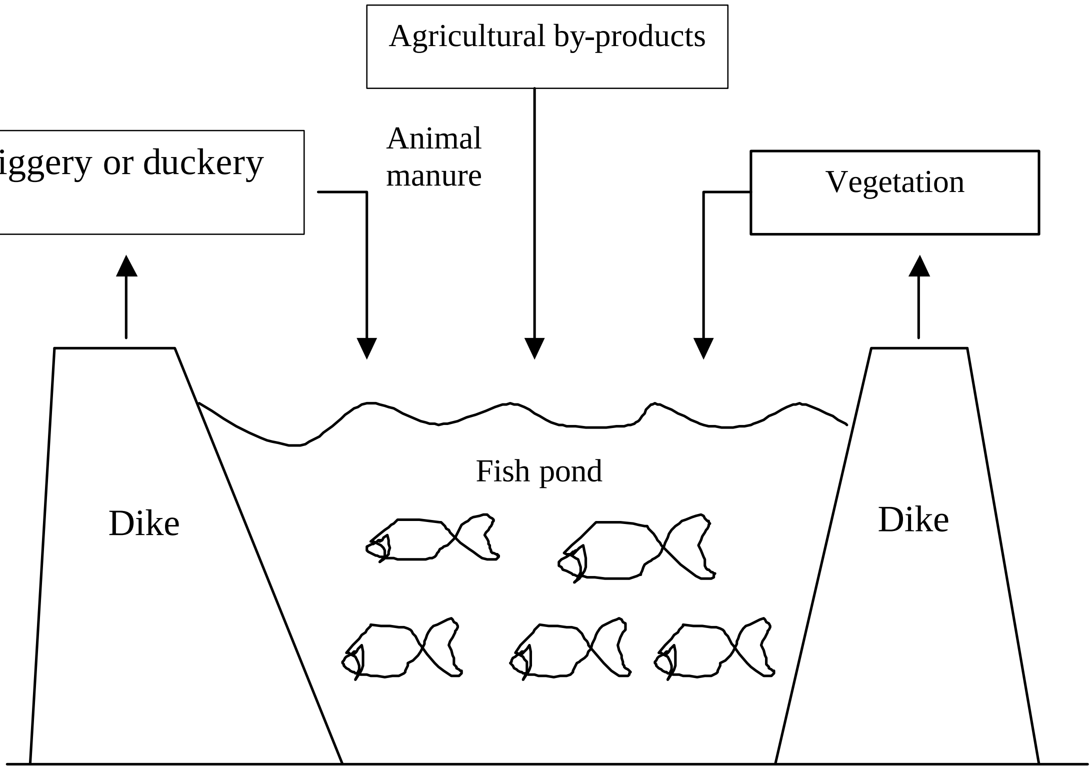

Figure 4. Chinese traditional system of polyculture

3. MAJOR PROBLEMS IN THE CHINESE SYSTEM OF POLYCULTURE

With the rapid development of aquaculture, the major problems faced by polyculture in China include: genetic degeneration of the Chinese major carps, deterioration of pond ecosystems and environmental pollution, frequent occurrences of fish diseases caused by *Aeromonas hydrophila*, poor quality feeds, and market competition between producers of the same species.

3.1. Genetic degeneration of the Chinese major carps

Traditionally, silver carp, bighead carp, grass carp, and black carp are referred to as the main cultivated fish in Chinese aquaculture. Improving the main cultivated fish through genetic research is a relatively new activity. Faster growth, higher yield, better feed conversion, and increased resistance to disease can all be improved through genetic manipulation (Jensen and Crews, 1997). Up to the present, most of the brooders of the main cultivated fish in China are derived from wild strains. Few producers work with mass selection or improved strains. Since it takes several generations of continuous culture to obtain a domesticated strain, almost no genetically improved strains have been obtained for the main cultivated fish in China. Because inbreeding and unsuitable genetic manipulation of carp are practiced by producers in some regions, indicators of genetic degeneration, such as slower growth, poor resistance to disease, and earlier maturation, have appeared. At the same time, wild strains are decreasing rapidly in natural bodies of water, partly because of over-fishing for initial stock of the main cultivated fish species.

3.2. Deterioration of pond ecosystems and environmental pollution

Traditional polyculture technology enables the productive potential of a body of water to be fully realized (Ye, 1984). The vertical water column, the natural food, and the mutual benefits between different species can be fully utilized through the stocking together of several species in reasonable proportions. With improved management of water quality and better input, such as fertilizer, artificial feed, and improved varieties of fingerlings, fish production per unit area may be substantially increased. The technical management and control of the pond ecosystem, however, is not easy and production risks are rather high. It is important to understand that Chinese traditional aquaculture differs in many aspects from the advanced aquaculture systems in industrialized countries. Water quality is an essential parameter for effective and disease-free aquaculture systems, but in quite a few fish farms there are no means to regulate and improve water quality (M.E. Nielsen et al., 2001).

There are a number of existing problems with traditional polyculture technology. Pond water quality may deteriorate because of the large amount of organic matter input into these systems. Large amounts of silt may also be deposited on the pond bottom, caused by erosion of pond dikes and by adding manure and other ingredients. In addition, wastes generated in the polyculture system can impact natural bodies of water through effluents. Further complications arise if the outside water source has been industrially polluted, as in some regions, rendering water exchange an ineffective measure to improve pond water quality. Thus, there are many more problems concerning water quality and pond bottom mud now existing than there were before with the traditional polyculture technology.

3.3. Frequent occurrences of fish diseases caused by *Aeromonas hydrophila*

Fish disease is the major risk factor in commercial aquaculture with millions of dollars lost annually, and in Asia, disease has emerged as a major constraint to the sustainable development of aquaculture (FAO 1997, Shariff 1998). *Aeromonas hydrophila* has been recovered from a wide range of freshwater fish species worldwide (Austin and Adams 1996). Fish bacterial septicaemia has been a severe infectious disease in main cultivated freshwater fish throughout China since 1989 (Qian et al., 1997). The major Chinese carp, including crucian carp, silver carp, bighead carp, and blunt-snout bream are the most sensitive species to this disease. Hundreds of bacterial strains have been isolated from diseased fish. Most of the isolates were *Aeromonas hydrophila* (Chen et al., 1997). Sakazaki et al. (1984) reported that Shimada identified two major subgroups of *A. hydrophila*, strains TPS-30 and PBJS-76, which belonged to two serotypes, 0:9 and 0:97, respectively (reported in Qian et al., 1997). Recently, *Aeromonas hydrophila* has been recognized as a common organism associated with disease outbreaks in aquaculture in China (M. E. Nielsen, 2001). *A. Hydrophila* is more abundant in waters with a high organic load than in relatively unpolluted water (Jeney and Jeney 1995). Frequent occurrences of this disease in summer are probably due to high stress in this period (e.g. high temperature, low DO content and heavy parasite infections etc.). High mortality of fish and a resulting low profit or loss of income can be caused by outbreaks of the disease (Qian et al., 1997).

3.4. Poor quality feeds

The main feed used for Chinese traditional polyculture includes fresh organic ingredients and nutritionally incomplete compound pellets with unsatisfactory physical properties. Some problems such as coarsely ground ingredients, poor water stability and shortage of the actual quantity of vitamins for the compressed pellets can be found among the products of feed manufacturers. Overfeeding is observed to be much more common than underfeeding, especially among farmers with limited experience of using high quality feeds (H. R. Schmittou et al., 1998). Large amounts of feed wastes released into the water, together with poor feeding practices, can result in critical water quality deterioration of pond ecosystems. On the other hand, limited success has been achieved by using compound pellets, mainly because of the diversity of species in the polyculture system.
For improving feed efficiency, fish farmers are realizing the need to move to a feed-based production system and to switch to high quality manufactured feeds. However, it is probably unrealistic to expect one type of compound pellets to meet the nutrient requirements of several different species of fish.

3.5. Market competition between producers of the same species

Pond polyculture of the major carps is a relatively profitable undertaking requiring low investment, with low costs and quick results, in comparison with rice planting and animal husbandry. In recent years, freshwater fish culture has been considered one of the main ways for improving the standard of living for people in rural areas. Many farmers have gradually directed their efforts to the development of aquaculture. The economic efficiency of the traditional systems, however, rapidly declines when production of the major carps is greater than market demands. As a result, market competition has become more intense between producers of the same species since 1986. Careful attention to the quality of farmed fish (nutritional value, texture, appearance, freedom from residues, parasites and pathogens, etc.) is also required (New, 1997). The development of new products and the marketing promotion of fish as a healthy food are essential for the continued success of Chinese aquaculture.

4. FUTURE SOLUTIONS

4.1. Improving Chinese major carps through genetic selection

Results from research on genetic selection for silver carp have been encouraging. The semi-domesticated strains of silver carp have shown better growth rates than wild strains (Zhejiang Institute of Freshwater Fisheries, unpublished). In addition, Chinese scientists have carried out some work on selection, strain identification, and evaluation of the major carps (Li, 2001). For the sustainable development of carp culture, producers should practise mass selection and try to obtain improved strains for crossbreeding. In particular, carp producers should not inbreed their stocks. Wild carp stocks are important resources for future genetic improvement programmes (Pullin, 1986). Effective measures should be adopted to protect from the threats from pollution and from fish and water transfers. It is also recommended that researchers conduct further genetic studies on crossbreeding, hybridization, polyploidy, sex reversing, and gene-splicing to improve growth rates, feed conversion rates, and disease resistance of the major carps.

4.2. Vaccination for the prevention of motile Aeromonad septicaemia

Fish vaccination is considered to be an effective method for preventing infectious diseases, but there are few descriptions of fish bacteria in China. An early fish vaccine used in China was the tissue-homogenized vaccine for haemorrhage in grass carp, made from the internal organs of diseased fish and inactivated with formalin (Chen et al., 1997). Recently, a good deal of work on the development of bacterial vaccines for the prevention of motile *Aeromonad septicaemia* of the major carps has been done at the Zhejiang Institute of Freshwater Fisheries. With the popularization of the vaccination techniques, instead of using antibiotics and other drugs, the survival rate of the major carps may be improved and adverse environmental impacts on natural and aquaculture ecosystems may be reduced as well.

4.3. Use of nutritionally complete compressed feeds for the Chinese major carps

Feeds for the Chinese major carps cultured in ponds should be nutritionally complete and balanced. Nutritionists have conducted extensive research on the nutrient requirements for the Chinese major carps.
A feed-based system, which combines traditional Chinese polyculture and U. S. monoculture technology, has been developed by the American Soybean Association. In this system, termed 80: 20 pond fish culture, approximately 80% of the harvest weight comes from only one high value, high consumer demand species that consumes the feed, and the other 20% comes from "service species" such as silver carp, which help clean the water, and mandarin fish (*Siniperca chuatsi*), which control wild fish and other competitors (H. R. Schmittou et al., 1998). Together with proper feeding practices, feeding the major species (the 80%-group fish) a nutritionally complete and high physical quality compressed feed results in better feed conversion, faster growth, and higher profits than those obtainable in traditional polyculture systems. This type of feed-based system has much less impact on the environment than traditional polyculture technology. Thus, it also fulfils a major requirement of sustainable aquaculture. Demand for high quality, extruded aquafeeds will increase, led by eco-

nomic and environmental concerns. The future production increases will be obtained mainly from better management and use of high quality feeds. Moreover, with the world`s fish meal supply which is stagnating due to over-fishing and limiting availability of natural fish stocks, efforts should be continuously made for the replacement and/or partly replacement of fish meal in the aquafeed by soybean meal: a cheaper source of protein with a more stable supply than fish meal.

4.4. Water treatment system for water supply and drainage canals of fish farms

For each fish farm in China, a canal system is constructed to serve as water supply and for drainage. In most cases, the system of water supply to the ponds, both for initial filling and for periodic topping off, is operated by strategically located pump stations. Some small portable pumps are used to empty ponds, when necessary. Introducing a water treatment system which includes biological and mechanical filters for water supply and drainage canals of the fish farms may ensure the quality of the water source for the initial filling, and regulate the effluent quality within specific criteria. The filters can capture suspended solids from water and simultaneously provide a large surface area for cultures of bacteria (*Nitrosomonas* sp. and *Nitrobacter* sp.) which remove dissolved nitrogenous wastes. For fish ponds that have been cultivated for many years, the bottom mud that has accumulated in the pond should be dug up and used to repair dikes or to enrich agricultural croplands.

4.5. Processing of the Chinese major carps and improving culture techniques

The population of China now totals over 1.2 billion. Traditionally, people like buying live fish, but the techniques for delivering live fish to the markets are currently available only for short distances from the farms. Thus, the market for Chinese major carps is relatively limited. Limited success has been achieved in the processing of the Chinese major carps. Promotion of the market for the processed products is to be strengthened in the future. If the producers are able to sell the processed products, such as fish fillets, iced fresh fish, and frozen products, in the supermarket or through other commercial channels, the fish market will be expanded rapidly. From the point of view of improving the traditional culture techniques, a fish culture strategy referred as stocking and harvesting in rotation should be implemented widely in future. The rotation method begins by stocking pond with several size classes of each fish species cultured. Throughout the growing season, fish reaching market size are captured once in every two to three months. At the same time, additional fingerlings are added to replace the fishes removed (Li, 1990). Thus, a consistent supply of the Chinese major carps can be maintained to meet the demand of customers all year round.

With the improving nutritional status of the Chinese people, however, consumer demands are changing. In response, market-driven aquaculture production technologies in China are undergoing a revolution, rapidly expanding and changing from an emphasis on the Chinese major carps to higher valued species, and higher technology levels for improved economic and resource efficiency and for environmental concerns. In the 21st century, profitable and sustainable aquaculture will be the major target for Chinese fish producers.

REFERENCES

Austin B. and Adams C., 1996. Fish Pathogens. In: Austin B., Altwegg M., Gosling P. J., Joseph S. (Eds) The Genus *Aeromonas*. John Wiley & Sons,Chichester, p197-243.

Chen Y., Qian D., Shen Z., Shen J., Cao Z., Yin W., and Zhang N., 1997. Immunization of bacterin for fish bacterial septicemia. I. Studies on Bacterin preparation. The Fourth Asian Fisheries Forum. Beijing, China: China Ocean Press.

FAO., 1997. Aquaculture Production Statistics. Fishery Information Data and Statistics Unit, FAO Fisheries Dept. FAO Circular No. 815, Revision 9, 189, Rome.

Food and Agriculture Organization of the United Nations (FAO). FAO Fisheries Statistics Series (1998).

Jeney Z., and Jeney G., 1995. Recent Achievements in Studies on Diseases of Common Carp (*Cyprinus carpio L.*). Aquaculture 129:397-420.

Jensen, J. and Crews J., 1997. Channel catfish production in ponds. Circular ANR-195. Alabama Cooperative Extension System, Auburn University, Auburn. [On-line]. Available: http://www.aces.edu/dept/extcomm/publications

Li S., 2001. About Fish Breeding Engineering Construction. Scientific Fish Farming 5, 6, 7: 3-4.

Li S., 1990. Recent Advances in Freshwater Aquaculture in China Aquaculture in Asia: 141-161.

Nielsen M. E., Hoi L., Schmidt A. S., Qian D., Shimada T., Shen J. Y., and Larsen J. L., 2001. Is *Aeromonas hydrophila* the Dominant Motile *Aeromonas* Species that Causes Disease Outbreaks in Aquaculture Production in the Zhejiang Province of China? Diseases of Aquatic Organisms 46: 23-29.

New M. B., 1997. Aquaculture and the Capture Fisheries-balancing the scales. World Aquaculture 28 (2): 11-30.

Qian D., Chen Y., Shen J., and Shen Z., 1997. Studies on the pathogen of fish bacterial septicemia in Zhejiang Province during 1989-1992: Biochemical characteristics, virulence and serogroups of *Aeromonas hydrophila*. pp. 242-245 In: The Fourth Asian Fisheries Forum. Beijing, China: China Ocean Press.

Pullin R. S. V., 1986. The Worldwide Status of Carp Culture. 21-34 In: Aquaculture of Cyprinids, INRA, Paris.

Sakazaki R. et al., 1984. O-serogrouping scheme for mesophilic *Aeromonas* strains. Jpn. J. Med. Sci. Biol. 37: 247-255.

Schmittou H. R., Zhang J., and Cremer M. C., 1998. Principles and practices of 80:20 pond fish farming. American Soybean Association. 3-13.

Shariff M., 1998. Impact of Diseases on Aquaculture in the Asia-Pacific Region as Exemplified Epizootic Ulcerative Syndrome (EUS). J. Appl Ichtyol 14: 139-144.

Shi W. et al., 1998. High Efficiency Feed Formulas for Fish, Shrimp and Crab. China Agricultural Press.

Tu F., 1998. Opening remarks. pp. 3-5 In: Proceedings of Aquatic Animal Nutrition and Feeding Technology Committee, China Society of Fisheries (Vol. 1). Beijing, China: China Ocean Press.

Yang J., Wei B., Sun H., Chen Y., and Wu W., 2000. The basic experience of fisheries development in China. Chinese Fisheries Economy Research 4: 6-8.

Ye J., 1984. Production-increasing potentiality in an ecosystem of fish pond for intensive culture. Journal of Zhejiang College of Fisheries 3(1): 105-107.

Mangrove Friendly Shrimp Culture Technique: Research Plan for Thailand

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ABSTRACT: A program of Mangrove friendly shrimp culture technique sponsored by the SEAFDEC/AQD for the year 2001 has been carried out in four regional areas located on the coast of Thailand. The four regional organizations belong to the Department of Fisheries which has the responsibility for conducting the experiments concerning the application of the several techniques corresponding to the mitigation of the impact of the effluent from shrimp farms and its results on the water quality improvement. The physical and biological treatment process had been applied to the culturing pond, drainage canal and the quality of seawater and sediment were monitored experimentally. Additionally, the feasibility of mangrove forest used itself as a wetland unit to treat the shrimp farm effluent was also tested.

1. INTRODUCTION

Shrimp aquaculture has been criticized as one of the activities affecting the surrounding environment in many aspects such as mangrove forests, coastal eutrophication and even social conflicts. At the moment, the development of environmental friendly shrimp aquaculture concerns not only the shrimp producers but also shrimp-consuming countries. In order to develop a sustainable shrimp aquaculture, environmental friendly shrimp culture technology will be one of the crucial constituents for the future shrimp culture in Thailand.

2. PROGRAMME

2.1. Programme research areas

A research programme was set up comprising four research areas, for which the regional organizations of the Department of Fisheries were responsible, as follows.

1) Integrated physical and biological technologies for water recycling in shrimp farming under the responsibility of the Marine Shrimp Research and Development Center, Songkhla.
2) Mitigation measures of effluent from shrimp farming on mangrove and coastal resources under the responsibility of the Andaman Sea Marine Shrimp Research and Development Center, Phuket.
3) Evaluation of seawater irrigation for intensive marine shrimp farming at Kung Krabaen Bay, Chantaburi, Eastern Thailand under the responsibility of the Kung Krabaen Bay Royal Development Study Center, Chantaburi.
4) Study on Mangrove Plantation for Enhancing Natural Food Web in Water Recycle Shrimp Farm: the Initial Period under the responsibility of the Chachoengsao Coastal Aquaculture Development Center, Chachoengsao, eastern Thailand

2.2. Progress of Research Programme

2.2.1. Integrated physical and biological technologies for the water recycle in shrimp farming

The integrated physical and biological technology was used as a treatment system to improve the quality of the effluent discharged from shrimp culture. Tilapia, oyster (*Crassostrea belcheri*) and seaweed (*Gracillaria* spp.) were used as the biological units where a sand filtration box volume of 1.2 ton was used as a physical filtration of suspended particles prior to recycling to the shrimp pond. The results showed that stability of water quality parameters in grow-out pond was found after the effluent was recycled through the treatment pond using integrated physical and biological technology.

2.2.2. Mitigation measures of effluent from shrimp farming on mangrove and coastal resources

The shrimp larvae of *Penaeus monodon* were held in the 16 ha reservoir for the mitigation measures experiment. Unfortunately, the shrimps died after 55 days because of a SEMBV outbreak. However, the preparation of the material used in the mitigation program such as seaweed culture was conducted in the experimental site. The quality of the natural seawater in front of the experimental site was being investigated for a baseline data of this study.

2.2.3. Evaluation of seawater irrigation for Intensive Marine Shrimp Farming at Kung Krabaen Bay, Chantaburi, Eastern Thailand

The results indicate that under the seawater irrigation system for intensive shrimp culture, the effluent from shrimp culture did not make any significant impact on the water quality in the bay and the drainage canals. However, the results showed a significant sedimentation in the drainage canals indicating that there was an accumulation of organic matter and fermentation in a sediment layer of the drainage canals. The results from the study on using Mangrove forest as a wetland treatment unit for shrimp farm effluent are still being analysed.

2.2.4. Study on mangrove plantation for enhancing natural food web in water recycle shrimp farm: the initial period

The results showed that 700 kg of shrimp were harvested from the 2400 m2 of mangrove integrated recycle shrimp farm after being cultured for 140 days. The growth of mangrove trees (*Rhyzophora* sp) measured from stem was 0.125 cm/month.

3. FUTURE PLANS

The actual plans for the year 2002 are expected to be carried out at three regional sites: Chantaburi, Phuket and Songkhla.

- Integrated physical and biological technologies for the water recycle in shrimp farming, Songkhla Thailand.
- Mitigation measures of effluent from shrimp farming on mangrove and coastal resources, Phuket Thailand.
- Evaluation of seawater irrigation for intensive marine shrimp farming at Kung Krabaen Bay, Chantaburi Eastern Thailand.

The actual plans for the year 2002 and their budget are detailed below.

Project subtitle 1: Integrated physical and biological technology for the water recycle in shrimp farming, Songkhla Thailand.

Title	Activities	Budget (Baht)
1. Designing of the large scale integrated physical and biological technology for the water recycle farm	a. Quantitative estimation of the nutrients loading from shrimp farm to the water treatment	40,000
	b. Study on efficiency of bivalves, seaweed and fish in the organic and nutrient removal from the shrimp farm effluent under the field condition	60,000
	c. Study on the efficiency of large scale sand filtration on quality improvement of the shrimp farm effluent under the field condition	25,000
	d. Proposal of effluent recycle facility using the integrated physical and biological technology for the commercial shrimp farm	
2. Demonstration of the large scale integrated physical and biological technology for the water recycle farm	e. Operate the designated water recycle facility in a 3.5 ha shrimp farm located at Songkhla for about 4 - 6 months	60,000
	f. Observe the water quality in the water recycle pond	
	g. Evaluate the performance of water recycle facility	

Project subtitle 2: Mitigation measures of effluent from shrimp farming on mangrove and coastal resources, Phuket, Thailand

Title	Activities	Budget
Mitigation measures of effluent from shrimp farming on mangrove and coastal resources	a. Measure the mitigated volume of some parameters of water quality of effluent from shrimp culture by biological treatment (with seaweeds and bivalves). b. Monitoring some water quality conditions in the shrimp farm system and the discharge directions.	200,000

Project subtitle 3: Evaluation of seawater irrigation for intensive marine shrimp farming at Kung Krabaen Bay

Title	Activities	Budget
Evaluation of seawater irrigation for intensive marine shrimp farming at Kung Krabaen Bay	a. Impact assessment of the intensive shrimp farming under seawater irrigation facility on sediment and water quality in Kung Krabaen Bay	60,000
	b. Study on the variation of sediment and water quality in the intensive marine shrimp farms discharge canals	40,000
	c. Study on the possibility of using mangrove forest as a wetland treatment unit for shrimp farms effluent	70,000
	d. Study on the variation of mangrove forest at Kung Krabaen Bay	40,000

Marine ingredients: challenges to their use in aquafeeds

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ABSTRACT: This presentation provides a brief review of the current and projected use of marine ingredients in aquafeeds, based on an FAO study in which the author has been involved. It also introduces the challenges which the use of marine resources create for the intensive farming of carnivorous aquatic animals, in order to stimulate discussion within the context of responsible aquaculture.

1. INTRODUCTION

My topic concerns environmentally sustainable grow-out systems in the sense that it covers the use of a resource - the marine capture fisheries for reduction to fish meal and fish oil. This topic has become one of the environmental challenges to the aquaculture industry in terms of its public image.

Well over a decade ago, Wijkstrom and New (1989) first looked at this topic and coined the term 'the fish meal trap' - the point at which certain types of aquaculture might be constrained by a lack of fish meal (and/or fish oil).

Since then, reports of fish meal and fish oil usage by aquaculture, and forecasts of future use, have become a feature of reports by the fish meal/oil manufacturing industry association - IFOMA/IFFI (e.g. Pike 1998; Barlow 2000) and others (e.g. Chamberlain 1993; Tacon 1998).

Figure 1. Global production of fish meal 1976-1999 (mt)

Last year, FAO decided to look at this matter again. My brief presentation is partly derived from information contained in a recent report based on that study (New and Wijkstrom 2002).

2. SUPPLIES

As predicted (Wijkstrom and New, 1989), global supplies of fish meal (Figure 1) from conventional sources have peaked and show no sign of increasing. Naturally there are annual variations in supply but there is no trend of expansion or decline. The same observation applies to supplies of fish oil (Figure 2).

Unlike fish meal, fish oil has important markets beyond animal feedstuff, including pharmaceutical (some is even burnt in power production). Availability remains generally static.

Figure 2. Global production of fish oil 1976-1999 (mt)

3. CURRENT AND POTENTIAL USAGE

Estimates of fish meal (Figure 3) and fish oil (Figure 4) use in aquafeeds in the year 1999 and projections of usage in 2015 and 2030 have been determined (New and Wijkstrom 2002). The estimates for 1999 were based on global aquaculture production data (FAO 2001) and varying figures for the percentage of each species or species group produced through commercial feeds, typical ingredient inclusion rates, and characteristic FCRs. Projections for 2015 and 2030 were based on an examination of production trends (APRs) and other factors.

Aquafeeds are currently using a significant proportion of global fish meal supplies (Figure 3); this proportion will certainly increase further. Our estimates showed that China was already using 10% of the global fish meal supply by 1999. Last week, at the annual meeting of the World Aquaculture Society (WAS) in Beijing, we heard estimates that China used about 2 million mt of fish meal in aquafeeds in 2000. Personally, I think those estimates (some three times as great as ours) are probably rather too high. However, even according to our more modest estimates and assuming current trends continue, China will certainly be using at least 30% of the total fish meal supply by 2015, a proportion similar to the consumption by the whole of the global aquaculture industry now.

Aquafeeds use an even greater proportion of fish oil supplies (Figure 4) than fish meal. The expected expansion of aquaculture production in China alone, particularly of carnivorous species, has the potential to utilise all of the global fish oil supply within the next three decades.

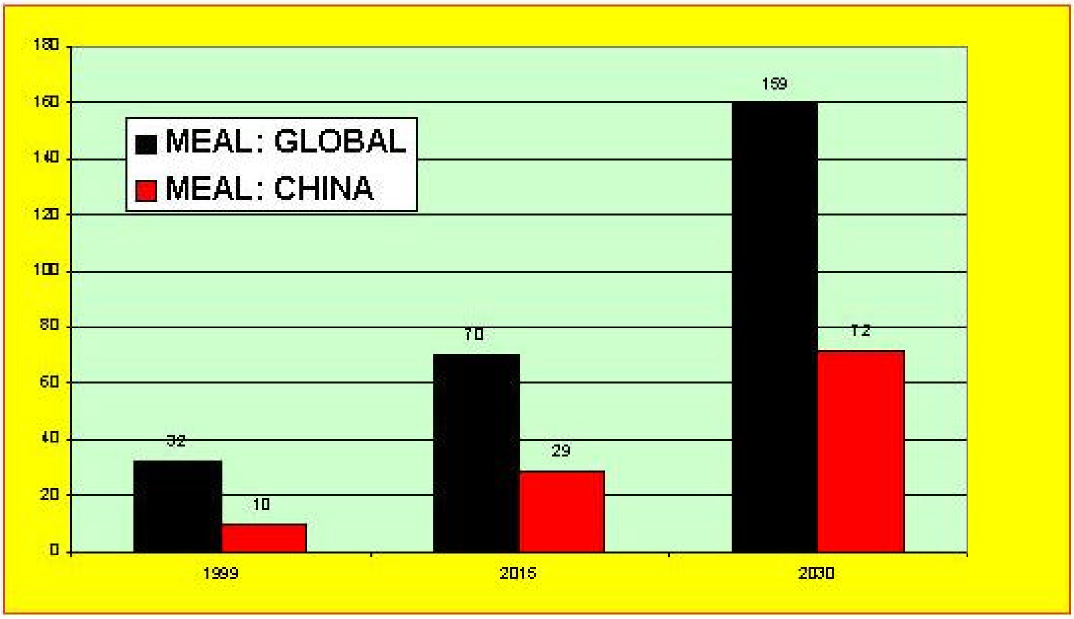

Figure 3. Projections of fish meal use in aquafeeds (% of global supply)

Assuming that supplies continue to be steady, aquaculture thus has the theoretical potential to utilise the total annual fish meal supply by 2020 (Figure 5) and all of the annual fish oil supply (Figure 6) within about five years from now. Chinese aquaculture alone has potential requirements for nearly half the global supply of fish oil by 2015.

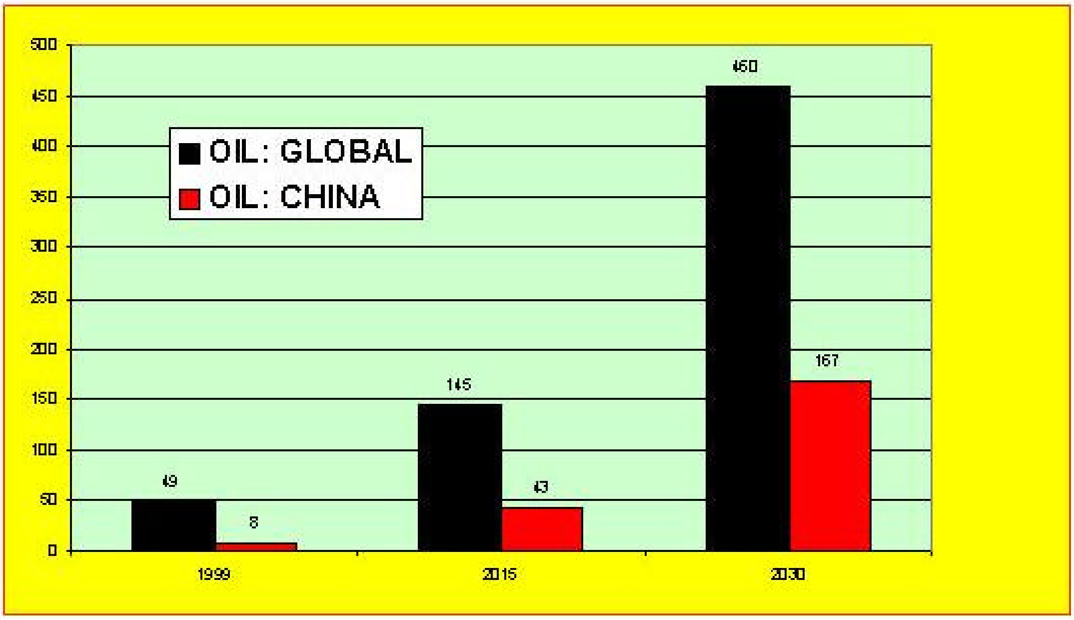

Figure 4. Projections of fish oil use in aquafeeds (% of global supply)

4. PROBLEMS

The estimates in Figures 3-6 show the potential demand for fish meal and fish oil from the aquaculture industry. In practice, however, aquaculture can never consume all of these resources. If new sources of supply are not found, competition for the currently available levels of supply, the resultant changes in their cost to feed manufacturers, and the need to reduce production costs in fish and shrimp farms will soon become the determining factors. Acceptable and economic alternative means of supplying the nutritional requirements of aquacultured species must be found, or the further expansion of intensive aquaculture production (particularly of carnivorous species) will be constrained.

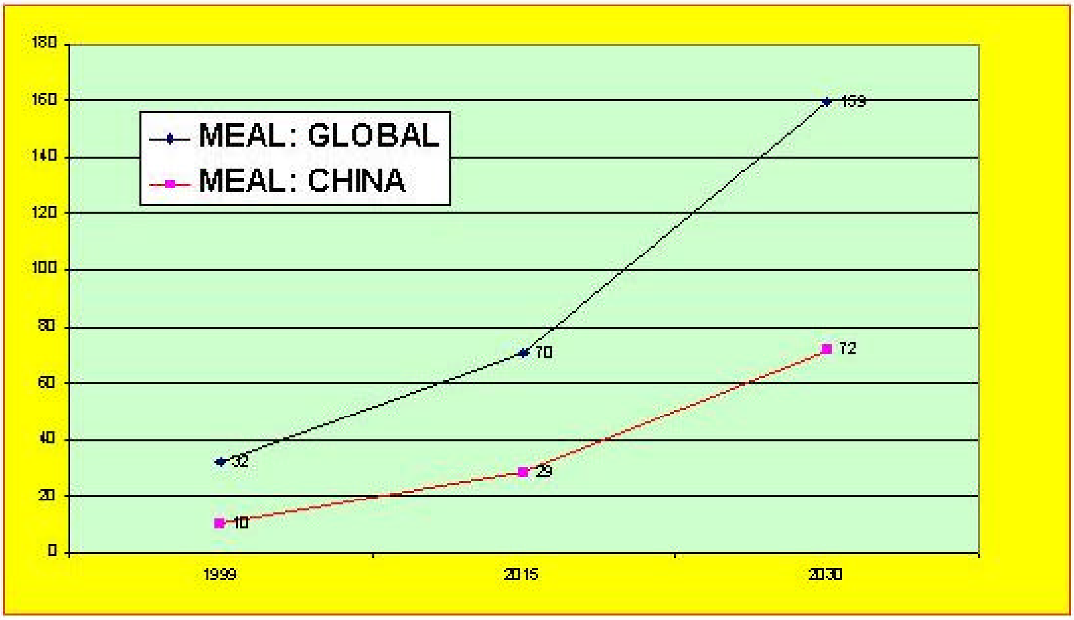

Figure 5. Date when aquafeeds could utilise 100% of fish meal supplies

There have been considerable research efforts to find ingredients which can totally or partially replace fish meal and fish oil as ingredients in aquafeeds. However, many problems remain, both in nutritional terms and because of public concerns about the safety of some alternative ingredients. The most urgent problem to be solved relates to fish oil replacement. In view of this the EC has sponsored a large programme to network research on alternative lipid sources. However, I think it may be impossible to replace all the fish oil in diets for carnivorous fish and shrimp. It is essential to consider the effect of replacement on the quality of aquaculture products, as well as ensuring acceptable growth and survival from an aquaculture producer's point of view. Those of you who heard Professor Michael Crawford's keynote paper [this paper is not yet published but a related paper has already appeared (Crawford et al. 1999)] at the opening of the WAS annual meeting here last week will know how important it is to keep the DHA levels in the fish that we consume high. You will hear more about these topics, and many other aspects of the search for marine resource replacers in a later session of this workshop.

The feedstuff industry currently faces many headaches in the aftermath of the scares related to BSE and dioxin residues, to name just two. The industry is subject to increasingly stronger regulation. The availability and acceptability of ingredients for aquafeeds forms just one component of a wider panorama.

The expansion of currently popular forms of intensive aquaculture (e.g. salmon, marine fish, and shrimp culture) will certainly be constrained because of shortages in marine ingredient supplies unless one of two things occur. Firstly, the value of marine ingredients may become high enough to make the development of potentially alternative supplies by the capture fisheries and fish meal/oil industries feasible. Secondly, nutritionists and aquafeed manufacturers may find practical and economic means of utilising alternative ingredients in feeds which not only promote satisfactory growth and survival of healthy fish but result in safe and nutritionally excellent products for human consumption. However, even if practical alternatives are found, this will only delay the impact of the 'fish meal trap' on the expansion of the intensive aquaculture of carnivorous species unless alternative supplies of marine resources are developed.

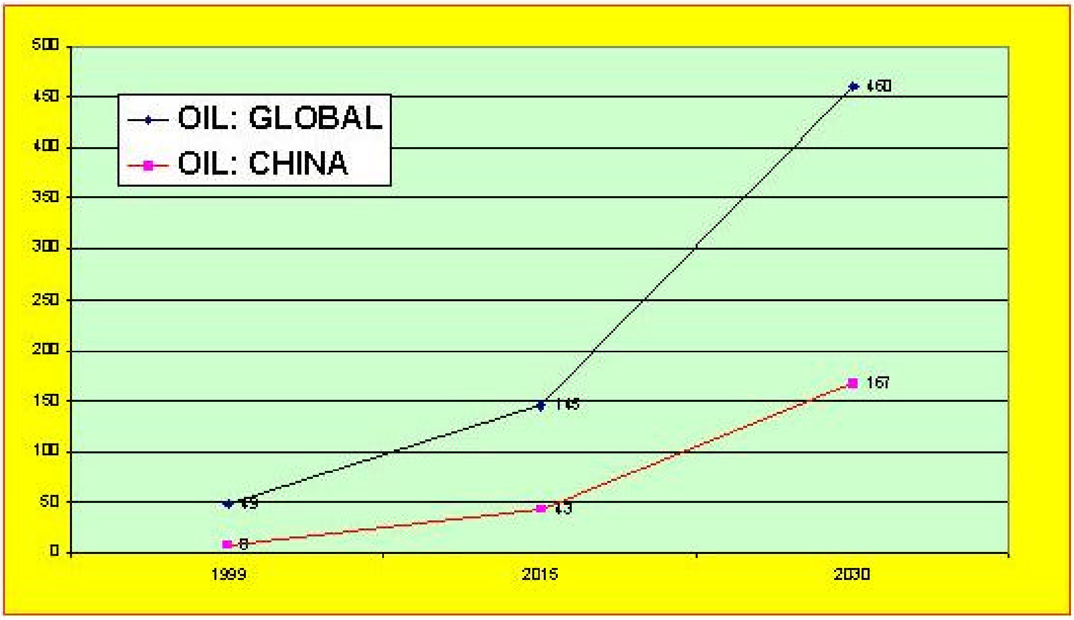

Figure 6. Date when aquafeeds could utilise 100% of fish oil supplies

5. DEVELOPMENT OF ALTERNATIVE SUPPLIES AND ESSENTIAL R & D

Wild fish stocks currently exploited by dedicated fish meal fisheries and other sources of raw material (e.g. offal, fish processing wastes) are not likely to permit any significant and sustainable increases in the supplies of fish meal and fish oil, even as the global price of these commodities increases in real terms. However, our study (Wijkstrom and New 2002) indicated that by the time that the prices of marine ingredients doubled in real terms, the development of dedicated fisheries for mesopelagics (and possibly also krill) for use in animal feedstuff may become economically viable.

Meanwhile, further research on replacers is essential. For fish oil replacers, the need is especially urgent. Such research must not only measure the effect of replacers on standard farming parameters (e.g. growth and survival rates; FCR) but also their impact on other factors (e.g. immune function and disease resistance). In addition, it is imperative that the impact of potential marine resource replacers on the nutritional, sensory, processing, and safety characteristics of aquacultured products be carefully considered. The economic production of fast-growing healthy fish or shrimp may prove feasible. However, if they prove unacceptable in the market place, due to compositional inadequacies, or the presence of toxic residues, or consumer resistance (for example) there will be fewer jobs for producers and researchers alike!

6. FINAL COMMENTS

Finally, I would like to make a series of comments and thoughts for the future:

- The whole of my presentation in this workshop has assumed that the farming of carnivorous species will continue to expand. I hope that it will, because these industries are great generators of employment, wealth and export earnings. However, we also need to promote types of aquaculture that create less demand for marine resources (e.g. the culture of omnivores and herbivores) and/or the use of less intensive production systems.
- By 1999, farmed salmon and marine shrimp are estimated to have consumed some 40% of the fish meal and 46% of the total fish oil used in aquafeeds. Yet these sectors contributed only 6% of the total volume and 20% of the farm-gate value of global food fish (includes molluscs) production at that time. Is this disparity justifiable?

- Aquaculture is a major consumer of wild marine resources and has suffered severe media criticism following the publication of a paper in Nature (Naylor et al., 2000); public perception of our industry is now a major concern. However, in my opinion, there is no evidence that the growth of our aquaculture industry has caused any impact whatsoever on the depletion of the capture fisheries dedicated for fish meal and fish oil production. We are just using a greater proportion of static supplies, with less going to feeds for other livestock. In the unlikely event that we stopped using all fish meal and oil in aquafeeds tomorrow, the available supply would be taken up immediately by the feedstuff industry for use in poultry, pig and (to a lesser extent) ruminant feeds.
- In my presentation, I have been talking only about the use of processed marine resources in aquafeeds. However, unprocessed resources, such as 'trash fish' (a contentious term, since what is regarded as 'trash' in some countries is valuable human food in others), are also utilised. In the WAS meeting last week we heard an estimate that 3-4 million mt of 'trash fish' is currently being used for marine aquaculture in China alone. In my view, this practice certainly causes environmental problems and is totally unsustainable.
- There are a variety of networks in Europe that focus on developing fish meal and fish oil replacers in aquafeeds. These networks could be extended to Asia. A network that helps to coordinate research and sustainable implementation of the utilisation of marine resources, as well as work on fish meal and fish oil substitution in aquafeeds within ASEM countries, in order to ensure future supplies of good quality and safe aquaculture products, would (in my view) have merit.

REFERENCES

Barlow, S., 2000. Fishmeal and fish oil: sustainable feed ingredients for aquafeeds. Global Aquaculture Advocate, 3(2): 85-88.

Chamberlain, G.W., 1993. Aquaculture trends and feed projections. World Aquaculture, 24(1):19-29.

Crawford, M.A., Bloom, M., Broadhurst, C.L., Schmidt, W.F., Cunnane, S.C., Galli, C., Gehbremeskel, K., Linseisen, F., Lloyd-Smith, J. and Parkington, J., 1999. Evidence for the unique function of DHA during the evolution of the modern hominid brain. Lipids, 34:S39-S47.

FAO, 2001. Fishery statistics Vol. 88/2: aquaculture production. FAO Fisheries Series No. 58/FAO Statistics Series No. 160. FAO, Rome, Italy. 178 pp.

Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H. and Troell, M., 2000. Effects of aquaculture on world fish supplies. Nature, 405:1017-1024.

New, M.B. and Wijkstrom, U.N., 2002. Use of fishmeal and fish oil in aquafeeds: further thoughts on the fishmeal trap. FAO Fisheries Circular (975): FAO, Rome Italy. (in press)

Pike, I., 1998. Future supplies of fish meal and fish oil: quality requirements for aquaculture with particular reference to shrimp. pp. 39-49 In: International Aquafeed Directory & Buyers' Guide 1998. Turret RAI plc., Uxbridge, United Kingdom.

Tacon, A.G.J., 1998. Global trends in aquaculture and aquafeed production 1984-1995. pp. 5-37 In: International Aquafeed Directory & Buyers' Guide 1998. Turret RAI plc., Uxbridge, United Kingdom.

Wijkstrom, U.N. and New, M.B., 1989. Fish for feed: a help or a hindrance to aquaculture in 2000? INFOFISH International, 6/89:48-52.

Development of European aquaculture and environmental concern

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ABSTRACT: Europe, with production representing only 5% in volume and 7,5% in value, contributes only a small part to world aquaculture production which is largely dominated by Asian countries. However European aquaculture has experienced some important mutations over the last 20 years, some of them contributing widely to applications in many other areas of the world. The lessons learned during this evolution of new production opportunities in a changing economy and society allow us to analyse the major determinants of aquaculture development, the conditions for success and the reasons for failure. Among the growing constraints for sustainable aquaculture, the concern about environment preservation has become a major challenge for the aquaculture industry.

The activity basically relies on "traditional" activities such as shellfish farming in coastal waters (*Crassostrea gigas* and *Mytilus* sp.) and trout culture in fresh water (*Salmo gairdneri*), which underwent a rapid expansion during the 70's and 80's. But it is also characterized by the rapid development of marine fish culture in coastal waters, boosted by the northern Europe Atlantic salmon (*Salmo salar*) production, appearing in the early seventies and developing into an industrial activity during the 80's. Moreover European research, mainly Great Britain and France, widely contributed to the domestication of marine fish species such as the European seabass (*Dicentrarchus labrax*), gilt head seabream (*Sparus aurata*) and turbot (*Psetta maxima*). These three major innovations rapidly spread outside Europe and facilitated aquaculture diversification in many parts of the world.

The different technologies used by the industry for all these productions are briefly described with reference to the possible environmental impact of the production activities: pollution load and nutriment discharge, use of chemical and antibiotics, introduction and transfer of live animals, pathology spreading, genetic impact of farmed populations, with regard to potential management or technological innovations (carrying capacity of coastal waters, rearing technologies and feeding, reduction of the pollution load, integrated aquaculture, prophylactics, GMOs).

The major challenges facing the rapidly growing European aquaculture will be to provide solutions for increasing usage conflicts for markets (compared to other human foods), for space (land use, conflicts with agriculture, industry, leisure), for water use (access, use rights, pollution), for innovative technologies or biotechnologies conferring strategic advantages and better profitability. Some of these are particularly critical in Europe due to the limited space available, especially in highly populated coastal areas where competition between activities becomes extremely tense.

Paper not available

Zero Discharge, a possible future for Recirculating Aquaculture Systems?

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ABSTRACT: Intensification of fish farming inevitably leads to higher waste production and an increased ecological footprint in terms of water use and fossil energy demands. A solution to these ecological concerns is the rearing of fish in closed recirculating aquaculture systems (RAS). RAS are especially suited to cut water requirements. Average water needs per kg production may decrease from several m3 in common flow-through systems to less than 100 litres in RAS. Similarly, COD discharge may be reduced to 10%, comparing RAS with a common stagnant fish pond.

In Europe, environmental regulations have encouraged the development of RAS, especially where taxes have to be paid on the discharged amounts of COD, Nitrogen and/or Phosphate. Commercial farming of fish in RAS has become standing practice in the Netherlands with a commercial expertise of 15 years, farming mainly eel, African Clariid catfish, tilapia, turbot and recently, also sole. The applied water treatment configuration usually consists of a suspended solids removal unit, UV treatment, a trickling filter and oxygenation. The farm effluent is often collected in a septic tank to concentrate waste and to further reduce waste discharge costs. The best environmental performance nowadays is realised by systems which also incorporate a denitrification unit, a flocculation unit, a belt filter and a sludge storage facility. These systems meet the strictest environmental criteria for effluent discharge. Yet, feed nutrients which are not retained in the fish biomass are still discharged, either as less harmful volatile products (N_2, CO_2), or concentrated in a sludge which can be used for composting.

A more challenging way to improve the ecological sustainability of recirculation systems is the incorporation of water treatment processes, which convert waste nutrients into harvestable products. Innovations for such sustainable recirculation systems are: 1) fixed bacterial biofilms are replaced by harvestable biofilms in suspension (to be used as single cell protein); 2) the incorporation of phototrophic organisms such as micro-algae or macro-phyta, which can either be harvested directly or by herbivorous organisms; 3) the incorporation of detrivorous organisms to convert remnants of solid waste.

Paper not available

Adaptation of modern technologies to the local conditions for sustainable aquaculture

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ABSTRACT: Most of us (scientists, researchers, lecturers... and in general "white collar" people) are well aware of the meaning of sustainable and friendly aquaculture. However, the people who are really involved are those who directly produce the aqua-products: farmers, investors, capitalists. Quite naturally they all want to earn as much profit as possible and either do not understand or do not want to follow the sustainable aquaculture model, because they favour the "intensive" culture system. The government itself also wants a high export value every year.

Therefore, our most appropriate action is to find out the resolutions or technologies towards which the activities of the producers can be oriented or adapted.

What happens and is repeated every year in the shrimp industry is the higher risk of shrimp disease for the those aquaculturists who use the extensive culture system for their production. In Vietnam, it is said that the shrimps like rich people. Thus the roles of capital and proper technologies are very important in aquaculture.

There are certain topics of very great interest for all aquaculturists (rich and poor) such as: supplying disease-free broodstock and seeds, reducing transportation duration of seeds by setting up hatcheries everywhere possible (in Vietnam now there is a trend of re-distribution of shrimp hatcheries with more and more hatcheries built in the Mekong Delta), producing more efficient artificial pellets, irrigation planning for small groups of stakeholders, adaptation of modern technologies to local conditions (many examples such as: live food production of rotifers in outdoor system and intensive system; re-circulating systems and improved technologies for larviculture of multi-species using local materials as improvement for the traditional open system; rapid transfer of aquaculture technologies or culture models) to producing stakeholders or organizations, for instance, Artemia production, shrimp growout and shrimp/prawn larviculture).

1. BACKGROUND

On the basis of the evaluation report of the Ministry of Fisheries of Vietnam, two years after the fulfilment of the 1999-2010 plan of Aquaculture Development, a great leap forward in both the quality and quantity of aquaculture products has been achieved. By the end of 2001, the total aquaculture area and production of Vietnam had reached 751.000 ha and 725.827 metric tons, an increase of 34% and 24,9% respectively, compared to the previous year.

2. MANGROVE FORESTS

2.1. Decline in mangrove forests

In the 1940s the coastal zone of Vietnam had about 400,000 ha of mangroves. However, population growth, economic development pressure and herbicides led to extensive loss. By 1983 only 252,000 ha were still in existence. From 1983 to 1993, there was a further rapid decline caused by the conversion of mangrove forests to shrimp ponds. A determined effort by the government to restore mangroves resulted in the rehabilitation of 64,000 ha mangrove from 1993 to 2000. In 2000 about 42% of the original mangrove area remained in existence. The loss of mangrove forests has been related to various causes, but is mainly due to deforestation for shrimp culture because 80% of aquaculture area is located in coastal provinces. It is estimated that 12% of the mangrove loss in Asia is a consequence of this.

2.2. Legislation relating to mangrove use

Mangrove plantation is always encouraged. A Directive on the technical procedure for the establishment and maintenance of mangrove forests was issued on 24th Oct 84. There was a Prime Minister-enacted Instruction for the establishment of forest plantations for the protection of the environment, including coastal and estuarine habitats on 24th Feb 90). There are regulations for the Full Protection Zone (FPZ) and Buffer Zone (BZ).

2.3. Full Protected Zone

In the FPZ, permitted activities are listed as: reforestation, forest patrolling, forest management (thinning and pruning of rehabilitated/planted forest allowed only when necessary as a silvicultural measure to improve the coastal protection function of the plantation), eco-tourism development, scientific research, collecting of small marine organisms (snails, small crabs, mud skippers and shellfish, but no fish and shrimp/shrimp larvae), collecting dead wood, agricultural activities in areas not suitable for mangrove planting. Non-permitted activities are tree felling, collection and destruction of life vegetation, soil mining, settlements, aquaculture, commercial fishing with nets and traps, illegal hunting and trapping of wild animals and other forms of exhaustive resource uses.

2.4. Buffer Zone

In the BZ, permitted activities are as follows: forest management, protection and forestation, patrolling and control of illegal fellings, silvicultural treatment, thinning and tending of forests, sustained yield management on a 20-30 year rotation (depending on species), harvesting of forest by-products and dead wood, breeding of bees and other animals, allocation of forest/land lots to households for forest-cum-shrimp production by means of standard contracts. Overall area allocated for aquaculture development is not to exceed 40%. The remainder of the land (60%) is used for mangrove forest development in support of aquaculture (or agriculture where mangrove growing is not feasible, e.g. on higher ground), recreation, scientific research, eco-tourism development, settlements in existing community centres. Non-permitted activities are: illegal fellings, forest clearing and destruction, illegal settlements and encroachment onto forest lands, illegal hunting and trapping of wild animals and other activities that affect the concept of land use.

3. SUSTAINABLE USE OF RESOURCES

3.1. Profitability issues

Most of us (scientists, researchers, lecturers... and in general "white collar" people) are well aware of the meaning of sustainable and friendly aquaculture. However, the people who are really involved are those who directly produce the aqua-products: farmers, investors and capitalists. Quite naturally they all want to earn as much profit as possible and either do not understand or do not follow the sustainable aquaculture model, because they favour the "intensive" culture system. The government itself also wants a high export value every year.

For these reasons, the mangrove area lost to shrimp culture is unlikely to be completely recovered. Therefore, our most appropriate action is to find out the resolutions or technologies towards which the activities of the producers can be oriented or adapted.

3.2. Risk of shrimp disease in extensive culture

What happens and is repeated every year in the shrimp industry is the higher risk of shrimp disease for those who use the extensive culture system for their production. In Vietnam, it is said that that shrimps like rich people. Thus the role of capital and proper technologies are very important in aquaculture.

3.3. Preventive measures

There are certain topics of very great interests for all shrimp culturists (rich and poor) such as:

- Disease-free broodstock and seeds have to be in sufficient supply. This issue is the key point because in reality, in the period of heavy epidemic (white spot disease), the intensive shrimp culture ponds are subject to a lower mortality rate than extensive ponds that stock infected shrimp post larvae. This can be done in a cheaper way by checking the broodstock with PCR facilities prior to spawning.
- Reducing transportation duration of seeds by setting up in every possible location hatcheries equipped with the recirculation system. In Vietnam now there is a trend of re-distribution of shrimp hatcheries (about 4000 backyard hatcheries in the whole country) with more and more hatcheries built in the Mekong Delta. The above-mentioned type of hatchery appears suitable because in this region the salinity decline of seawater in the rainy season does not allow normal operation for those using the open system.
- High-quality artificial pellets and medication products are increasingly supplied by many companies. Research institutions should support their extension staff in terms of scientific theory because they are mostly well selected by the companies and active in advertisement and extension.
- Irrigation planning for a small group of householders (this can take place more easily and faster than regional master planning). Farmers in the same area often chat or debate during their morning coffee about the jobs involved, for example, about their experiences in shrimp growout. The experiences of extension staff can be more convincing if he/she also joins them at this time.

4. POSSIBLE WAYS FORWARD

4.1. New technologies

New production models or technologies should be applied and transferred as quickly as possible to the involved majority. Many backyard hatcheries in the Mekong Delta are supplied with pure micro-algal stock that helps to improve the performance and survival rate of the shrimp PL considerably in comparison to natural-harvested or dry algae. Modern equipment can be localized and produced in series at a low cost for many local users (e.g., protein skimmers).

4.2. Cooperation models

The cooperation between an institution and local individuals or organization can be much more efficient via a direct join-venture (e.g., a shrimp hatchery). This type of cooperation could be developed to an applied research and pilot production station and could become attractive extension centres for the farmers in the region. In addition, the cooperation could also bring in extra finance for the institutions to receive more staff to continue contractual research projects.

THEMATIC AREA II

Interactions between coastal resource users: aquaculture, shipping and coastal urban development and their influence on changes in biodiversity

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1. INTRODUCTION

1.1. Background

Historically, the coastal zone has been a major habitat for societal development in most European countries, even though some have relatively short coastlines (e.g. Germany). Since the Vikings the use of the sea for transport has become more and more important. Harbours not airports were the nucleii for industrial development in the past and are of ever-growing importance today. With the globalisation of markets, more than 80% of the world's cargo is presently shipped across the oceans and along the coasts. The coastal zones continue to be areas in which modern society finds its highest potential for development. It is anticipated that by about 2025 more than 60% of the worlds population will live within 30 km of the shoreline.

There exists growing awareness in the public at large that pressures on coastal zones and aquatic resources are rapidly increasing, giving rise to numerous unforeseen conflicts among both traditional resource users and the "newcomers" who just explore and exploit the rich opportunities in goods and services which coastal ecosystems offer.

There exists also a growing concern among stakeholders that their opportunities for the use of its resources will be diminished by others who enter the scene. Environmental concerns are often expressed not necessarily for environmental protection but more for the protection of stakeholder interests in resource use without due consideration of other users.

1.2. Aquaculture users

Aquaculture in coastal waters is one such example which receives much public attention. It is considered by NGOs as being one of the potentially huge waste generators in the coastal zone, interfering with the development of numerous activities such as fisheries, tourism, and rural settlements. This image of aquaculture persists despite the fact that serious attempts to minimize and control environmental impacts have been made and have achieved impressive results (Rosenthal et al., 1987, Black et al., 1997, ICES, 1998, 1999). They range from predictive modelling of waste dispersal and benthic impacts (allowable to set limits), to drastic reductions in the use of antimicrobials and substantially reduced output of nutrients per unit biomass of fish produced. With the growth of the industry, there is certainly a need for further improvements, in particular when dealing with escaped fish that might interact with natural populations. Here, promising concepts to reduce risks of species interaction have been proposed for salmonids, using their homing instinct to recover most of those accidentally released specimens from fish farms. This concept needs to be studied further and its possibilities explored under a variety of habitat and environmental conditions.

Aquaculture is presently the fastest growing sector in aquatic food production and will certainly continue to grow in the new millennium. With increasing numbers of units, aquaculture will encounter an increasing number of interactions with other coastal users and needs not only to adjust its performance to become more environmentally friendly but also must formulate and present its own need to be protected from the effects of the inadequate environmental management engaged in by other stakeholders who had been allowed - in the past - to pollute as they were at the time the only water resource user in many areas.

In parallel with the growth of the industry, conflicts have also grown and are likely to further increase. This is not only because of increased pollution risks but also because of (a) the increasing competition for goods and services in the coastal zone, and (b) the increasing closeness of aquaculture units to other resource users which may have not at all been restricted or regulated despite of their potential direct negative effect on aquaculture.

1.3. Shipping

One of the aquatic resource user recently being recognized as a potential threat to the aquaculture industry is the shipping industry which can transmit parasites, diseases and nuisance species in large quantities from a variety of taxa through the deliberate release of ballast water. Several recent studies indicate that a globalisation of trade and markets is met by increasing ship traffic (Carlton and Geller, 1993, Gollasch and Leppakoski, 1999; Rosenthal et al., 1999). The following examples provide some insight into the dimension of the problem by asking the question "Why do invasions continue to occur when the transport vector has long been in place?" First of all, the scenarios in which the transfer of non-native species may be successful have drastically changed in reent years. Some of these changes can be identified as follows:

i). Increasing number of aquaculture activities along the coasts

ii). Increasing density of aquaculture units near shipping routes (infrastructure)

iii). Increasing sea traffic (globalisation of markets; more ships and routes)

iv). Increasing speed of ships, resulting in shortened transfer times

v). Increasing size of ships (larger ballast volumes, more oxygen available)

vi). Changing strategies of ballast water management (cleaner water in tanks)

vii). Changing human population density in the coastal zone (e.g. nutrient output)

viii). Increasing poverty in small coastal communities (lack of infrastructure)

ix). Lack of satisfactory hygienic conditions in many harbours around the world

x). Changing donor and receiving environments (habitat modifications and climate change)

Modern ships are faster, larger, and carry more ballast water than ever before. Survival and the number of specimens transferred have greatly increased. An estimated 10-12 billion tonnes of ballast water are traded annually across the oceans while about 4000 species are in intercontinental transit daily. These species include (a) micro-algae which can be involved in toxic algal blooms, (b) disease agents and parasites that can destroy entire aquaculture industries locally or regionally while also forcing the industry to use more chemicals for treating and combatting the new invasions that are harmful to their operation (see case histories reproted by Gollasch et al., 1999).

2. BIODIVERSITY CHANGES THROUGH AQUACULTURE AND UNINTENTIONAL INTRODUCTIONS

2.1. An example of studies on benthic diversity changes under cage farms

An example on how biodiversity studies can help to identify benthic community indicators to follow the level of bottom deterioration as well as recovery after the stressor has been removed has been given by the study of the Lime-Kiln Bay (New Brunswick, Canada) study. A farm site was moved and benthic fauna composition was studied in comparison to a nearby long-term trend monitoring site. The information on the original grey Publication by Pohle and Frost (1997) can be obtained through Dr. Wildish (St. Andrews Biological Station of DFO, Canada, St. Andrews, New Brunswick).

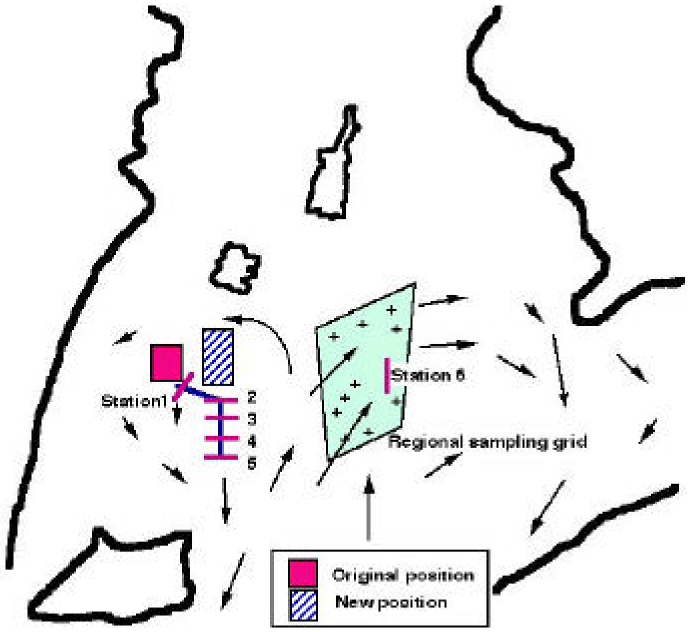


Figure 1: Site location of the farm (full square = original position; rectangle, hatched = new position) and sampling transect stations (1-5) as well as control site (station 6 seasonal sampling) within the regional sampling grid (+ = annual sampling stations) for long-term benthic monitoring. Arrows represent general flow pattern (residual current) in the bay (modified after Pohle and Frost, 1997).

The distributional method employed in this study was similar to Clark's (1990) approach when studying sandy beach community diversity patterns in Australia by using an intermediate method between univariate summaries and multivariate analysis , extracting patterns of relative species abundances without reducing information to single summary statistics (difference to univariate analysis). At the same time universal features of the community structure are extracted which are not the function of the specific taxa present but relate to levels of biological "stress" (Clarke and Warwick, 1994). The adopted method relies on k-dominance curves (= abundance curves with cumulative ranked abundances plotted against species rank; in decreasing order). More elevated curves represent the lowest diversity representing more "impacted" sites (Lambshead et al., 1983). Figure 2 depicts schematically the results for low, medium and high organic ("pollutional") enrichment.

Figure 3 provides an example of the results obtained in the Lim Kiln Bay study at sampling station 1 (abandoned site) about half a year after this site has been given up, indicating that time elapsed since abandonment was not sufficient to see reasonable recovery in the diversity of the benthic community. This demonstrates the principal usefulness of such studies to determine recovery time. To exactly determine recovery time is important for management in areas where site rotation is considered. Site rotation should not be practised where full recovery for the abandoned sites considered for future use is not known.

It has to be recognized that such sampling is time-consuming and expensive and although the scientific quality of the data is certainly excellent, for practical reasons (cost-effectiveness) such monitoring would not be advisable as it also provides information in retrospect and not online. The approach today by many countries has been to use benthic video documentation while focussing on a rough indicator system with certain benthic target species that allow for quick and almost "on-line" assessment of the actual situation. Descriptions of such systems can be found in the recent MARAQUA publications (e.g. Maroni, 2000; Pedersen, 2000, Henderson and Davies, 2000).

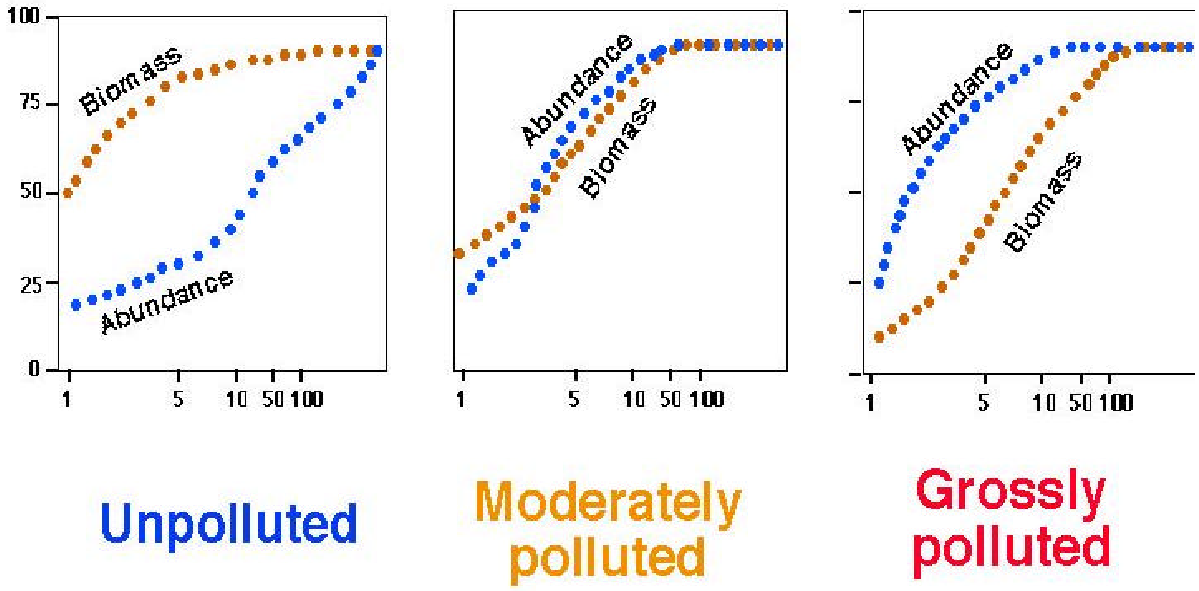


Figure 2: Schematic representation of hypothetical k-dominance curves for species biomass and abundance using species ranking. Y-axis represents cumulative percentages (modified after Clark 1990).

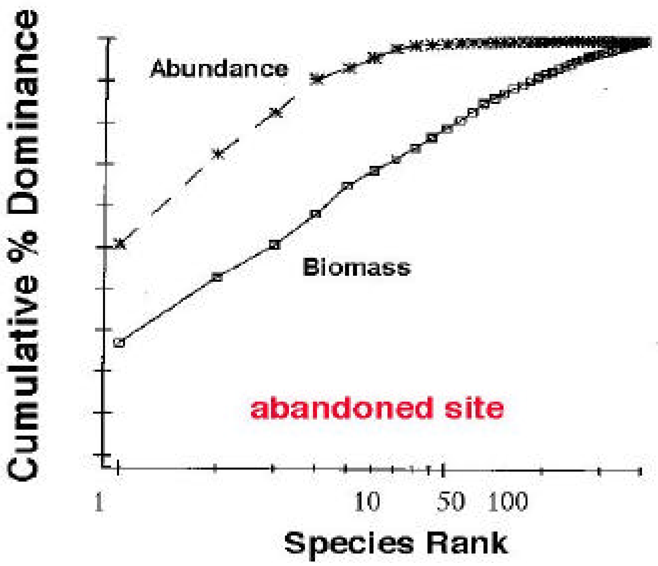


Figure 3: Example of benthic monitoring site 1 (abandoned site at Lim Kiln Bay, New Brunswick, Canada) after a certain fallowing period, indicating that recovery time has not yet been sufficient to return to initial k-dominance curves as compared to control sites (modified after Pohle and Frost, 1997).

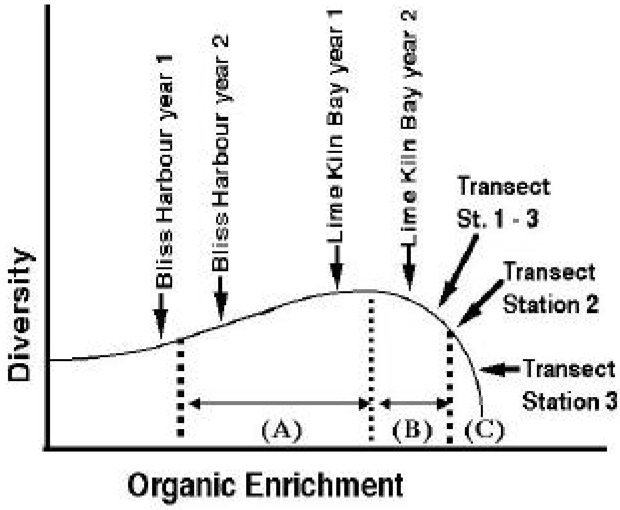


Figure 4: Hypothetical diversity changes in relation to organic enrichment in New Brunswick coastal systems inferred from site specific benthic community studies (modified after Pohle and Frost 1997).

Referring further to the basic study undertaken by Pohle and Frost (1997), the authors compared various sites within the hydrodynamic regime and hypothesized that there are areas in which organic enrichment can be demonstrated while sites also seem to indicate early warning signs of overloading. Further studies indicated that because of the hydrodynamic regime in the area, flushing is incomplete and cumulative effects from various farms are obvious. While the benthic diversity studies provided site specific indications, the challenge to determine "holding capacity" for an area or hydrodynamic system could only be met when combining with other mass balance studies including hydrography. Here still is a challenge to effectively provide modelling tools that capture different and complex systems such as estuaries, open or enclosed bays and fjords.

2.2. Examples on biodiversity changes through unintentional introductions via shipping

As outlined in the introduction, the number of foreign species transmitted per unit time is still increasing. Overall, estimates range from 3000 to 4000 species that are in intercontinental transit daily while it has been suggested that on average every 12-14 weeks a species, which can no longer be eradicated, is established along the US coast. Figure 5 demonstrates this situation clearly (after Cohen and Carlton, 1998) showing the dramatic increase in the arrival of new species since the 1970s (69 species in about 25 years, compared to 45 species in 70 years prior to World War 2). Figure 6 depicts the situation for the Baltic and North Seas, indicating that the number of species succeeding every decade (over a century) is constantly on the rise. These introductions certainly represent substantial changes not only in diversity but often in species abundances causing shifts in food webs.

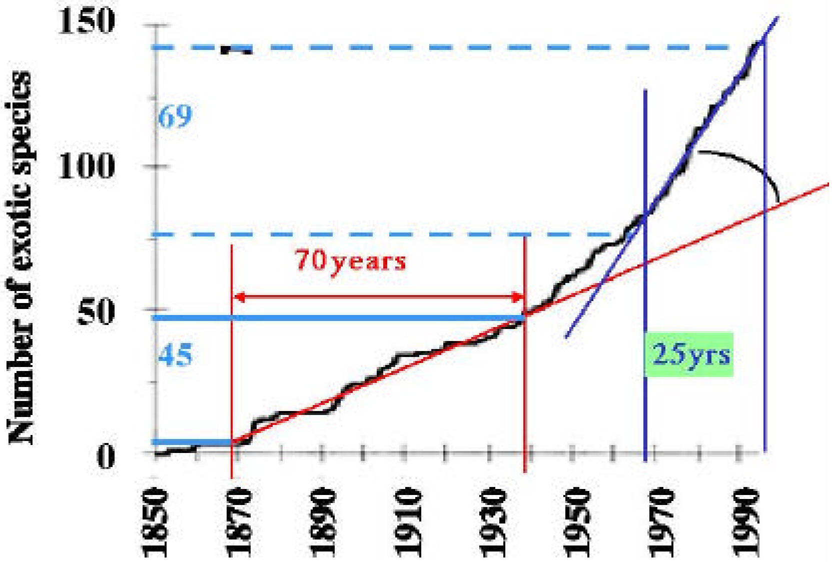


Figure 5: Cumulative number of established exotic species in the San Francisco Estuary (using time series analysis = Box-Jenkins methodology) (modified after Cohen and Carlton, 1995, 1998).

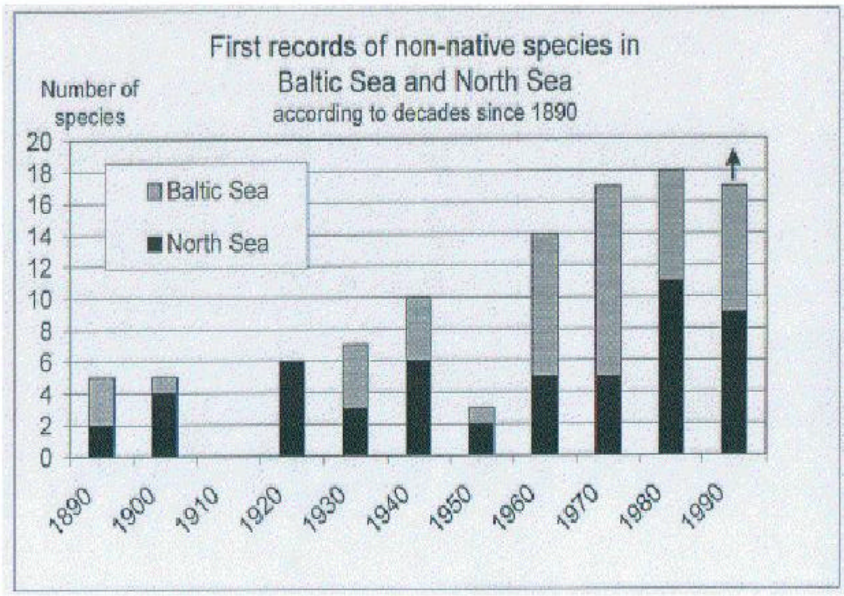


Figure 6: Estimated number of species introduced into the Baltic and North Seas over a century. Data represent number of species per decade. (modified after Gollasch and Leppakiski, 1999).

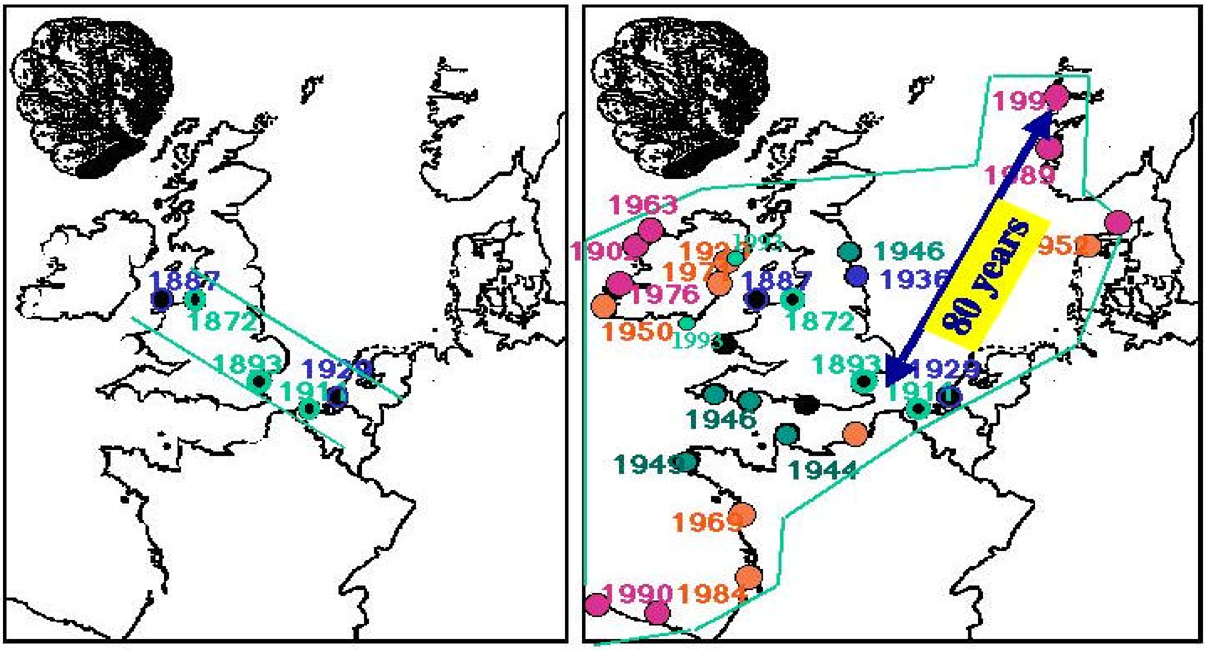


Figure 7: Early records on the introduction of *Crepidula fornicata* and its range extension over more than a century. The spread towards the northwest of Europe (direction of residual currents) from its early record places took over 80 years) Data are extracted and compiled from over 100 publications registered in the data-band compiled by Rosenthal (2002) .

Introduction of exotics through whatever mode continues and once introduced, there is no chance for eradication of the species and the environmental consequences of such permanent introductions certainly prevail and expand. The following figures do present some examples to demonstrate such spread over large areas after the initial introductions. The case of the well-known and early introduction of the slipper-limpet (*Crepidula fornicata*) provides a good example on the mode of introduction and the continued spread of the species. Figure 7 (left panel) shows that all of the early records occurred in or near important oversea harbours, while the spread continues via various vectors, including sport and commercial fisheries, ferry boats and commercial shipping (Fig. 7 right panel). Figure 8 depicts the well-documented case of the introduction of the tunicate *Styela mammiculata* which was introduced to Europe via ship hull fouling most likely with the fast warships of the Royal Navy returning to, Plymouth (left panel of Fig 8) after the Korean war in 1952. Although *Styela* is a sessil species, its spread was much more rapid towards the northeastern part of the North Sea, reaching northern Denmark within 22 years (Fig 8. Right panel).

The question arises whether aquaculture as one of the coastal resource users can be affected by such introductions? A recent event indicates that there is a high likelihood that the Asiatic sealice, *Caligus flexispina*, was introduced into the southern hemisphere (Chile) via bulk carriers who arrive from Japan in full ballast to load wood chips for the pulp and paper industry in Asia. Between November 1998 and March 1999, this new sealice infestation was claimed to have caused a mortality of 15.000 tonnes of Atlantic salmon. The industry is now forced to use chemicals to combat this parasite, thereby not only adding to the cost of production and increasing the risk of periodic epizootic mortalities, but also being unintentionally exposed to environmental critics while using more chemicals, a necessity now imposed on the industry by other, uncontrolled "polluters". The introduction of the zebra mussel to the Great Lakes and its spread to the Mississippi drainage system has affected native unionids in that system, thereby threatening the use of these native species to obtain implant-material for the pearl oyster industry. Recently, new seaweeds have been introduced most likely with hull fouling and/or ballast water to Chile as well as to Norway (e.g. *Dasysiphonia* sp). These are spreading rapidly and

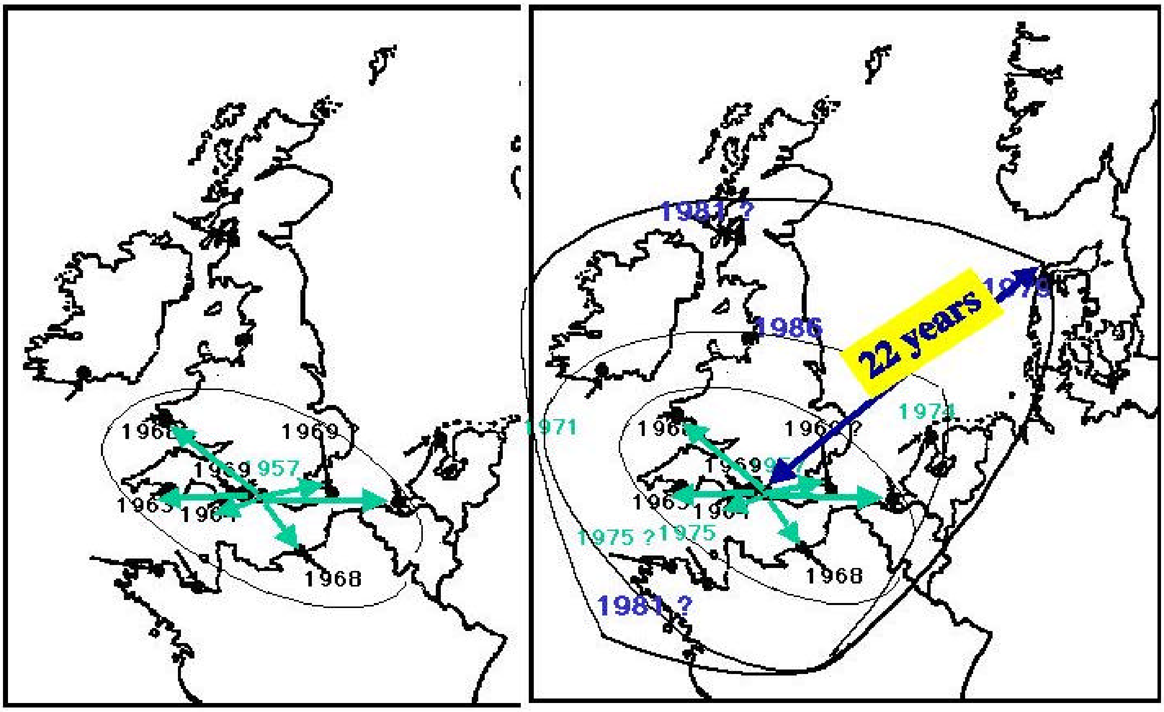


Figure 8: Initial introduction and spread (left panel) as well as subsequent range extension (right panel) of the tunicate *Styela mammiculata* into Europe. (Data compiled from numerous publications and local records registered in the exotic databank by Rosenthal 2002).

provide additional fouling organisms on cage nettings. This certainly adds to the maintenance costs and - in severe cases - may cause reduced current flow through cages, limiting water exchange and oxygen supply. These few examples may stand for many others. Further information on transfers and introductions which may cause harm to aquaculture, fisheries and tourism can be obtained from a recently completed report on "Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters" which resulted from an European Union Concerted Action (Rosenthal et al., 1999).

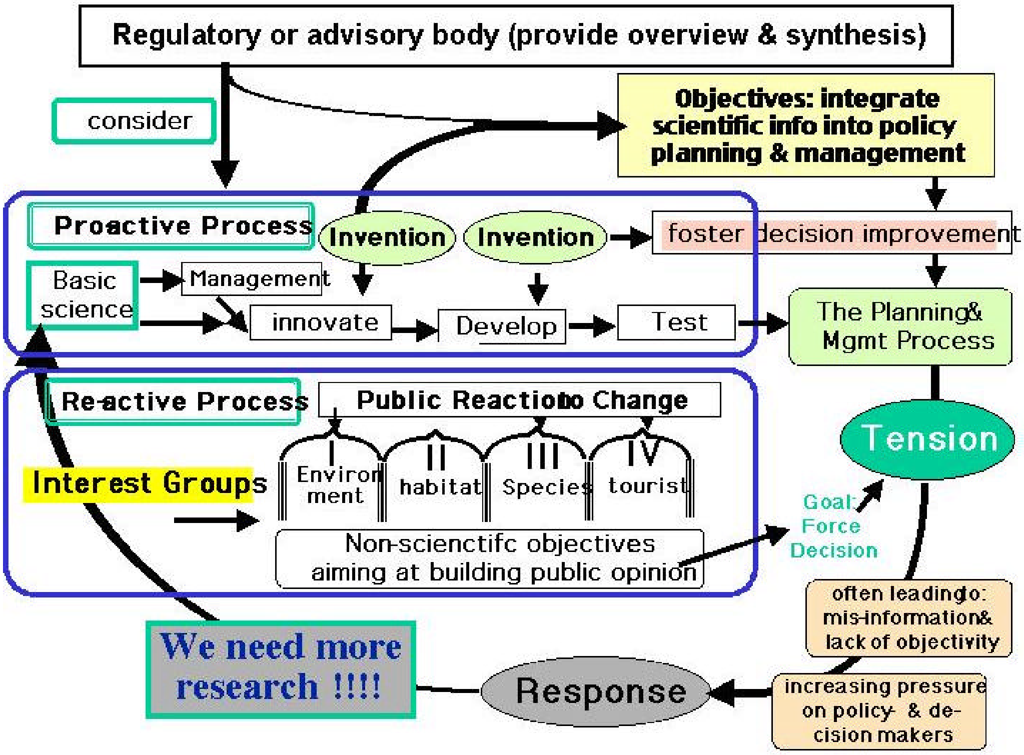
For the first time the protection needs of the aquaculture industry have been formulated through the EU Ballast water Concerted Action programme. In turn, the creation of problem awareness has already led to various ideas for improving site selection criteria so as to maintain certain distances between aquaculture and shipping.

Although the shipping industry is only one of the extensive water resource users in coastal and open sea waters that does interfere with aquaculture and fisheries, there are many others such as agriculture, tourism (in particular), industrial and rural developments. These issues cannot be addressed here in full but one additional use may stand for many others: the sport fishing industry as these activities have been (and in the future will continue to be) a risk factor in local transmission of aquatic nuisance species ones these have established self-sustaining populations in areas to which sport fishermen are "frequent travellers".

3. TENSIONS BETWEEN COMPETING INTERESTS AND THE NEED FOR CO-MANAGEMENT

The process of tension building among competing interests in the Coastal Zone is one of increasing significance in several jurisdictions. In the past, environmental regulations (for example those related to mariculture development) were built on a reactive process rather than a more constructive, pro-active approach. This is one reason why over-regulation often follows a pioneering period in response to a build-up in public pressure. It is recognized that public reaction to any new form of development is often conditioned by a limited understanding of the potential positive and/or negative influence of that development. This misunderstanding can be increased because interest groups who may oppose the development often employ non-scientific information in forming their opinions and may misuse information to strengthen support for their views. This process is visualized in Figure 9. The diagram has been developed by the ICES working group on "Environmental Interactions of mariculture" in an attempt to facilitate the understanding of the independent pro-active and re-active processes created under any sectoral development scheme (Rosenthal et al., 1995, ICES WG, 1998).

Figure 9: Interaction between regulatory and planning authorities in the management decision process with other stakeholders and the role of scientific advice in improving decision processes (modified after ICES, 1998).



Such re-active processes can mis-inform the general public creating entrenched positions where sound scientific information is not used to good effect in promoting sustainable economic and environmentally responsible developmend. This will cause adverse and unnecessary pressures on the coastal resource uses including mariculture and on the decision process and contradicts the principle of ICZM in building consensus based on best available knowledge. It seems therefore necessary in the future to strengthen factual reasoning into the entire process by early promotion of direct inputs from the scientific and innovative technology disciplines (upper, "pro-active" box in Figure 9) as well as simultaneously from the re-active "response"-process (lower box in Fig. 9) into the Planning and Management process in order to minimize the built up of tensions while developments are in progress and can hardly be changed or adjusted. This would allow to put emerging "tension" through a quality assurance path (objectivity gateway) before finalizing the response to either the pro-active, science-based improvement process or the developer (proposer).

4. CONCLUSIONS AND OUTLOOK

Looking at the development of mariculture, there exists very strong evidence that it will develop irrespective of current constraints, such as competition for access to resources and adverse environmental conditions caused by poor standards of environmental management of other coastal activities. If positive steps are not taken to make more effective use of available scientific and management knowledge on how to integrate mariculture into the ICZM process there is a grave danger of mounting conflicts and loss of potential economic, social, and environmental benefits to current and future generations.

Considering the above there is a need to develop scientific tools to better assess the interactions between aquatic resource users in coastal zones including the environmental and economic consequences. Aquaculture could serve as a role model to identify criteria for sustained management practice. Some of the tools that could serve to test the effectiveness of integrated coastal zone management approaches are presently under development in many countries and agencies and involve so-called DSS (Decision Support Systems) using Chaos-theory and fuzzy logic (Rosenthal et al., 2000, McGlade 1997, McGlade and Price, 1993).

In order to foster a better understanding of the needs for protection of natural coastal resources and the interactions between resource users, educational tools for improved application of multidisciplinary and multitasking methodologies are urgently needed across sectors and at all levels of integration (including planners, policy makers, investors, regulators, farmers, and community management).

With regard to aquaculture in coastal habitats, the EU-ASEM cooperation should foster networks on monitoring and managing of coastal aquaculture because recent activities within EU research programmes and within Asean countries indicate that there exist common objectives in this area were mutual benefits can easily be gained through effective networking. In particular monitoring methodologies can jointly be employed and utilized with the aim to support modelling in providing comparative measures on global change effects by target and indicator species (communities, species network structures). One of the beneficiaries would be the aquaculture industry and its governing national and regional bodies. There are also opportunities for cooperative research projects that focus on comparative environmental studies of farming systems. This would greatly assist to improve the empirical data base for predictive modelling approaches presently evolving in EU countries and elsewhere.

REFERENCES

Black E., Gowen R., Rosenthal H., Roth E., Stechy D. and Taylor F.J.R. 1997. The costs of eutrophication from salmon farming: implications for policy - a comment. J. Environmental Management 50: 105-109.

Carlton J.T. and Geller J.B. 1993. Ecological roulette: the global transport of non-indigenous marine organisms. Science (Wash.) 261(5117): 78-82.

Cohen A.N. and Carlton J.T. 1995. Nonindigenous aquatic species in a United States estuary: A case study of the biological invasions of the San Francisco Bay and Delta. A Report for the US Fish and Wildlife Service, Washington D.C., December 1995. 246 pages plus Annexes.

Cohen A.N. and Carlton J.T. 1998. Accelerating invasion rate in a highly invaded estuary. Science 279: 555-556.

Gollasch S. and Leppakoski E. 1999. Initial Risk Assessment of Alien Species in Nordic Coastal Waters. Nord 1999(8): 1-244. (Nordic Council of Ministers).

Gollasch S., Minchin D., Rosenthal H. and Voigt M. (Eds.). 1999. Exotics across the ocean: Case histories on Introduced species: their general biology, distribution, range expansion and impact. Logos Verlag Berlin. 62 pp.

Henderson A.R. and Davies I.M. 2000. Review of aquaculture, its regulation and monitoring in Scotland. J. Appl. Ichthyol. 16(1): 200-208.

ICES 1998 (International Council for the Exploration of the Sea) 1998 Report of the Working Group on Environmental Interactions of Mariculture, Esbjerg, Denmark, 1-5 March, 1998. ICES CM 1998/F: 2 (Mariculture Committee; Ref: ACFM+ ACME+E): 62 pages plus 17 Annexes.

ICES 1999. (International Council for the Exploration of the Sea) 1999 Report of the Working Group on Environmental Interactions of Mariculture, Montpellier, France, 15-20 March, 1999. ICES CM 1998/F: 2 (Mariculture Committee; Ref: ACFM+E): 24 pages plus 11 Annexes.

Maroni K. 2000. Monitoring and regulation of marine aquaculture in Norway. J. Appl. Ichthyol. 16(1): 192-195.

McGlade J.M. 1997. SimCoast: An expert system for sustainable Coastal Zone Management. ASEAN-EU SimCoast Workshop Report "Managed Ecosystems", 18-22 August 1997, Makati City, Manila, Philippines, 18 pp.

McGlade J.M. and Price, A.R.G. 1993. Multidisciplinary modelling: an overview and practical implications for the governance of the Gulf Region. Mar. Poll. Bull. 27: 361-377.

McMahon T. Regulation and monitoring of aquaculture in Ireland. J. Appl. Ichthyol. 16(1): 177-181.

Pedersen P.B. 2000. Monitoring and regulation of marine aquaculture in Denmark. J. Appl. Ichthyol. 16(1): 144-147.

Pohle G.and Frost B. 1997. Establishment of standard benthic monitoring sites to assess long-term ecological modifications and provide predictive sequence of benthic community succession in the inner Bay of Fundy, New Brunswick. Final Report. 119 pp. Atlantic Reference Center, Huntsman Marine Science Centre. St. Andrews, N.B. EOG 2X0. New Brunswick, Canada.

Rosenthal J.H., 2002. An annotated bibliography on Transfers and introductions of non-indigenous species and their consequences for aquaculture and ecosystems. Electronic databank, last update June 2002; to be published shortly (after the NEOBIOTA Conference , Halle, Germany, October 2002).

Rosenthal H.,Burbridge P., Black E., Ackefors H., Bilio M., Thomson M. and Smith C. 1995. Principles and practical measures for the interaction of mariculture and fisheries in coastal area planning and management. Report. ICES Working Group on "Environmental Interactions of Mariculture" ICES C.M. /F: 50 (Mariculture Committee). 31 pp.

Rosenthal H., McGlade J., Bottrell H. and Marshall J. 1999. Promoting multi-use concepts in coastal zone planing and management through the development of decision support systems. pp. 53- 61. In: Gee K., Kannen A., Sterr H. 2000. Integrated Coastal Zone Managment: What Lessons for Germany and Europe? Reports of the Christian-Albrechts University, Kiel, Germany No 21: 1-125 (ISSN 0940 - 9475).

Rosenthal H. Weston D., Gowen R. and Black E. (eds.) 1987. Report of the ad hoc Study Group on "Environmental Impact of Mariculture". Coop. Research Report 154: 1-83. (ICES, Working Group on Environ. Impact of Mariculture, Copenhagen).

Richibucto Environment and Resource Enhancement Project: An Ecosystem Approach for Developing a Model of Integrated Coastal Zone Management in Atlantic Canada

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ABSTRACT: The Richibucto watershed covers approximately 1300 km^2 and is located in New Brunswick, Canada. The Richibucto estuary and its associated river system have always played an important role in the lives of those communities that reside along its shores. Over the years many of the natural finfish and shellfish stocks have become jeopardized, and in some instances totally depleted. Increasing habitat destruction has resulted in significant portions of the estuary becoming permanently or conditionally-closed to shellfish aquaculture and harvesting. In 1996 the University of Moncton in collaboration with local communities and support from other scientists as well as government and voluntary organizations, undertook a major environmental study of the Richibucto waters. This multi-community investigation consisted of two phases: Phase1 identified factors that contributed towards the deterioration of the aquatic environment, proposed certain rehabilitative measures to address and correct problems and applied newly-gained information in helping to develop strategies that could contribute towards enhancement and aquaculture development of certain species. Phase 2, initiated in the spring of 2001, focuses on developing a thorough and integrated investigation of the economic carrying capacity of the Richibucto estuary for shellfish aquaculture. The latter is structured around four components: i. Oceanographic modeling, ii. shellfish farming at a commercial test site, iii. environmental health and iv. participatory coastal zone management. We anticipate that the program will contribute to long-term social, recreational and sustainable economic benefits for the residents of the area and ultimately serve as a model for other watersheds in Atlantic Canada

1. INTRODUCTION

1.1. Background to study

The Richibucto watershed covers approximately 1300 km^2 and is located in New Brunswick, Canada. The Richibucto estuary and its associated river system have always played an important role in the lives of those communities that reside along its shores. The people depended on the waters for subsistence, recreation, transport and different capture fisheries. Over the years many of the natural finfish and shellfish stocks became jeopardized, and in some instances totally depleted. Increasing pollution resulted in significant portions of the estuary becoming permanently or conditionally-closed to shellfish harvesting.

1.2. Study

The Environmental Sciences Research Centre (ESRC) of the Universite de Moncton in collaboration with local communities, government agencies and voluntary organizations, undertook a major environmental study of the Richibucto waters. This multi-stakeholder, multi-disciplinary investigation, which became known as the Richibucto Environment and Resource Enhancement Project was initiated in early 1996 and consisted of 2 phases.The Richibucto Environment and Resource Enhancement Project is one of the programs that falls under the Canada-German Bilateral Cooperation Agreement in Science and Technology in the field of Integrated Coastal Zone Management, whose German Coordinator is Professor Harald Rosenthal of the University of Kiel, Germany.

2. RICHIBUCTO ENVIRONMENT AND RESOURCE ENHANCEMENT PROJECT

2.1. Phase 1

Phase 1 (1996 -2001) identified factors responsible for the deterioration of the aquatic environment, proposed certain rehabilitative measures to address and correct problems and applied newly-gained information in helping develop strategies that contributed towards enhancement and aquaculture development of certain targeted species. The specific lines of research were defined after public consultations were held in early 1996 with the various stakeholder communities (including French, English and several MicMaq First Nations), representatives of the aquaculture and fishing industries, environmental groups and government and university scientists.

A management scheme was established consisting of a Steering Committee, an Executive Council, a Technical Advisory Committee and four Working Groups.

The mandates of the Working groups were as follows:

i. Collaboration with First Nations and with Industry

ii. Environmental Monitoring

iii. Environmental and Applied research

iv. Training, Graduate Research and Advice to community groups

Numerous sub-projects formed part of Phase 1, some of which included: monitoring of water quality, studies of various oceanographic variables, identification of sites for oyster culture, exploring the possibilities for culture of new shellfish species, the effects of introduction of peat particles into the Richibucto estuary, studies on the ecology of striped bass, studies on the presence and the effects of parasites of shellfish and work related to the impacts of over-wintering of surf clams and ice restrictions on grow-out opportunities.

2.2. Phase 2

Phase 2 (2001-2006) was initiated last year and drew on previous experience and recorded findings resulting from the work performed during Phase 1. The current work focuses on:

i. undertaking a thorough and integrated investigation of the economic carrying capacity of the Richibucto estuary for shellfish aquaculture and

ii. developing a knowledge-base model for the shellfish culture industry in Atlantic Canada.

2.3. Four Thematic areas

The project is built around four major themes:

i. oceanographic modelling,

ii. shellfish farming,

iii. environmental health and

iv. participatory coastal zone management.

2.3.1. Oceanographic modelling

The modelling component is expected to provide a new paradigm for aquaculture development in the region. It will permit the establishment of an effective predictive tool kit to be used in supplying information on optimal site selection, proper farm configuration for desirable economic growth and a clearer definition of the role of sustainable bivalve culture in a healthy ecosystem. The work includes detailed hydrodynamic studies of circulation and flushing patterns, accompanied by comprehensive work on suspended particulate matter, primary production, rates and levels of deposition and resuspension, benthos and larval recruitment, as well as many other variables.

2.3.2. Shellfish system-oyster culture operation

The modelling component will reveal the economic sustainability of the watershed at the macro level, and will be implemented and tested at a specific oyster culture operation (micro level) that was established in the spring of 2001 and which will be expanded over the next 5 years. The information generated for this site will be combined with a detailed economic and marketing study, and simulation models based on realistic scenarios will be used to contribute towards profit maximization of the operation. Investigations related to the optimization of oyster production and the evaluation of alternate techniques for over-wintering will represent the thrust of this component.

2.3.3. Environmental Health aspect

Monitoring of environmental impacts will "test the pulse of the system" during the course of the program and will depend on the use of bivalve biomarkers, physiological indicators and comparative studies employing indices of biotic integrity sampled from various sites throughout the Richibucto Estuary.

2.3.4. Participatory coastal zone management

Finally, a comprehensive Integrated Coastal Zone Management plan (ICZM) is being developed to reduce conflict and facilitate consensus building for all resource users of the region. The approach, which we hope will ensure long-term social, recreational and sustainable economic benefits for the residents of the area, will hopefully also serve as a model for other watersheds.

Impacts of intensive mariculture on coastal ecosystem and environment in China and suggested sustainable management measures

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1. INTRODUCTION

Mariculture in China has grown dramatically since the late 1970s. In 2000, the total mariculture production of China was 10.6 million MT. Figuring most prominently was the production of both bivalves and macroalgae (82% and 11% respectively) mostly cultivated in coastal zones by the suspension culture method. As is well known, the growth and reproduction of bivalves rely mainly on the supply of microalgae and detritus; however, the growth and reproduction of macroalgae, microalgae and seaweeds depend mostly on the supply of inorganic nutrients coming from their living water body. Any variation in phytoplankton, the basic food chain element in marine ecosystems, will not only directly influence the growth and reproduction of bivalves, but will also cause changes in the whole marine ecosystem in the coastal zone by limiting secondary production and then influencing the fisheries resources. Similarly, if the supply of inorganic nutrient is limited in the mariculture region, competition for inorganic nutrients will take place between phytoplankton and macroalgae.

In addition to what is described above, great attention should be paid to the study of the impacts of mariculture on the coastal zone environment. All aquaculture is based on an underlying requirement for a clean environment for two very practical reasons. First, since the final marketed product is for human consumption, the product must meet high quality standards. Second, as in any husbandry operation, production is highest when environmental stresses are minimized. To some extent, then, environmental degradation due to mariculture is directly related both to human health and to the water quality of the coastal zone.

2. IMPACTS OF MARICULTURE ON ECOSYSTEMS AND THE ENVIRONMENT

Certain projects have therefore been launched by the Chinese government to investigate the impact of mariculture on ecosystems and the environment. Summarizing the projects, some research results are showed as follows:

2.1. Effects of intensive macroalgae mariculture on ecosystem and environment

Macroalgae such as kelp *Laminaria japonica*, *porphyra spp.* etc., are important economic species cultivated in the coastal zone of China. In 2000, the total macroalgae mariculture yield of China was more than 1 million MT. The results of these studies showed that 1MT Kelp in dry weight would absorb about 10-15 kg N from seawater. Such quantities of N can produce 100-150 kg POC. If the mariculture sites are N deficient, the intensive macroalgae culture will certainly reduce the primary production. Therefore, intensive macroalgae mariculture on a large scale will influence the stabilization of coastal ecosystems by depleting the nutrients. In addition, the decay of kelp will occur during the summer season if they cannot be harvested in time. The detritus dropped from the decayed front part of kelp can make the seawater so mucous that it will be harmful to the hatcheries, or may cause blooms of some species of harmful macroalgae in the mariculture sites.

2.2. Effects of intensive bivalves mariculture on ecosystems

Study results showed that the mean feeding ration of scallop *Chlamys farreri* with shell height of 5-6 cm is about 11 mg POC/d/ ind. Moreover, bivalves have a strong capability of filtering water at optimal temperatures. For example, scallops *Chlamys farreri* with shell height of 3-4 cm, 4-5 cm, and 5-6 cm can filter about 60 L, 100 L and 120 L water respectively during a period of 24 hours. Experimental results showed that one scallop *Chlamys farreri* (shell height: 5 cm) could decrease the phytoplankton concentration from 8800 cell/ml to 200 cell/ml within 1h in 3000 ml water volume at temperature 15~200. If the culture biomass of bivalves exceeds the carrying capacity of mariculture regions, intensive bivalve mariculture will decrease the quantity of phytoplankton rapidly so as to decrease the primary production. Without sufficient phytoplankton in the coastal seawater, the growth and reproduction of zooplankton and other herbivorous marine animals will be affected and then the coastal eco-system will change.

2.3. Effects of intensive mariculture on benthos ecosystem

Experimental results show that scallop *Chlamys farreri* (shell height: 5~6 cm) and oyster (shell height: 8~10 cm) can produce amounts of faeces up to 50~60 gr and 120 gr in dry weight respectively each year. Some parts of such faeces will be decomposed into dissolved matter and will be carried by the current away from the culture site, but most will sediment to and accumulate on the sea bed under the suspension culture facilities. This particulate organic matter is so fine that it will change the texture composition of the seabed. When the texture of the seabed is changed, the population of organisms living on or in the mariculture seabed will consequently change, and then the benthos ecosystem will change in conjunction with the accumulation of the bio-sediment on the seabed year by year. Comparing the present data of benthos biomass of organisms with the historical data, we found that the biomass of seaweed and bivalves in the seabed of intensive mariculture areas has declined dramatically since the 1970s. For example, although the resources of eelgrass *Zostera marina* were so rich that it could be found almost everywhere along the coastal zone from north to south of China before the 1970s, it is now very difficult to find. Although there are many factors causing the decline of eelgrass resources, the accumulation of bio-sediment from the intensive suspending culture may be the one of the most important factors involved.

2.4. Effects of resuspension of bio-sediment on cultivated organisms

Generally speaking, the longline culture density of bivalves (scallops, oysters) is about 50ind./m^2, and most of the intensive mariculture areas in China have been developed for about 20 years. This means that the bio-sediment accumulated on these intensive mariculture areas reaches so far about 10 cm in the seabed. This bio-sediment matter can change not only the texture of the seabed, but can also be disturbed into the water column, especially during the storm season. This resuspended particulate not only can cause heavy mortality by blocking the gills of bivalves, but may sometimes induce the occurrence of harmful microalgae blooms because it can increase nutrient concentrations such as N, P, etc., in the intensive mariculture areas very rapidly during a very short period after storms. According to the statistical data, heavy mortality of bivalves cultivated in coastal zone has increased year by year since early 1990s in China. Though it is not known whether such heavy mortalities are caused by the turbidity of seawater, or by disease, it is recognised that the accumulation of bio-sediment on the intensive mariculture seabed is harmful to the ecosystem, the environment, and to mariculture.

3. RECOMMENDATIONS

In order to develop the marine aquaculture resources in a sustainable way, some suggestions or recommendations are made as follows:

1) To establish models to predict the potentiality of new sites for mariculture based on their mariculture carrying capacity and ecological carrying capacity.
2) To pay great attention to study the impact of mariculture on ecosystem and environment, the interaction between mariculture and environment, the relationship between intensive mariculture in the coastal zone and the variability of marine fisheries resources, etc.
3) To re-evaluate intensive mariculture sites in coastal zones not only based on their carrying capacity, but also according to standards of human health.
4) To establish a sustainable management system that can determine and control the mariculture species, areas and scale, density, culture models in different sites based on the specific ecological and environmental conditions of different regions.

The need for a paradigm shift in Asian aquaculture

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ABSTRACT: Asian Aquaculture has gone through immense changes in growth and technology developments during the last three decades. A variety of fish, mollusk and crustacean species are being cultured in many different systems such as cages, ponds, tanks, rafts, pen, and raceways, located in different environments; rivers, reservoirs, mudflats, estuaries and bays. Production has increased manyfold to satisfy the demand at home and abroad as the marine fisheries catches dwindled due to over-exploitation and pollution. Despite the advances in technology, an analysis of the aquaculture production per unit area reveals that yields are not increasing in tandem with the expansion of the industry. The decrease in production in many cases is due to unsustainable aquaculture practices. However, many agencies in the Asian region have given attractive incentives to accelerate the aquaculture industry, resulting in rapid development at the expense of the environment. Since the mid-80's the aquaculture industry in the Asian region has been plagued with serious disease problems resulting in severe losses.

Water has been used extensively in aquaculture activities, resulting in reduced mangrove forests, eutrophicated rivers and coastal waters, and salt water intrusion. The lack of sustainable aquaculture practices has already created a negative impact on the industry. The unsustainable approach for optimization of water resource utilization will eventually result in water as a limiting factor in commercial fish production. There is a need for a drastic change in paradigm to shift to sustainable aquaculture practices using newer technologies that will optimize the use of water. One approach would be to integrate the aquaculture system with other agriculture based industries. Aquaponics, which integrates hydroponics with aquaculture, is a good example of a successful integration. The integration of fish and plants increases diversity and thereby enhances system stability. The principle of the integrated system is to optimize the utilization of nutrients derived from aquaculture for agriculture use. Hence, nitrogen, phosphorus and other nutrients in aquaculture effluent could be effectively removed and utilized by plants of commercial value. However, further studies are necessary concerning the carrying capacity of cage aquaculture, and integrated farming with livestock should be further investigated to reduce pollution and conflicts in the use of water.

Newer technologies could also be considered for incorporation of integrated systems adopting traditional practices such as rice fish culture. Rice cum fish culture is not practised extensively due to shallow waters, use of chemicals such as pesticides and the additional manpower input. If newer technologies could be adapted to overcome these constraints, a vast potential exists in the integration of fish culture and the acreage of large rice fields. Several other examples of integration to turn the aquaculture industry around to a more positive outlook should be studied and implemented.

Another concept of sustainable aquaculture practice would be to use environmental friendly recycling technology with near zero discharge. Such systems have already proved to work well in the developed countries though they would require major technology transfer for adaptation in the Asian region. The major constraint would be the adaptability of such new technologies to tropical conditions to suit the local cultured species. Pilot projects require substantial research and development (R&D) input. Thus, the financial implications of adapting and testing the new technologies involving high capital cost need to be addressed. Successful pilot scale testing would be useful to convince the entrepreneurs to adapt the technology for the promotion of sustainable aquaculture. In addition, the development of a strong consortium between different sectors is necessary to ensure the sustainable use of limited resources.

Paper not available

Mariculture's Two Side Effects on Environment and Their Utilization in Practice

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ABSTRACT: Mariculture is an important industry, however, its rapid development has drawn much world attention to fish supplies and coastal environmental damage. Mariculture has two side effects on the coastal environment: some types of mariculture improve the coastal environment and increase food supply, but others deplete wild fisheries stocks and damage the coastal environment.

According to the driving factors of systems aquaculture ecosystems can be divided into two groups:
a). autotrophic or natural trophic systems such as kelp culture system and raft culture system for scallops, which obtain energy from solar radiation and nutrients from water; b). heterotrophic or artificial trophic systems, such as net culture system for feeds - feeding fish and pond culture system for shrimp, which obtain energy mainly from artificial feeds. There are many features of ecological mutual compensation between the two types of aquaculture systems. Nowadays most mariculture production is produced from autotrophic systems in China. However, we should not neglect the negative effects of some types of mariculture on the coastal environment in our aim towards sustainable mariculture.

There are several ways to reduce mariculture pollution: structure optimization of single culture system or complex system, control of carrying capacity, treatment of discharge water and so on. Structure optimization of a single culture system selects cultured species among or between which there is mutualism in niche or in food resource utilization, though not a predatory or competitive relationship, determining the best culture forms, the best ratio and amount of cultured species in culture waters or culture systems. Structure optimization of complex systems is the compound or intercrop of ecologically compensational systems, that is, heterotrophic and autotrophic systems to reduce reverse effects of mariculture on the coastal environment, to improve the carrying capacity and ecological stability of mariculture systems, and to gain substantial commercial profit.

Paper not available

THEMATIC AREA III

Genetics & Biotechnology in Aquaculture: Status, Promises & Issues

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ABSTRACT: With rapid advances in the genomics, proteomic and bioinformatic sciences, the impact of biotechnology on aquaculture will continue to increase. Already there have been promising developments in: (1) transgenesis whereby fish with enhanced performance such as fast growth and increased disease resistance are produced; (2) molecular diagnostics and vaccines of pathogens; (3) molecular genetics and selection; (4) microbial/microalgal genetic engineering for water quality management or as probiotics/feed supplements; (5) reproductive and sex control; (6) nuclear transplantation and cloning, etc.

However, such developments also raise issues such as risks to human health and the environment (Genetically Modified Organism issues), and ownership (Intellectual Property issues). One of the latter concerns that is particularly relevant to Asia region, is marginalization of small-holders in rural areas, who are unable to pay for such biotechnology advances.

INTRODUCTION

Great advances have been, and are rapidly being made in our knowledge of the genetics and molecular biology (including genomics, proteomics and structural biology) of aquatic organisms. The puffer fish (*Fugu rubripes*) genome has already been sequenced (Aparicio et al., 2002) and the genomes of two other species, the zebrafish and the Japanese medaka, will soon follow. Global molecular profiling technologies have been or are being developed. These include microarrays using DNA or oligonucleotide chip, and protein and lipid chips are being developed. With such advances in knowledge and platform technologies, biotechnological applications are inevitable, and aquaculture should not be left out. Indeed such biotechnological applications have been made in aquaculture (Hulata, 2001; Hew and Fletcher, 2001; Melamed et al., 2002), but there are ecological, food-safety and other issues which need to be resolved before the biotechnologies could be fully integrated in commercial aquaculture. In this introductory presentation, I will focus on the following areas:

1. Improvement of aquaculture stocks
2. Preservation of genetic resources
3. Disease diagnosis and control
4. Microbial/microalgal genetic engineering

1. IMPROVEMENT OF AQUACULTURE STOCKS

1.1. Selective breeding

Conventionally, genetic improvement of aquaculture stocks involves selection, cross/out-breeding and/or hybridization. Selectively bred stocks with superior traits such as disease resistance and rapid growth have been produced and used in commercial aquaculture (Hulata, 2001). If these stocks are inbred, genetic depression and deterioration of seed quality would eventually occur. A proper breeding program should include both selection and cross/out breeding, and even hybridization. More than one selectively bred stock/strain should be developed for each species so that cross breeding among them can be done to ensure heterosis (Kirpichnikov, 1993; Sumantadinata, 1995).

Hybridization is particularly useful if it results in triploid, sterile or all-male progeny (see review by Hulata, 2001).

1.2. Marker-assisted breeding

Many molecular markers are now available for genome analysis, fingerprinting, and genetic linkage mapping (Kumar, 1999). These include RELPs (restriction fragment length polymorphisms), AFLPs (amplified fragment length polymorphisms) and RAPD (random amplified polymorphic DNA). There are also specific PCR markers based on target sequence primers such as short tandem repeats and simple/short sequence repeats, which are also referred to as microsatellites. These markers can be employed to tag quantitative trait loci (QTLs) and assist the breeding program (Agresti et al., 2000). In addition, the molecular profiling microassays mentioned earlier can be used to determine the genes that are expressed, upregulated, or downregulated in a particular desirable trait. This information may then be used to design appropriate markers for the breeding program.

1.3. Transgenesis

Transgenic technology has been developed in a number of fish species (Hew and Fletcher, 2001; Melamed et al., 2002). It is a short cut to achieving genetic change for fast growth, disease resistance and other desirable traits. By just microinjecting into freshly fertilized eggs, a fish-growth-hormone gene, linked to a suitable fish promoter, transgenic fish with remarkable growth rates have been obtained (Devlin et al., 1994; Devlin, 1998; Hew and Fletcher, 2001). Recently, transgenic zebrafish with different body colours have also been produced by using the green or red fluorescent protein receptor gene linked to a skin-or muscle-specific promoter (Wan et al., 2002). This has implications for the ornamental fish industry.

Research is being pursued to produce transgenic fish carrying genes that encode antimicrobial peptides such as lysozyme (Melamed et al., 2002). This is one approach to obtain disease resistance in fish. Hew and Fletcher (2001) have tabulated other transgenic approaches to enhance disease resistance in fish including using antisense and ribozyme technologies against viral RNA.

In principle, transgenic technology can be used to induce or enhance other traits in fish once the relevant genes are known. Similarly the technology may be applied to other aquaculture organisms.

1.4. Transgenesis via embryonic stem cells and cell/nuclear transplantation

This is a new approach to transgenesis that yields better transgene integration and expression compared to the direct transgenesis described above (Fig.1; Hong and Schartl, 1966; Hong et al., 1998a,b). With the availability of a fish embryonic stem (ES) cell line (Hong et al., 2000), ES cells can be transfected with a particular gene construct or expression cassette and screened for homologous recombination (gene targeting; Hong et al., 1998b). The transfected cells can then be transplanted into early embryos/blastulae, either directly or via removal of nucleus and nuclear transplantation (Yan, 1998). The pluripotent ES cells/nuclei can enter cell lineages and colonize the germ line (Hong et al., 1998 a, b). Thus the transgene will be properly integrated and expressed. In contrast, transgenesis by the direct injection of a gene construct to the embryos will result in a high rate of random integration and mosaicism (Fig.1).

1.5. Gender manipulation and sterility induction

Chromosome-set and gender manipulations in fish have been reviewed several times, more recently by Arai (2001), (Beardmore et al., 2001) and Hulata (2001). The technologies include hormonal sex reversal, gynogenesis, androgenesis and polyploidization. Gynogenesis, hormonal sex reversal and triploidization may be combined to produce all-female sterile triploid fish. The technologies have been adopted by commercial aquaculture (see the reviews quoted above).

It may be possible to induce sterility in fish by transgenic means. For example, transgenesis involving the use of antisense /ribozyme technology to degrade mRNAs of GnRH (gonadotropin releasing hormone) or GtH Iâ (gonadoptropin Iâ) has been proposed (Hew and Fletcher, 2001).

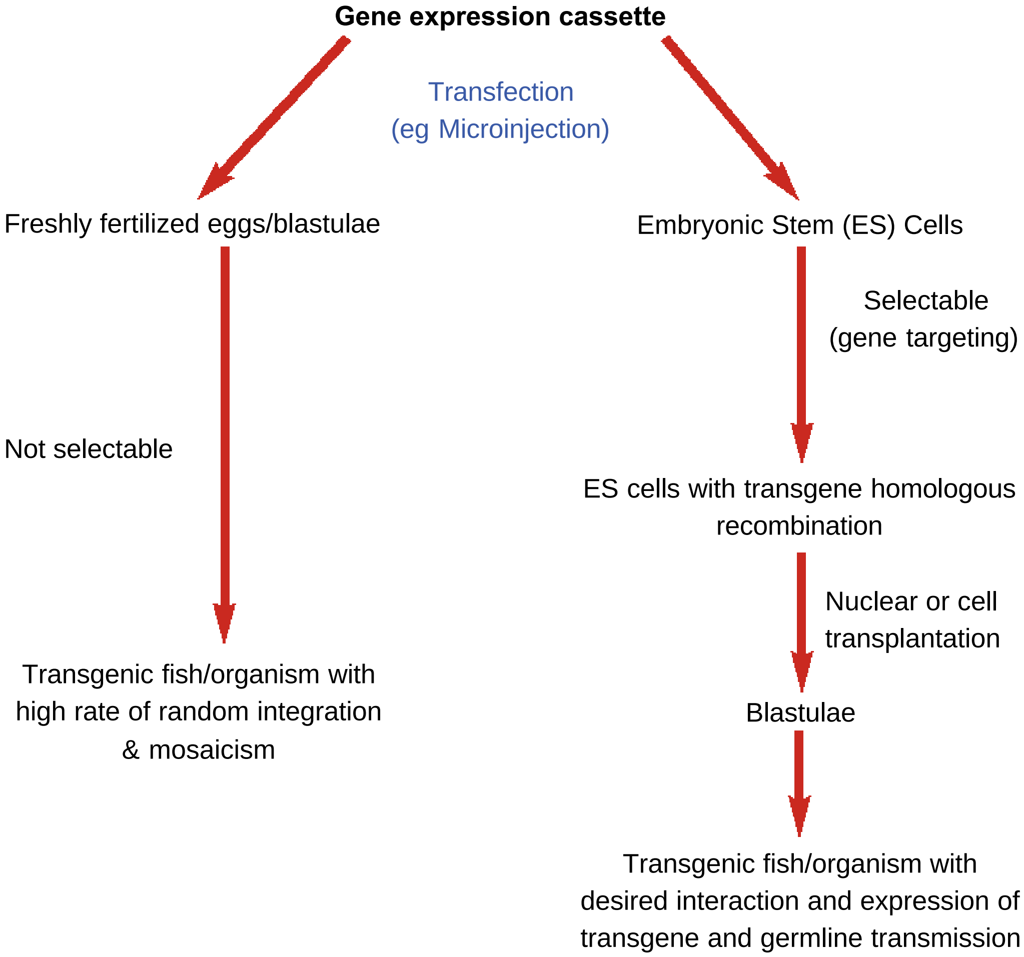

Figure 1. Rapid Genetic Improvement of Aquaculture Stocks by Transgenesis

1.6. Issues

A major concern is the escape or release of genetically managed aquaculture stocks and their genetic and ecological impacts on the wild stock populations and habitats. It is feared that such escapes/releases would cause introgressive hybridization in the wild stocks and other ecological effects. Thus the release of hatchery-bred juveniles to the wild for stock enhancement or sea ranching should be carefully planned and monitored. Such stocks for release should be bred differently from those for captive culture. While the latter are selected for desirable culture traits, the former should aim for minimum genetic change and maximum genetic diversity.

The concern for an escape of transgenic or genetically modified organism (GMO) is understandably much greater. Risk assessment should therefore be done (de la Fuente et al., 1996). One approach to minimizing the risk is to produce sterile GMO (Devlin and Donaldson, 1992).

There are other GMO concerns. First and foremost is the food safety concern of the public. Allergic and other undesirable reactions to the novel encoded protein are one such concern. This concern appears to have entered the public psyche and it is difficult to reassure the public to accept GMO as food without much additional information. Thus food safety evaluation of transgenic organisms should be done (Guillen et al., 1999). It is mainly due to the above concerns that the commercialization of transgenic Atlantic salmon, though technically ready, is impeded (Hulata, 2001).

There is also the concern of possible unexpected consequences of GMO (pleiotropic effects) and the issue of intellectual property marginalizing small-scale farmers unable to afford the technology. The latter is particularly relevant to the developing countries where many small-scale aquaculture farmers exist.

2. PRESERVATION OF GENETIC RESOURCES

Besides wild stock conservation, genetic resources may be preserved through gamete cryopreservation. While sperm cryopreservation is well established (Lahnsteiner, 2000; Suquet et al., 2000), that for ova/embryos/early larvae is still experimental except for some invertebrates like mollusks (Chao and Liao, 2001). The establishment of sperm or seed banks for aquaculture will facilitate preservation and dissemination of stocks, and hence, breeding programs.

Cell lines, particularly ES cell lines, offer another means of genetic conservation. Biodiversity can be rescued from cells by cloning through nuclear or cell transplantation (Fig.2; Hong and Schartl, 1996).

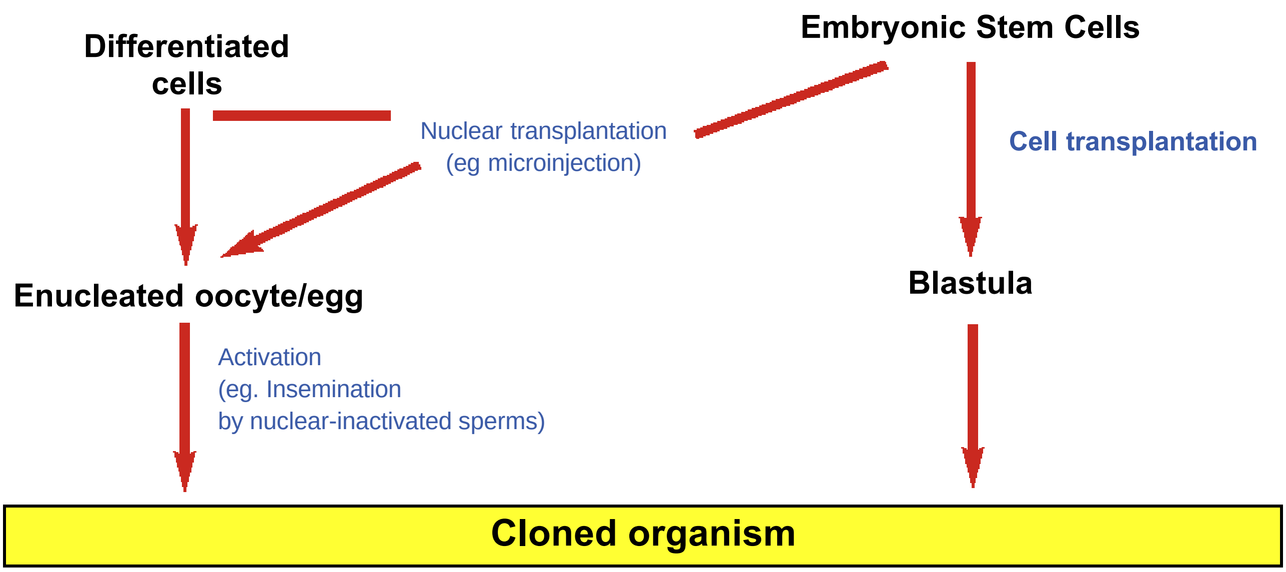

Figure 2. Rescue of Fish Biodiversity by Cloning

3. DISEASE DIAGNOSIS AND CONTROL

This is an area where molecular technologies would find fruitful applications. Monoclonal antibodies and PCR may be used to develop rapid diagnostics of pathogens (Nicholson, 1993), while DNA or DNA recombinant vaccines (Heppell et al., 1998; Tighe et al., 1998; Lorenzen, 1999) may be produced for protection against diseases (Fig.3). Additionally, transgenesis may be sought to confer or enhance disease resistance as mentioned earlier (I.3).

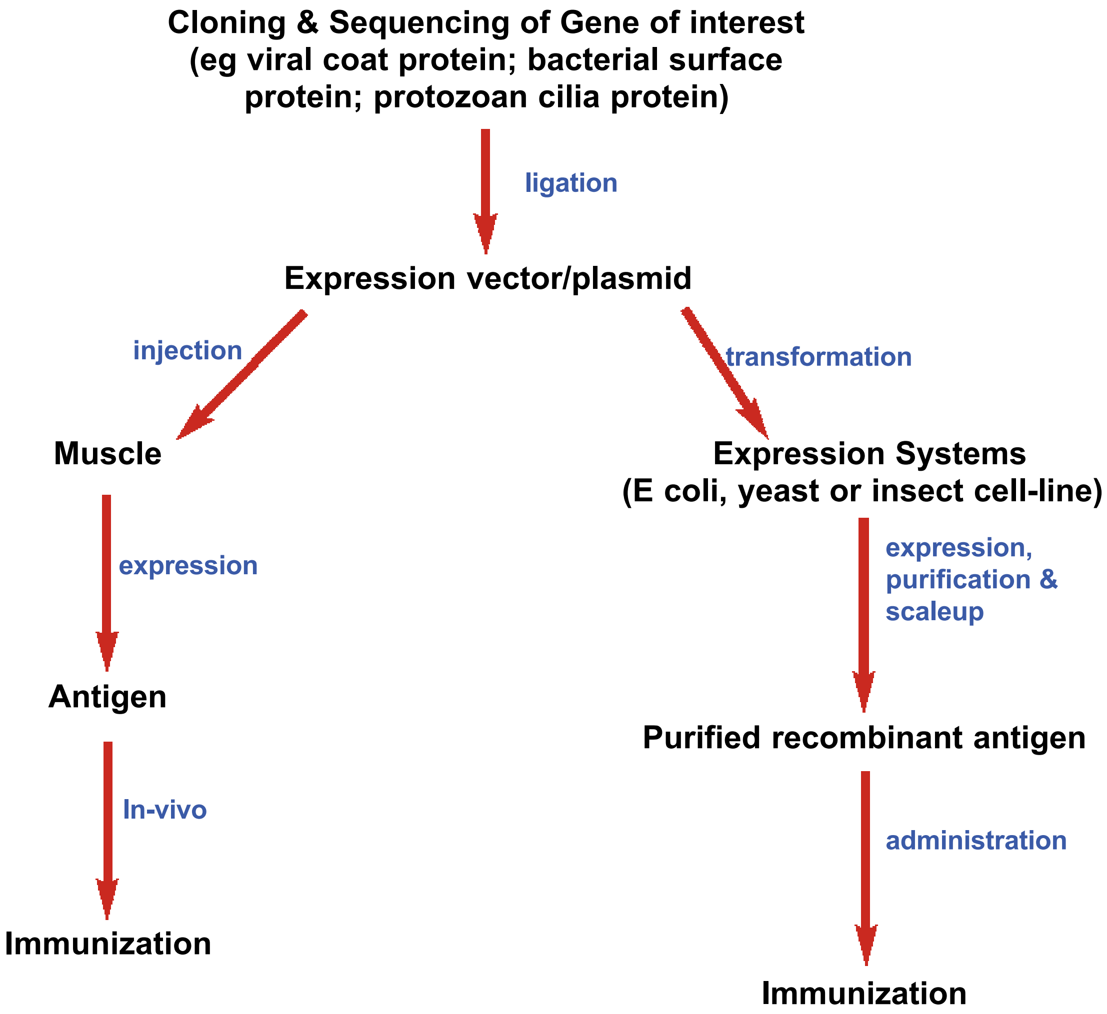

Figure 3. Production of DNA and DNA recombinant vaccines

4. MICROBIAL/MICROALGAL GENETIC ENGINEERING

Water quality management is an important issue in aquaculture. Here the role of bacteria is well recognized. These bacteria could be genetically engineered to enhance their efficiency in waste/nutrient recycling and in bioremediation.

Other beneficial bacteria like those in the gut (probiotics) that aid digestion and crowd out pathogenic bacteria (competitive exclusion), may also be genetically engineered to improve their value and efficiency.

Similarly, genetic engineering may be applied to microalgae to enhance their nutritional quality as health supplements not only for fish/shellfish but also for humans. Microalgae are known to be a good source of nutrients such as n3 highly unsaturated fatty acids and antioxidants, and also immunostimulants and antimicrobials.

CONCLUDING REMARKS

The tide of molecular and information sciences (genomics, proteomics, structural biology, molecular and cell biology, and bioinformatics) is sweeping various fields of human endeavour. Aquaculture cannot and should not be an exception. However, adverse public perception is putting up some barricades against the tide. The barricade is particularly strong in the area of GMO as food, but in other areas the barricade is weak or absent. These latter areas, which include marker-assisted breeding program, preservation of genetic resources, and disease diagnosis and control, should feel the impact of the tide. Even in the area of GMO, the barricades may not hold for long as the tide gathers strength and the risks are minimized.

REFERENCES

Agresti, J.J., Seki, S., Cnaani, A., Poompuang, S., Hallerman, E.M., Umiel, N., Hulata, G., Gall, G.A.E., and May, B., 2000. Breeding new strains of Tilapia: development of an artificial center of origin and linkage map based on AFLP and microsatellite loci. Aquaculture 185: 43-56.

Aparicio, S., Chapman, J., Stupka, E., Putnam, N., Chia, J.M., Dehal, P., Christoffels, A., Rash, S., Hoon, S., Smit, A., Gelpke, M.D., Roach, J., Oh, T., Ho, I.Y., Wong, M., Detter, C., Verhoef, F., Predki, P., Tay, A., Lucas, S., Richardson, P., Smith, S.F., Clarke, M.S., Edwards, Y.J., Doggett, N., Zharkikh, A., Tavtigian, S.V., Pruss, D., Barnstead, M., Evans, C., Baden, H., Powell, J., Glusman, G., Rowen, L., Hood, L., Tan, Y.H., Elgar, G., Hawkins, T., Venkatesh, B., Rokhsar D. and Brenner, S., 2002. Whole-genome shotgun assembly and analysis of the genome of Fugu rubripes. Science, 297(5585): 1301-1310.

Arai, K., 2001. Genetic improvement of aquaculture finfish species by chromosome manipulation techniques in Japan. Aquaculture 197: 205-228.

Beardmore, J.A., Mair, G.C. and Lewis, R.I., 2001. Monosex male production in finfish as exemplified by tilapia: applications, problems, and prospects. Aquaculture 197: 283-301.

Chao, N.H. and Liao, I.C., 2001. Cryopreservation of finfish and shellfish gametes and embryos. Aquaculture 197: 161-189.

De la Fuente, J., Hernandez, O., Martinez, R., Guillen, I., Estrada, M.P. and Lleonart, R., 1996. Generation, characterization and risk assessment of transgenic Tilapia with accelerated growth. Biotechnologia Applicada 13: 221-230.

Devlin, R.H., 1998. Production and evaluation of transgenic fish for aquaculture. Austral. Biotechnol. 8: 222-227.

Devlin, R.H. and Donaldson, E.M., 1992. Containment of genetically altered fish with emphasis on salmonids. In: Hew, C.L. & G.L. Fletcher (eds). Transgenic Fish. World Scientific Publishing, Singapore, pp.229-265.

Devlin, R.H., Yesaki, T.Y., Biagi, C.A., Donaldson, E.M., Swanson, P. and Chan, W.K., 1994. Extraordinary salmon growth. Nature 371: 209-210.

Guillen, I., Berlanga, J., Valenzuela, C.M., Morales, A., Toledo, J., Estrada, M.P., Puentes, P., Hayes, O. and J. de la Fuente, 1999. Safety evaluation of transgenic tilapia with accelerated growth. Mar. Biotechnol. 1: 2-14.

Heppell, J., Lorenzen, N., Armstrong, N.K., Wu, T., Lorenzen, E., Einer-Jensen, K., Schorr, J. and Davis, H.L., 1998. Development of DNA vaccines for fish: vector design, intramuscular injection and antigen expression using viral haemorrhagic septicaemia virus genes as model. Fish & Shellfish Immunol. 8: 271-286.

Hew, C.L. and Fletcher, G.L., 2001. The role of aquatic biotechnology in aquaculture. Aquaculture 197: 191-204.

Hong, Y. and Schartl, M., 1996. Embryonic stem cells, cell transplantation and nuclear transplantation in fish. Proc. International Colloquium on Preservation Techniques Applied to the Management in Fish Farming, March 1996, Bordeaux, France.

Hong, Y., Chen, S., and Schartl, M., 2000. Embryonic stem cells in fish: current status and perspectives. Fish Physiol. Biochem. 22: 165-170.

Hong, Y., Winkler, C., and Schartl, M., 1998a. Production of medaka fish chimeras from a stable embryonic stem cell line. Proc. Natl. Acad. Sci. U.S.A. 95: 3679-3684.

Hong, Y., Chen, S., Winkler, C. and Schartl, M., 1998b. Medakafish embryonic stem cells as a model for genetic improvement of aquaculture livestocks. In: Le Gal and Halvorson (eds). New Developments in Marine Biotechnology. Plenum Press, New York, pp.129-134.

Hulata, G., 2001. Genetic manipulations in aquaculture: a review of stock improvement by classical and modern technologies. Genetica 111: 155-173.

Kirpichnikov, V.S., Ilyasov, Ju I., Shart, L.A., Vikhman, A.A., Ganchenko, M.V., Ostashevsky, L.A., Simonov, V.M., Tikhonov, G.F. and Tjurin, V.V., 1993. Selection of Krasnodar common carp (*Cyprinus carpio L.*) for resistance to dropsy: principal results and prospects. Aquaculture 111: 7-20.

Kumar, L.S., 1999. DNA markers in plant improvement. Biotechnol. Adv. 17: 143-182.

Lahnsteiner, F., 2000. Semen cryopreservation in the Salmonidae and in the northern pike; in special issue: cryopreservation of gametes in aquatic species. Aquacult. Res. 31: 245-258.

Lorenzen, N., 1999. Recombinant vaccines: experimental and applied aspects. Fish & Shellfish Immunol. 9: 361-365.

Melamed, P., Gong, Z., Fletcher, G. and Hew, C.L., 2002. The potential impact of modern biotechnology on fish aquaculture. Aquaculture 204: 255-369.

Nicholson, B.L., 1993. Use of monoclonal antibodies in identification and characterization of fish viruses. Annual Rev. of Fish Diseases, pp.241-257, 1993.

Sumantadinata, K., 1995. Present state of common carp (Cyprinus carpio L.) stocks in Indonesia. Aquaculture 129: 205-209.

Suquet, M., Dreanno, C., Fauvel, C., Cosson, J. and Billard, R., 2000. Cryopreservation of sperm in marine fish; in special issue: cryopreservation of gametes in aquatic species. Aquacult. Res. 31: 231-243.

Tighe, H., Corr, C., Roman, M. and Raz, E., 1998. Gene vaccination: plasmid DNA is more than just a blue-print. Immunol. Today 19: 89-97.

Wan, H., He, J., Ju, B., Yan, T., Lam, T.J. and Gong, Z.Y., 2002. Generation of two-color transgenic zebrafish using the green and red fluorescent protein receptor genes, gfp and rfp. Mar. Biotechnol. In press.

Yan, S., 1998. Cloning in fish - nucleocytoplasmic hybrid. IUBS Educational and Cultural Press Ltd., Hong Kong.

Genetic considerations in the introduction of aquacultured fish to natural ecosystems

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ABSTRACT: Introduction in the natural aquatic ecosystems of fish grown in captivity is a common phenomenon, which usually results either from planned stocking activities or from accidental escapes from farms. Although the introduction of genetic material in wild populations may be in some instances advisable, in most of the cases this practice is loaded with several threats for the genetic integrity of receiving populations. The inundation of a broad area by introduced genetic material may result in the loss of the genetic structure and variability and thus in the genetic homogenization of the populations in this area. Valuable gene pools, such as genes or co-adapted gene complexes could be lost through their replacement by exogenous genes, a phenomenon known as *genetic introgression*. This happens when the released fish interbreed with the wild ones and the genetic characteristics of the former differ from those of the latter.

Since the existence of natural population subdivisions may imply adaptation to local conditions, genetic assessments of the degree of population structuring and gene flow are necessary not only to preserve the existing biodiversity, but also to keep valuable adaptive resources. The assessment of the degree of genetic differentiation between cultivated and wild populations, as well as monitoring of the changes in genetic composition of the receiving populations after release, should constitute an integral part of any translocation or restocking program. Several types of genetic markers can be used for the analysis of genetic variation in populations, most of which are considered as evolutionary neutral. Between them, microsatellites are currently the most extensively used, since their high mutational rate and polymorphism offer high-resolution power. The inclusion in the studies of markers under selection could help in the understanding of the relationship between genetic divergence and fitness differences implying local adaptation in the populations.

A common practice of stocking is supportive breeding, whereby a certain number of wild fish are caught and reproduced in captivity and the progeny is released into the environment. This practice may be harmful for the native populations, even if no exogenous genetic material is introduced and the released fish are not adapted to the artificial rearing conditions, because it may lead in a reduction of the effective population size and hence of the genetic diversity of the receiving stocks.

To avoid problems caused by the accidental escapes of reared fish, specific measures such as farming of local stocks, manipulation of sex and ploidy (e.g. production of mono-female or sterile triploid fish) etc, should be employed.

1. INTRODUCTION

The term translocation is used to describe the movement of species or strains outside their native origin. Translocations are usually performed for the purposes of *stocking* or *farming*, and in both cases the majority of donor strains are of hatchery origin. The release into the natural aquatic ecosystems of fish grown in captivity is a common phenomenon nowadays, especially after the abrupt expansion of aquaculture activities in the last decades. This release can be either intentional, in the case of stocking (introduction, reintroduction, enhancement), or accidental, in the case of escapes from aquaculture farms. Although the introduction of genetic material in wild populations may be in some instances advisable, for example when a natural stock has been depleted for a long time, in most cases this practice is loaded with risks concerning the genetic integrity of receiving populations. Several studies have explained the possible genetic impacts of the release of stocked fish into the aquatic environment (Hindar et al., 1991; Ryman et al., 1995; Rhymer and Simberloff, 1996; Cross, 2000; Johnson, 2000; Youngson et al., 2001).

In broad terms, there are two kinds of genetic impacts on wild populations from the release of captive-bred fish: a) *introgression* of exogenous genetic material, and b) reduction of effective population size, a specific situation occurring in the case of stocking with natives (or *supportive breeding*).

2. INTROGRESSION OF EXOGENOUS GENETIC MATERIAL

2.1. Risks involved

Introgression of exogenous genetic material in the receiving populations happens when the genetic characteristics of the cultivated populations are different from those of the wild populations, and there is interbreeding between introduced and wild individuals. There are several threats associated with this phenomenon. The first is that the natural genetic architecture can be altered by the loss of valuable genetic material, like locally adapted genes or gene complexes, or the homogenization of a previously structured population through continual flooding with exogenous genes (Ryman et al., 1995). Genes or gene complexes promoted by artificial or domestication selection, which most likely will not be fit in the natural environment, may erode the native genetic pool. Moreover, re-adaptation of local populations, after the first introduction of exogenous genetic material, may be prevented. Finally, weakening or even loss of natural populations may occur, through the exclusion of native fish by introduced fish, which finally demonstrate low reproductive success.

A critical question concerns what fraction of wild genes can be replaced by exogenous genes without compromising the genetic characteristics of wild populations, especially the ones with adaptive significance. Unfortunately, only very general *a priori* predictions can be made. Based on the population genetics theory we could make sound predictions if we knew a number of parameters, like the size and evolutionary history of both the cultivated and natural populations, the acting selective forces etc. But actually we usually have very limited knowledge of the genetic characteristics of the populations, especially the wild ones (Ryman et al., 1995). Our knowledge pertains mainly to a small number of neutral genetic markers and we have no information about loci related with characteristics with adaptive significance.

2.2. Assaying the genetic effects of the introduction of captive-bred fish

The most basic requirements for assaying the genetic effects of the introduction of captive-bred fish is to obtain an estimation of the degree of genetic differentiation between cultivated and wild populations, to determine the genetic population structure of the wild fish and to monitor changes in the genetic make-up of receiving populations after release.

It has been recommended (Ryman et al., 1995) that acceptable levels of introgression should be correlated to levels of gene flow occurring naturally. The idea is that an estimation of the degree of gene flow between natural populations should be obtained and similar levels of introduction of captive fish into the wild populations should be allowed.

Gene flow can be estimated either by observations of actual migrations of fish or from the observation of the patterns of genetic differentiation, based on the methods of population genetics. The first approach can produce both overestimations and underestimations of the actual gene flow, while the second appears more realistic, even if theoretical assumptions of the population genetics theory are not strictly met. The level of the gene flow is usually approximated by using the fixation index F_{ST}, which expresses the portion of total genetic variation of a set of populations that is attributable to differences between the populations. F_{ST} is calculated from the formula:

$$F_{ST} = \sigma^2(p) / \bar{p}\,(1-\bar{p})$$

where $\sigma^2(p)$ is variance of the allelic frequencies in the populations and $\bar{p}$ is the mean allelic frequency. F_{ST} is related to gene flow through the formula:

$$F_{ST} = 1/\,(4Nm+1)$$

where N is the effective population size, m is the migration rate and Nm is the number of migrants per generation. Therefore, the critical parameter is the number of migrants rather than the migration rate. The estimated number of migrants per generation (Nm) can be used as a guideline for the acceptable levels of introgression. For example, if F_{ST} is estimated at 0.10 (which, as explained above, means that 10% of the total genetic variability residing in the populations is due to population subdivision), only two individuals per generation can be released if the local population is to keep its genetic identity.

2.3. Examples from salmonid fish

Salmonid fish provide the most appropriate fish group to study the impact of the introduction of aquacultured fish into the environment, since they are characterized by strong population subdivisions, both at macro- and microgeographical levels, and deliberate (stocking) and unintentional (escapes) releases of farmed fish in the natural aquatic environment is a very common phenomenon. From the numerous studies contacted there are not examples of better performance of captivity-bred fish than the wild ones in the natural environment, and reduction of survival rates is the most frequent observation.

In an experiment designed to compare the fitness of native and farmed Atlantic salmon (*Salmo salar*) and their hybrids in a natural environment of Ireland (McGinnity et al., 1997, Cross, 2000), four categories of families (wild x wild, farmed x farmed, wild x farmed hybrids, farmed x wild hybrids) were produced. The eggs were released in a stream and some months later juveniles were recovered and assigned to families by parentage identification performed by profiling for minisatellite loci. While the expectation was for equal survival, the native fish showed significantly better survival than expected, the farmed survived significantly less well, and the hybrids were close to expectations.

A number of other recent studies have used highly variable genetic markers to assess the interactions and the degree of genetic introgression of various species of stocked salmonids to wild populations [Chilcote et al., 1986 (steelhead, *Oncorhynchus mykiss*); Fleming et al., 2000 (Atlantic salmon, *Salmo salar*); Koskinen et al., 2002 (grayling, *Thymallus thymallus*); Poteaux et al., 1998, Ruzzante et al., 2001, Hansen, 2002 (brown trout, *Salmo trutta*)]. In all these works lower fitness of the captive stocks in the natural environment was detected.

2.4. Recent advances in the use of molecular genetic markers

The latest advances in the area of molecular genetic markers, as well as developments in the corresponding theory and methods for statistical analysis, have offered new possibilities for assaying the genetic impact of the farmed animals in the wild conspecifics. DNA can nowadays be extracted from minute amount of tissues, even from museum material (e.g. scales, otoliths), and thus the analysis of historical samples and the comparison with contemporary ones is now feasible (e.g. Nielsen et al., 2001; Koskinen et al., 2002; Hansen, 2002).

Microsatellites are currently the most extensively used markers, because they offer high-resolution power due to their high mutational rate and polymorphism. Tools for the analysis of the population admixture proportions (i.e. the proportion of contemporary gene pools derived from indigenous and cultivated stocks), and the individual admixture proportions (i.e. the proportion of the genome of individual fish derived from indigenous and introduced fish), have been developed (Chikhi et al., 2001; Pritchard et al., 2000). Using these methods, Hansen (2002) examined the long-term impact of stocking domesticated trout in brown trout populations of two rivers in Jutland, Denmark. He estimated that in one river there was small genetic introgression of domesticated trout (app. 6%) and the majority of individual were non-admixed, which was interpreted as a result of low fitness and poor performance of domesticated trout in the wild. In the other river, strong genetic contribution from domesticated trout (57 - 88%) was detected. In this case, survival of domesticated trout and admixture with indigenous fish in a local broodstock was invoked to explain the high degree of introgression. Moreover, since stocking can be regarded as migration and since domesticated fish can be removed from the natural environment by selection, introgression seems to be dependent on the interplay between the opposing forces of migration and selection (migration - selection balance). In this way, it was considered that the immigration rate (*m*) might be higher in the second river, while the selection coefficient (*s*) might be lower in this river. It should be noted that from the analysis of the historical samples, the local stocks in the two rivers were found not different from each other before the beginning of the stocking activities.

2.5. Molecular markers as predictors of fitness

Another critical question is to what extent the differences between the cultivated and wild populations, as estimated by the use of the molecular markers, which are considered as neutral (not subject to natural selection), can be considered as good predictors of differences in adaptive characteristics and thus of the differences in fitness. In a pioneer experiment, Áltukhov and Salmenkova (1987) compared the rate of return of chum salmon *Oncorhynchus keta* for three different pairs of populations, which differed in the genetic distance between the source and the recipient population. They found an inverse proportionality between genetic distance and rate of return. Even if the low number of pairs examined renders this result rather preliminary, an important finding from this study was that low success of transplanted individuals can occur, even when the genetic differences are small (Johnson, 2000). It has been suggested (Cross 2000) that markers under selection should be included in the studies for better understanding of the relationship between genetic divergence and fitness differences implying local adaptation in the populations.

2.6. Escapes of farmed fish

Several methods have been proposed to minimize the escapes of fish from aquaculture farms, under the understanding that complete avoidance of escapes is not feasible. Between them the following are included (Cross, 2000):

- Matching equipment, such as sea cages and moorings, to the environmental conditions of the site.
- Introducing sanctuary zones near spawning or nursery areas, where aquaculture activities are prohibited.
- Use of sterile animals in aquaculture by manipulation of sex and ploidy.
- Farming of natives whenever possible.
- Keeping healthy wild stocks, by avoiding overfishing and habitat deterioration.

It should be noted, however, that sometimes the biological and ecological characteristics of the species help to limit adverse genetic effects of escapes. This is true for both the main aquacultured Mediterranean species, the gilthead sea bream (*Sparus aurata*) and the sea bass (*Dicentrarchus labrax*) (Youngson et al., 2001). Sea bream is a protandrous hermaphrodite species and the sex reversal occurs at the age of 2-3 years. This means that most of the fish in the farms are almost entirely males, since harvesting of fish is typically performed before this age. On the other hand, wild sea bream breed in lagoonal areas, a habitat rather rare in the Mediterranean. These facts mean that escaped males have to disperse for long distances, in order to breed with wild females. Sea bass often show a highly skewed sex ratio in reared stocks, and this means again that the majority of escaped fish are males. It is not known if they are capable of migrating in breeding areas and if they have synchronous maturity cycles with local fish so that interbreeding is possible (Youngson et al., 2001).

3. STOCKING WITH NATIVES (SUPPORTIVE BREEDING)

3.1. Dual aim

In the case of stocking the aim is twofold: to maximize the performance of the donor strain, while minimizing the detrimental effects on receiving population(s). The ideal would be to produce a large self -sustaining population by a single or a restricted number of interventions, but what is actually done in most cases is that hatchery fish are produced and released in each generation (Cross, 2000). The genetic effects on the wild stocks can be either direct, when genetic introgression occurs through interbreeding with natives, or indirect, when the introduced species or race outcompetes native species or races.

3.2. Choice of donor strain

The focal point in translocation for stocking is the choice of the donor strain. The translocation between locally differentiated groups of populations (races) should be avoided. Also, measures to avoid genetic changes, such as *inbreeding depression*, which quite often occurs in aquaculture practices, should be applied and artificial selection (genetic improvement) not be performed. Inadvertent *hatchery* or *domestication selection* is difficult to avoid, so strains to be used in stocking should not be kept in the hatchery for more than one generation (Cross, 2000). Often, in order to enhance the local wild populations, a number of wild breeders are brought into captivity and their offspring released into the wild environment. In this case, there is no introgression of alien genetic material and adaptation in artificial conditions can be minimal.

3.3. Effects of supportive breeding

The main problem with this practice, often described as *supportive breeding*, is the impact on the genetically *effective size* of the population. The effective size is the size of the population that actually counts for the maintenance of the genetic variability and the evolutionary fortune of the population. Usually the effective size is much lower than the census size of the population. It is equivalent to the size of an "equivalent" ideal population, that is of a population with a sex ratio of 1:1, random matings, non-overlapping generations and equal number of progeny per family. Deviations from these conditions of ideal population result in reduction of the effective size. Small effective population size has detrimental effects on the fitness characteristics of the population, which are known with the term *inbreeding depression*.

Supportive breeding increases the variance in family size, since the fish bred in captivity contribute much more offspring in the next generation than the fish that reproduced in the wild. Thus, supportive breeding may drastically reduce the effective population size, even if the census size is increased. The total effective size of the population equals the sum of the effective number of wild breeders and the effective number of the breeders artificially bred, only if the contribution of the offspring are proportional to the effective sizes of the parents. For example if the captive breeders are 1% of the wild breeders, then, only if the progeny born in captivity is the 1% of the progeny of the natural population, there is no reduction in the total effective size. Since the proportion of the captive progeny is usually much higher than that of the wild progeny, the effective population size is reduced, notwithstanding the fact that the census size of the population is increased. For example, if there are 200 wild specimens, 20 of them are bred in captivity and their released progeny contribute 40% of the progeny in the wild environment, then the effective size is reduced to 100 (Ryman et al., 1995).

Thus, supportive breeding results in a trade-off. There is a gain in the total production of progeny, but at the same time there is a loss of genetic variability, due to reduction of the effective population size. If a population has drastically decreased and is prone to extinction, its backing by artificial breeding is of course advisable, but care should be taken to avoid the problems related to the loss of genetic variability. Increasing as much as possible the proportion of the breeders bred in captivity is a measure that can be taken towards this end. Recent studies, however, have shown that decrease in the effective population size may not be necessarily a problem over multiple generations, if supportive breeding results in a substantial increase of the census population size (Wang and Ryman, 2001; Duchesne and Bernatchez, 2002)

4. CONCLUSION

The study of genetic population structure of natural populations and the estimation of the degree of divergence between wild and cultivated ones is a basic prerequisite of any programme that includes intentional release or the risk of accidental release of captive bred animals in the environment. The use of neutral genetic markers, even if does not provide direct information about genes controlling adapting characters can provide important insights for the degree of genetic differentiation of the populations.

The estimated degree of naturally occurring gene flow could be used as a measurement of the maximum allowable introduction of cultivated animals into the natural aquatic ecosystems. Special care to avoid introductions or escapes can be taken in the case that the reared populations are considerably divergent from the local natural ones, either as a result of their origin from a genetically differentiated race or population, or because of genetic changes brought by adaptation to artificial environment. The monitoring of genetic changes after the release should be an indispensable stage to be followed, in order to be able to ascertain the degree of genetic introgression into the natural environment. This will also allow for remedial measures to be taken. Eventual use of genetically modified organism (GMO's) in aquaculture should impose even greater measures to be taken to restrict escapes and monitor their impacts to natural populations.

Modern advances in the area of molecular genetics have opened new and unprecedented capabilities. The development of the hypervariable genetic markers, like microsatellite DNA, allows for the detection of even subtle genetic differentiations of populations and modern statistical tools offer the possibility of reconstructing the demographic histories of the populations.

REFERENCES

Altukhov YP, and Salmenkova EA, 1987. Stock transfer relative to natural organisation, management, and conservation of fish populations. I*n Population Genetics and Fishery Management* (Ryman N and Utter F, eds), pp: 333-344. University of Washington Press, Seattle, USA.

Chikhi L, Bruford MW, and Beaumont MA, 2001. Estimation of admixture propotions: a likelihood-based approach using Markov chain Monte Carlo. Genetics 158: 1347-1362.

Chilcote MW, Leider SA, and Loch JJ, 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions. Transactions of the American Fisheries Society 115: 726-735.

Cross T, 2000. Genetic implications of translocation and stocking of fish species, with particular reference to Western Australia. Aquaculture Research 31 (1): 83-94

Duchesne P, and Bernatchez L, 2002. An analytical investigation of inbreeding in multi-generation supportive breeding. Conservation Genetics 3: 45-58.

Fleming IA, Hindar K, Mjolnerod IB et al., 2000. Lifetime success and interactions of farm salmon invading a native population. Proceedings of the Royal Society London, Series B, Biological Sciences 267: 1517-1523.

Hansen NM, 2002. Estimating the long-term effects of stocking domesticated trout into wild brown trout (*Salmo trutta*) populations: an approach using microsatellite DNA analysis of historical and contemporary samples. Molecular Ecology 11: 1003- 1015.

Hindar K, Ryman N, and Utter F, 1991. Genetic effects on cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48: 945-957.

Johnson, MS, 2000. Measuring and interpreting genetic structure to minimise the genetic risks of translocations. Aquaculture Research 31 (1): 133-143.

Koskinen MT, Sundell P, Piironen J, Primmer CR, 2002. Genetic assessment of spatiotemporal evolutionary relationships and stocking effects in grayling (*Thymallus thymallus, Salmonidae*). Ecology Letters 5: 193-205.

McGinnity P. Stone C, Taggard JB, Cooke D, Cotter D, Hynes R, McCamley C, Cross T, and Ferguson A, 1997. Genetic impact of escaped farm Atlantic salmon (*Salmo salar L.*). On native populations: use of DNA profiling to assess freshwater performance of wild, farmed and hybrid progeny in a natural environment. ICES Journal of Marine Sciences 54: 998- 1008.

Nielsen EE, Hansen MM, and Bach L, 2001. Looking for a needle in a haystack: discovery of indigenous salmon in heavily stocked populations. Conservation Genetics 2: 219-232.

Poteaux C, Beaudou D, and Berrebi P, 1998. Temporal variations of genetic introgression in stocked brown trout populations. Journal of Fish Biology 53:701-713.

Pritchard JK, Stephens M, and Donnelly P, 2000. Inference of population structure using multilocus genotype data. Genetics 155: 945-959.

Rhymer JM, and Simberloff D, 1996. Extinction by hybridisation and introgression. Annual Review of Ecology and Systematics 27: 83-109.

Ruzzante DE, Hansen MM, and Meldrup D, 2001. Distribution of individual inbreeding coefficients, relatedness and influence of stocking on native anadromous brown trout (*Salmo trutta*) population structure. Molecular Ecology 10: 2107-2128.

Ryman N, Utter F, and Hindar K, 1995. Introgression, supportive breeding, and genetic conservation. In Ballou JD, Gilpin M, and Foose TJ (eds) *Population Mamagement for Survival and Recovery*, pp. 341-365. Columbia University Press, New York

Wang J. and Ryman N., 2001 Genetic effects of multiple generations of supportive breeding. Conservation Biology15: 1619-1631.

Youngson AF, Dosdat A, Saroglia M, and Jordan WC, 2001. Genetic interactions between marine finfish species in European aquaculture and wild conspecifics. Journal of Applied Ichthyology 17: 153-162.

The fertility of tetraploid hybrids and the sterility of their triploid offspring

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ABSTRACT: The testes of tetraploids consisted of many lobules in which the germ cells such as the spermatogonia, spermatids and the mature sperm were observed. In the cytoplasm of sertoil's cells that surrounded the spermatogonia, the granules that were probably related to the formation of some sex steroid hormones were found. The ovary of tetraploids consisted of many ova. The structure of the gonads in tetraploids were similar to those in diploids, indicating that the tetraploid hybrids possessed the normal testes and ovary, producing the normal diploid sperm and diploid eggs, respectively. The diploid sperm and diploid eggs were respectively larger than the haploid sperm and eggs in sizes. The diploid sperm and diploid eggs can normally fertilize to produce next tetraploid generation.

During breeding season three types of gonadal structure of triploid crucian carp, produced by crossing allotetraploids (♂) with Japanese crucian carp (*Carassius auratus* Cavieri T. et S) (♀), were found. The first type was the testis that consisted of many lobules in which there were numerous spermatides. Some degenerated spermatides were found and no mature spermatozoon was observed. The second type was the ovary-like gonad consisting of many nests of small undeveloped cells and a few small growing oocytes as well as degenerated oocytes. The third type was the fat tissue, in which case, only two strips of fat tissue were located on the gonadal positions, neither testis nor ovary being observed. Over more than ten years, no fertile triploid was found. Combined with the structure of the tissues located in the gonad positions, the triploid crucian carp was proved to be sterile. The triploid caurian carp was produced on a large scale in China.

1. INTRODUCTION

The F3-F11 hybrids of red crucian carp (*Carassius auratus* red var.) (♀)xcommon carp (*Cyprinus carpio* L.) (♂) were proved to be allotetraploids with 200 chromosomes, showing the tetraploidy can be inherited from one generation to another. The sterile triploids were produced on a large scale by crossing tetraploids with diploids. The tetraploid hybrids will probably form a new species with 200 chromosomes. So it is necessary to make clear the structure of the gonads in tetraploids. One of the important aims for the production of tetraploids is for the production of sterile triploids. The sterility of the triploids can resolve the problem of precocious sexual maturation. The sterile triploids do not disturb the natural fish resources when they are put in natural water. The sterility of the triploids is also related to a faster growth rate.

2. METHODS

The electron microscope, scanning electron microscope and light microscope were used to observe the gonads in tetraploids and triploids.

3. RESULTS

3.1. The structure of gonads in tetraploids

i. Similar to the testis of diploid common carp, the testis of tetraploids consisted of many lobules in which the germ cells such as the spermatogonia, spermatids and mature sperm were observed. In the cytoplasm of Sertoil's cells which surrounded the spermatogoia, the granules that were probably related to the formation of some sex steroid hormones were found.

ii. Similar to the ovary of diploids, the ovary of tetraploids consisted of many normal ova.

iii. However there existed differences in the sizes between the diploid gametes produced by tetraploids and haploids produced by diploids. The diameter of the head of diploid sperm was about 2.40 μm that was obviously larger than that of haploid sperm with about 1.90 μm, produced by common carp. The size of spermatogonia in tetraploids was also larger than that in diploid common carp. The size of the diploid eggs with the diameter of 0.17 cm was obviously larger than that of haploid eggs of red crucian carp with the diameter of 0.13 cm.

3.2. The structure of gonads in triploids

Three types of gonadal structure were found in the triploid crucian carp.

i. The testis of triploids consisted of many lobules in which there were numerous spermatides. Some degenerated spermatides were found and no mature spermatozoon was observed.

ii. The ovary-like gonad in triploids consisted of many nests of small undeveloped cells and a few small growing oocytes as well as some degenerated oocytes. No mature ova was observed.

iii. Only two strips of fat tissue were located on the gonadal positions, neither testis nor ovary being observed.

iv. Over more than ten years, no fertile triploid was found. Combined with the structure of the tissues located in the gonad positions, the triploid crucian carp was proved to be sterile.

4. CONCLUSIONS

1. The structure of gonads of tetraploids was similar to that of diploids. With the larger sizes, the diploid gametes produced by the tetraploids were normal, indicating that tetraploidy can be inherited from one generation to another. The tetraploids will probably form a new species with 200 chromosomes. The formation of the tetraploid population has significance in both the biological evolution and the application.
2. The 100% triploids can be produced by mating the tetraploids with the diploids.
3. The three types of structure found in the gonad places in triploid crucian carp indicated that they were sterile.
4. The sterility of the triploids was related to the maternal and paternal parents. The tetraploid's maternal parent is red crucian carp. The tetraploid's paternal parent is the common carp. The triploid's maternal parent is the Japanese crucian carp. So the triploid crucian carp is allotriploid.
5. In triploids, the homologue chromosomes cannot normally pair during meiosis. It is probably one of the reasons for the sterility.
6. The sterility of the triploids can resolve the problem of precocious sexual maturation.
7. The sterile triploids will not disturb the natural fish resources when they are put in natural water.
8. It is possible that the triploids grows faster because the energy used in the gonad development will probably transfer to the energy used in the muscle development.
9. The sterile triploids will be the ideal object used for transgenic fish because of the sterility.

Defining sustainable breeding goals in aquaculture for the future

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ABSTRACT: SEFABAR, a 3-year EU-sponsored thematic network started in 2000, combines the expertise of over 40 scientists and business representatives in animal breeding, reproduction and socio-economics from all over Europe. The working group on aquaculture contains representatives from Belgium, France, Greece, Norway, the Netherlands, Ireland, Spain, the United Kingdom and the European Aquaculture Society (EAS). The project SEFABAR aims at finding sustainable, economically sound and accepted breeding scenarios for major European farm animal species, including fish. Its common principle, defined as 'Genetics for Future Use' links the main elements of quality (end-product, safety, healthiness to consumers), diversity (bio-diversity, product diversification to local markets, adaptation and robustness), acceptability (ethical aspects and animal welfare) and economic viability in the short and long term.

In respect of aquaculture, the main priorities are economic viability (high costs of fish production), the minimization of environmental impact (escapes and possible interbreeding of domesticated and wild animals) and the maintenance of animal integrity (normal physiological and reproductive functions). The main aims concern attempts to redefine breeding goals for fish within a wider perspective by a) producing animals with a economic productive life without giving signs of disturbed health and welfare in a specific environment and b) by optimizing input/output and feed efficiency with sustainable feed resources. Biotechnologies derived from plant breeding provide exciting possibilities for application in fish, but before they are implemented, and extended to new traits, good selection criteria have to be defined. Breeding schemes need to cover different production environments used in aquaculture, to be able to select animals that perform well in a wide range of production circumstances, and to select animals that are best adapted to specific farming environments.

1. BACKGROUND

Aquaculture, an important economic activity in Europe, had reached a total annual production had reached 2.03 million mt of fish, molluscs and crustacea in 2000 (40% higher than in 1991), with an annual value exceeding US$ 4.6 billion (FAO, 2002). These figures represent an increase of 40% by volume and 28% by value in a single decade (1991-2000). However, these averages obscure huge disparities in the importance of certain species. For instance, while production of common carp and silver carp declined during the decade, the output of rainbow trout (289,000 mt) increased by 32%. The production of Atlantic salmon increased by 171% to 615,000 mt, while the output of farmed gilthead seabream increased by 1,184 % to 58,000 mt and European seabass by 768% to 42,000 mt. Such rapid increases in the production of Atlantic salmon, seabream and seabass caused significant decreases in unit value. This resulted in much smaller increases in the total economic value of these species (82%, 296% and 151% respectively) than in their output by weight. In terms of economic value, the largest European aquaculture producers of finfish are Norway, the UK, Greece, Italy and Spain. Substantial further growth in European aquaculture production is expected. For the major species, the scale of increase will mainly depend on the development of regional markets for seabass and seabream and on potential expansion in the international market for salmon, modified by increasing competition from non-European producers. Production of farmed finfish is expected to become more diversified; with farmed cod, for example, expected to be a particularly important feature in the future. European aquaculture activities extend well beyond this continent; many producers elsewhere are fully or partly owned by European companies.

In Europe, aquaculture expansion will take place in a climate of closer public scrutiny, with increasing demands that good quality, safe aquatic products be produced by environmentally responsible technology. Breeding and reproduction have a critically important role in ensuring that the goal of increased production by acceptable means is achieved.

2. INTRODUCTION

The European farm animal breeding and reproduction industry is on the threshold of a new era with evolving biotechnologies and the challenge of finding a sustainable answer to breeding. Breeding and reproduction industries in Europe have started to direct their breeding strategies towards more sustainable breeding, including for example disease resistance, product quality, overall efficiency, longevity and other not direct economic traits into their breeding goals (e.g., Aqua Gen, 2001; Interbull, 1999; Lohmann, 2001; PIC, 2001; Seghers, 2001). At the same time, there is growing scientific and societal interest in genomics and other biotechnologies, for example, due to the recent imports of GM crops and the development of transgenic and/or cloned animals for medical purposes. Although European breeding organisations have little interest in the application of cloning and transgenesis for food production in farm animals, they are starting to use genomics (marker-assisted selection, marker-assisted introgression, parentage identification, traceability of food/animals) and reproduction biotechnologies (e.g., embryo technologies). Nevertheless society is concerned with both present and future breeding practices and would like to be involved (EC-ELSA, 1999).

In discussions about sustainable animal production there can be some confusion as to exactlywhat is meant by 'sustainability' (Olesen et al., 2000), particularly since in the realm of farm animal breeding and reproduction no common definition of sustainability is available. But with (bio)technological developments giving more possibilities on the one hand, and European societal opinion setting more and more constraints on the other hand, the need for clear, economically sound and society accepted breeding prospects for Europe is apparent.

In the present paper we will present one possible definition of sustainability in aquaculture and use this definition to review current practices and discuss future options for reaching a more sustainable aquaculture by breeding in Europe.

3. CURRENT STATUS OF SUSTAINABLE BREEDING AND REPRODUCTION

3.1. Traits to be considered

In many fish species, domestication has only just started. In recent years, selective breeding programmes have been initiated for the majority of fish species cultured in Europe. In only a very few species has domestication and selection been in progress for more than 7 to 8 generations (trout, carp, and salmon). In these breeding programmes, the following traits are considered:

3.1.1. Growth rate

Most breeding programmes in fish concentrate on improving growth rate and, related to that, meat yield. The response to such selection is often significant with increases from 10 to 14% of weight per generation reported.

3.1.2. Efficient feed conversion

Fishes are poikilotherms and that part of the energy budget spent on basal metabolism is lower than in higher vertebrates. In wild or recently domesticated animals, such as Atlantic salmon or seabream, improvement of FCR is suspected to be a result of improved growth efficiency and a decrease in energy spent in eating, rather than in the energy spent to maintain basal metabolism. In species which have been domesticated for several generations (carp and rainbow trout), trials to demonstrate improvement in FCR have failed. As for other species, increased growth rate results in improved feed efficiency due to a shorter growth period and hence the time for meeting maintenance requirements. However, the efficiency of such indirect selection decreases with an increasing growth rate. Other researchers have argued that selecting for fast growth rate is in fact synonymous with selecting for better conversion efficiency. In this case it is said that growth is faster in fish that exhibit enzymatic mechanisms that are more efficient at converting ingested nutrients into meat. Therefore, selection for growth rate is the consequence of selection for lower FCR, and these two characters are often correlated.

3.1.3. Carcass and meat quality traits

In the salmon and seabream industry, quality traits are now gradually included in breeding programmes. These are primarily muscle fat content, fat distribution and, in salmon, meat coloration. The first two are a consequence of feeding high energy diets, which are rich in fat (up to 30% or more). Feeding astaxanthin to the fish induces meat coloration and the efficiency in uptake of this compound has a genetic component. Body morphology is also introduced to improve fillet yield.

3.1.4. Resistance to specific pathogens and parasites

In many cases, fish farming is carried out in the open environment and many diseases cannot be controlled. In the salmon industry fish are being selected for increased resistance against furunculosis (bacteria) or the infectious salmon anaemia (ISA) virus. Genetic variation in resistance to sea lice in Atlantic salmon is being studied in Norway.

3.1.5. Deformities

Significant genetic variation in deformities such as short tail and jaw deformity has been reported for salmon. Such deformities can be a severe problem, and are being considered for inclusion in selective breeding programmes. However, in most cases, environmental and management conditions are seen as the primary causes of the malformations.

3.1.6. Age at first reproduction and spawning season

In many species, commercial size is achieved after sexual maturation. In salmon, the delay in spawning age by selection is practised to avoid deterioration in meat quality and processing yields. Natural genetic variation of the moment of spawning at one age has been used to select strains of rainbow trout of early or late spawning season. Control of reproduction time by photoperiod and temperature manipulation avoids selection on this trait. At the same time, reducing the generation interval by reducing the age at first reproduction will increase genetic progress significantly. Ideally, therefore, fish should be induced to reproduce early by environmental manipulation while at the same time selection would be for late maturation. However, recent reports indicate that advanced or delayed spawning can have negative impacts on the quality of fry, due to a mismatch between environmental parameters and developmental programmes.

3.2. Factors to be taken into consideration

3.2.1. Differences between fishfarming and animal livestock farming

Aquaculture being a relatively recent farming activity, the feeding and breeding technologies used are often adaptations from those used in livestock farming. However several factors combine to make fish decidedly different. Many fish species, in particular salmon and marine fish, are fed diets containing fish protein and highly unsaturated fatty acids, typically found in pelagic fish oils. While fish protein can be replaced by other sources (e.g. soybean), these species are highly dependent on dietary fish oils. Fish are also more dependent on their environment in terms of water temperature and quality. Finally, while livestock have little chance to breed with wild con-specifics, fish have many opportunities. The consequences of these and several other factors for the future development of aquaculture breeding programmes are discussed below.

3.2.2. Use of marine resources

The development of the aquaculture industry is mainly based on fish feeds containing ingredients derived from capture fisheries, particularly in the case of aquafeeds for carnivorous species. In recent years aquafeed manufacturers are increasingly trying to replace part of the marine protein by cheaper plant ingredients. Fish oil is however still an essential ingredient, although means to reduce its inclusion rate are being sought by a number of EU-funded networks. There is no evidence that the use of wild-caught feed ingredients in aquafeeds has had an impact on the stocks of wild fish (aquaculture is merely utilising an increasing proportion of static supplies of fish meal and oil, while use for feeds for other livestock is falling). However, unless increased supplies of these commodities become available (e.g. from mesopelagic fish and/or krill) or means of reducing their feed inclusion levels are found, the expansion of intensive farming of carnivorous species may be constrained (New and Wijkstrom, 2002).

3.2.3. Cost efficiency

Fish are three to four times more expensive than other animal meat, and a reduction in the costs of production is an important objective for aquaculture. Decreasing the duration of the farming cycle by increased growth efficiency is the first way of achieving this objective. This provides an opportunity to increase weight at slaughtering while minimising the risks and costs of rearing, and to diversify for processing and consumers. Other factors that influence indirect costs are diseases, efficiency of pigment retention, and optimised processing procedures.

3.2.4. Environmental impact

In fish, though lower feed conversion ratios are observed compared to terrestrial livestock (0.9 to 1.2 kg of feed / kg fish produced), the faeces are rich in suspended materials, phosphorus and ammonia. Fouling is a particular problem associated with marine cage culture, although beneficial effects (fauna enrichment) have also been recorded. In some countries, fish culture is practised in highly intensive land-based systems with complete filtration and recirculation of water. Such systems are more expensive than cage culture but have very limited environmental impact. It is not yet clear whether these systems give rise to better consumer perception than cage culture.

3.2.5. Dissemination of diseases

Aquaculture can disseminate associated diseases to surrounding wild populations. One of the reasons for the decline of natural populations is believed to be the result of increased parasitic load and other diseases originating from farmed fish. In salmon, infestations with sea lice are a common problem and some people believe that sea lice from farmed salmon are increasingly infecting wild populations.

3.2.6. Specialisation of genotypes for different farming environments

Several types of environments are used to farm the same species. Farming systems vary from extensive conditions in ponds (low density of 0.5 to 5 kg fish / m^3 of water without artificial feed) to semi-intensive conditions in raceways and cages (intermediate density of 15 to 80 kg fish / m^3 water; artificial feed). In systems which use complete recirculation, even higher high densities of 50 to 300 kg fish / m^3 water are used.

3.2.7. Genetic interaction with wild stocks

Marine fish species are reared in open environments. Breeders have often come from the wild only a few generations ago and can always reproduce with their wild con-specifics. Non-interaction with wild populations is therefore of prime importance to prevent modification of genetic characteristics of wild stocks. Current solutions focus on the production of triploids for aquaculture, but several reports indicate negative impacts of triploid induction on the physiology and morphology of the animals.

3.2.8. Animal integrity and reproduction

Here, 'animal integrity' relates to physiological and morphological traits. Selection on only a few traits related to growth can lead to similar types of intensive farming disorders as have already been seen in terrestrial animals. Examples are weak bones and malformations (head and fin shape), impaired swimming (deformed swim bladders), problems related to respiration (cardiac and breathing systems) and reproduction dysfunction. Aquaculture animals, because they are small, are produced in large numbers with no attention paid to individuals. Many environmental factors and production processes that interact with animal integrity during the larval stages are still not well known and are often manifested by deformities in the adult stages. Part of this problem is located in the poor efficiency of reproduction. In species like seabass and seabream, large larval mortalities are accepted, as producing huge numbers of eggs can compensate for them.

4. OPTIONS FOR CHANGE IN SUSTAINABLE BREEDING AND REPRODUCTION

4.1. New perspectives

To date very few negative effects are documented in cases where modern breeding programmes have been developed. The introduction of new traits in future breeding programmes is thus considered not as a necessity to correct negative effects which occurred in previous decades, but as a way to better adapt genotypes to new developments in the industry and to avoid the negative side effects which have been experienced in terrestrial farm animals. Modern reproduction technologies and genomics offer new perspectives for fish breeding programmes some of which are described below.

4.2. Specialisation of genotypes for different farming environments

Few experiments currently deal with interactions between farming systems and genotypes. The adaptation of one single genotype to the different conditions experienced in ponds, raceways, or sea cages, is unlikely. However, so far little evidence for genotype by environment interaction has been found. Apart from this, differences in rearing environments, in breeding programmes and breeding goals should be considered. The effects of density and water quality parameters in (semi-) intensive systems on the interaction between animal welfare and behaviour, and disease resistance and growth, need to be studied. Limits to rearing density are set by the carrying capacity of the system in terms of oxygen, pH, ammonia and nitrite. The negative effects of sub-optimal values for these parameters are well known and are part of the management of a system. On the other hand, little evidence has been found that high density by itself is stressful for fish (in fact, for some species, the opposite has been shown to be the case). There is also evidence that domestication selection by itself changes the behaviour of fish and reduces cannibalism. To further address this question, genotype by environment interaction needs to be studied further. Based on this the use of different environments could be considered in breeding plans as a way to obtain animals that are better adapted (more robust) and more capable of handling stress.

4.3. Improvement of meat quality traits

There is little knowledge concerning the genetic basis of fat level in muscle and flesh pigmentation. Even less is known about their interaction with texture and other factors such as collagen and muscle fibre recruitment. Knowledge of the genetic basis of processing traits (gutting, filleting) and the yield from smoking or cooking is also lacking. This will be very important in the future to optimise the general efficiency of farming by the increase of the final quantity and quality of flesh produced and consumed. The production of monosex and sterile fish populations may also contribute to the improvement of these traits.

4.4. Improvement of resistance to specific pathogens

Very little is known about the genetic bases of disease resistance in fish. Resistance can be either general, or specific to a particular pathogen. However, for many pathogens (*Yersinia ruckeri*, *Myxobacteria*, *Nodavirus* sp., etc.) it is not known whether a genetically determined resistance or susceptibility exists. Studies on the immune system and MHC genes in salmon show that although the organisation of the immune response in fish is similar to that of the higher vertebrates, the organisation of the MHC and the type of antibodies produced are essentially different. Information on the relationship between disease resistance and selection for growth rate or domestication selection is completely lacking.

It is generally recognised that the development of lines with better resistance to specific pathogens can improve overall survival. Selection for a general trait such as health/growth rate/domestication is an alternative to selecting for specific pathogens. This may result in a decrease in the use of antibiotics, and safer food for consumers. However, disease resistance is a difficult trait to measure in fish without killing them. Therefore, most efforts are currently concentrated on finding quantitative trait loci for resistance to specific diseases. It is not clear whether improved resistance to one disease leads to correlated responses in other traits, e.g. resistance to other diseases.

4.5. Ability to consume plant ingredients

Breeding programmes are currently selecting for animals showing better performance on high fat diets. Knowledge concerning the genetic basis of the ability to consume new aquafeed formulations composed with plant ingredients (proteins, lipids, and carbohydrates) is very scarce, and the selection of new genotypes better adapted to new feed formulations remains a challenge. A more critical look is needed at the globalization of food systems and the energy involved in specialization and distant transport of high volume food or feedstuffs.

4.6. Maintenance of animal integrity and animal welfare and prevention of related disorders

Phenotypic and genetic parameters of traits related to animal integrity (normal morphological development and normal swimming, respiratory and reproductive functions) and their correlation with production traits such as growth rate are lacking. More understanding of welfare indicators in fish is needed, as we know very little about their perception of pain and satisfaction, and what kind of environment they prefer. Ethical values and public acceptance are critical and should be taken into consideration.

4.7. Improvement of feed conversion

The selection of more efficient genotypes without altering growth is still not practised, primarily since technical ways to measure feed efficiency individually have not yet been invented. Because it is difficult to measure individual feed conversions in fish, instead FCR is measured for groups of siblings or families. Few studies have dealt with the genetic bases of the efficiency to use specific ingredients or biochemical compounds. Direct selection for feed efficiency is desirable, but this requires recording feed intake on individual fish or groups of fish, which may be very costly. Therefore, for a further increase in feed efficiency, selection for growth rate should be combined with selection for less energy in the gain. Furthermore, selection for feed efficiency may affect the requirement for energy and nutrients, and this should therefore be monitored in order to provide optimal diets. This topic is of particular importance for the reduction of water pollution. Attention should always be paid in selection programmes so that selection is for faster-growing fish with the same or better FCR and not for greedier fish.

4.8. Biotechnology and fish

As in plants, associations between quantitative genetic traits and genetic markers and parthenogenesis are currently being explored as means to improve selection strategies. Marker-assisted selection in combination with parthenogenesis can be used to find QTL, fix genes or to speed up the diffusion of the genetic progress. The only example used in fish today is to fix the sex-determining gene in trout to produce all-female populations. The extension of this approach to other traits could open new applications, but its cost-effectiveness will depend very much on the heritability of the trait in question.

4.9. Sterile fish and preservation of the wild stocks

Salmon can and do escape and breed with their wild conspecifics. To date the only method of prevention is to produce sterile fish by triploidisation. Public perception of polyploid fishes could be a problem, and information on environmental stakes needs to be initiated. More research is required on the subject of producing sterile fish in an acceptable (from the point of view of the consumer) and commercially viable way. This means that fish need to be as productive, or more productive, than their non-sterile counterparts. A possibly better alternative to producing genetically modified sterile fish may be the evolution of production technologies in closed (re-circulation) culture systems that will, to a great extent, end the risk of contamination of wild stocks with farmed individuals. Polyploidy induction is advocated as a tool to decrease genetic interaction between domesticated and wild populations. International organisations concerned with the development of aquaculture (FAO), the International Council of Exploration of the Sea (ICES), and the preservation of endangered species such as salmon (NASCO) are encouraging the use of sterile triploid salmon, which, as in plants, are not considered as GMOs (EU Directive 90/220/CEE of 23 of April 1990). Other ecological effects of escaped triploid fish, such as continued growth, also need to be studied. Furthermore, public perception could be the main problem, and information on environmental stakes needs to be initiated.

5. CONCLUSIONS

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REFERENCES: a full reference list can be obtained from the senior author by email only (Hans.Komen@alg.venv.wau.nl)

THEMATIC AREA IV

Nutrition and Feeding: Knowledge acquisition and transfer of know-how in feed production and management strategies

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ABSTRACT: All animal production depends on a controlled management of feeding practices which should provide for the essential nutrients and energy in the most acceptable form and manner. Aquaculture has a major role in ensuring nutritional security of humans. Irrespective of the culture system, economic as well as biological viability are dependant on the provision of the most adequate feed supply. Although a large variety of species are involved in aquaculture, our knowledge on the nutrition and feeding is limited to a few major groups. But, it is generally accepted that, in the absence of definitive information with regard to a particular species, much can be learnt from other closely related biological models. From a practical point of view, it is necessary to evaluate how far the variety of practices already in use have proved themselves to be efficient in serving aquaculture in a sustainable manner. The aim of this session will be a) to stress the importance of sound nutrition and feeding on most issues facing the aquaculture such as productivity, environmental and product quality and food safety; b) to illustrate the functional role of nutrition in ensuring complete domestication including reproductive success and larval development and c) to discuss on how far existing know-how can be extended to other species and situations.

1. INTRODUCTION

Fish are in general low in calories but high in protein of very good biological value with an ideal amino acid balance, rich in w3 polyunstaurated fatty acids and in several micronutrients. It has even been postulated that the evolution of the modern human brain depended very much on the dietary supply of docosohexanoic acid (DHA, a major polyunsaturated w3 fatty acid) provided by marine sources (Broadhurst et al. 1998; Crawford et al. 1999). It is well recognised that fish and shellfish contribute significantly towards human nutrition and health. Besides being an excellent protein source, fish is also the unique supplier of long-chain w3 polyunsaturated fatty acids involved in brain development and vision as well as in protection against cardiovascular diseases and some cancers (Nettleton, 1991; Sargent, 1997). It is also known that over the years, the fatty acid status of the human populations have undergone significant changes with a significant decline in w3 fatty acid intake with a concurrent rise in w6 and trans fatty acid intakes (Simopoulos, 2001), leading to a number of nutrition-related disorders.

It is evident that from a human nutrition perspective, a strong emphasis on fish intake is required, fish being the unique source of the long-chain w3 polyunsaturated fatty acids. However, it should also be borne in mind that the flesh composition of fish is very much related to the dietary fatty acid profile. In this context, aquaculture has a major role, in as much as tailoring fish flesh composition is possible (Kaushik, 1997) paving the way for the supply of the essential nutrients to those in need in an efficient manner.

Fatty Acid Status across Populations

Population	w6/w3 ratio
Paleolithic	0.79
Greece before 1960	1.00-2.00
Current United States	16.74
Current UK & N. Europe	15.00
Current Japan	4.00

From Simopoulos, 2001

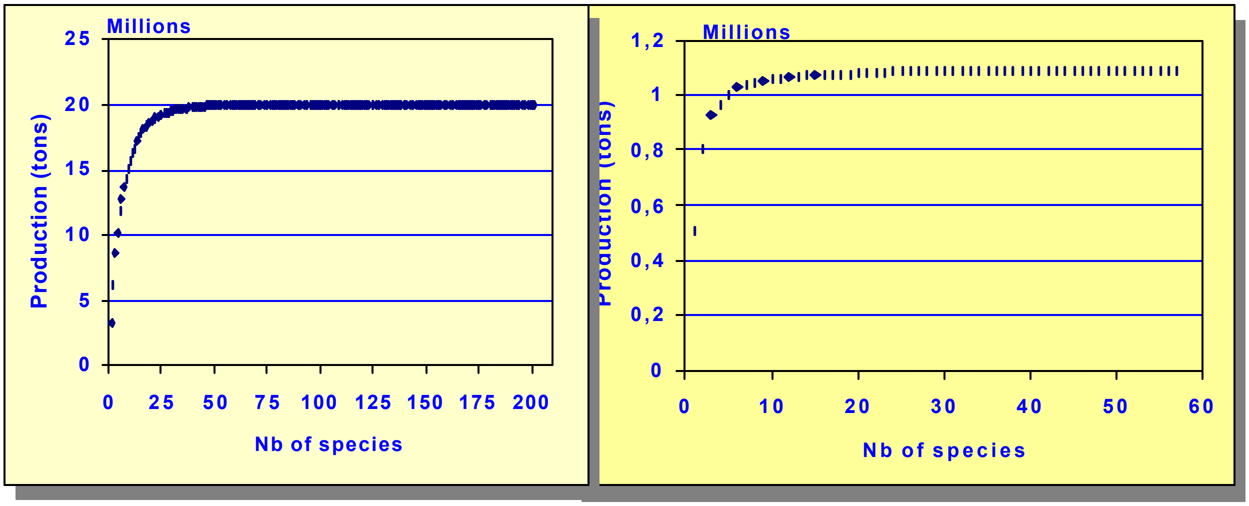
2. INCREASING ROLE OF AQUAFEEDS IN AQUACULTURE DEVELOPMENT

Indeed, aquaculture's contribution toward total world fisheries landings has more than doubled, increasing from 11.4% of total landings in 1984 to 26.3% of total landings by weight in 1996. Although as a continent, Asia is the primary producer as well as the consumer of fish and shellfish, differences do exist between countries and areas within countries. Aquaculture development currently witnessed in Asia is getting more and more towards intensification with the concurrent advantages and drawbacks.

Issues facing aquaculture are (i) to increase productivity, environmental and product quality and food safety, (ii) ensure complete domestication, reproductive success, larval development and (iii) strengthen our knowledge on the functional role of nutrition. Given the variety of species under culture, it is also of importance to know how existing knowledge and know-how from a limited number of species can be extended to other species and situations. Resource allocation management is another issue that we have to consider in the global context of provision of food for the human kind in the most efficient manner. In this context, it is worth considering the following facts. Compared to terrestrial animal production systems, aquaculture is (i) more efficient in terms of energy utilisation, (ii) more flexible in terms of production systems, but (iii) more demanding in protein and (iv) more sensitive to anthropogenic impacts affecting the aquatic environment

With an increasing demand for higher value species rather than for fish species that have traditionally been grown under semi-intensive pond based, polyculture systems and fed on natural food, formulated complete aquafeeds are being used more and more even in Asia (nearly 30 million metric tons). This increasing need for formulated feeds also leads to an increasing demand for good quality fish meal and fish oil, the production and availability of which has remained more or less stable over the last decade.

Since feed costs remain the major portion of the production cost, attempts towards reduction of such feed costs should not overlook the importance of the supply of essential nutrients and energy to the different species concerned. On a global scale, although the total number of species cultivated is high, quantitatively, less than thirty species represent more than 95% of production. Since precise quantitative data are not available even for these thirty odd species involved, the extension of data from one species to another has been a common practice. We need strengthened efforts to remedy this situation. In developing feeds, efforts should be made to develop formulae which depend on locally available ingredients rather than on relying on few major ingredients derived from marine fisheries.



Globally or on a regional basis, a very small number of finfish species represent more than 95% of production

3. NUTRITION AND FEEDING FOR SUSTAINABLE AQUACULTURE DEVELOPMENT

3.1. Research for alternatives to fishmeal and fish oil in fish feed

Research for alternatives to fishmeal and fish oil in fish feed has been a major thrust area for more than thirty years and considerable advances have been made. Under practical conditions, our objective is to make the aquaculture sector a net contributor to the world fish supply rather than being a net consumer of food-grade fishery resources (Naylor et al., 2000). While it has long been known that replacement of fish meal with plant protein sources is definitely possible (Kaushik, 1990; Kaushik et al. 1995), recent work towards the replacement of fish oil by terrestrial plant oils studies has also led to very convincing results (Regost et al. 2002). The true concern lies in the efficiency with which aquafeeds can incorporate a greater proportion of alternative ingredients supplying the essential nutrients while still maintaining the quality of fish products for human consumption.

3.2. Fish Nutrition and Environmental Quality

Besides resource allocation management, aquaculture, like any other animal production system, has to bear in mind the environmental consequences of the food production activity. In feed-based aquaculture, from a nutritional point of view, the major objective is to reduce the release of nutrients at the source, by improved feed formulations and through appropriate feed management strategies. It is of interest to note that finfish nutrition research has taken up the challenge and responded much faster than other terrestrial animal production systems as witnessed by several major symposia held on the "Nutritional Strategies for Management of Aquaculture Wastes (NSMAW)" (Cowey and Cho, 1991, J. Appl. Ichthyol., 1995, vol.11, (3-4); Aquat. Living Resources, 1998, vol. 11 (4)). It is clear that in this particular field, lessons learnt from some species can be extended to others, as evidenced by applicability of basic models developed for salmonids (Cho and Bureau, 1998) to other species (Kaushik, 1998).

3.3. Fish Nutrition and Flesh Quality

As mentioned above, a major concern is that of the provision of nutritious and safe food from aquaculture. There is an ever-increasing amount of information available on the possibilities of tailoring flesh quality at least as regards fat-soluble components such as fatty acids, fat soluble vitamins and pigments mostly in species under intensive culture conditions. There is a definite lack of such information for those species cultivated under semi-intensive conditions with nutrients being supplied both from natural productivity of the water body and from external feeds.

While in some cases, there is precise definition of quality and efforts are made towards "labelled products", criteria for the definition of "quality" tend to vary depending upon socio-geographic considerations. But, while the major objective here is to continue to ensure the nutritional value of aquaculture products, one might also question as to whether all aquaculture systems are capable of meeting such demands.

3.4. Role of nutrition in the Domestication of Cultivated Species

In the context of full domestication, nutrition has a major role not only in ensuring broodstock and quality of gametes, on which rely further development and growth over the full cycle. Proper understanding of the interaction between nutritional factors and endocrine regulation of growth and reproduction is an area which requires more attention. There is ample evidence today to show that dietary factors can modify broodstock quality and performance: while there are positive beneficial effects of essential fatty acids or vitamins on broodstock performance (Luquet and Watanabe, 1986), there are also situations where other feed derived phytoestrogens for instance can affect reproductive function (Bennetau et al. 2000). Thus there is a need for increased awareness of all possible effects of nutritional factors on reproductive function.

Too much dependence on live prey for larval culture should be reconsidered. Development of adequate larval diets can only permit us to determine the nutritional requirements of larval stages. Despite considerable success in this area with regard to cyprinids (Charlon and Bergot, 1984), and given the importance of cyprinid production in world aquaculture, it is surprising that they are still not under practice on a large scale. Recent work undertaken by Cahu et al. (1998) and subsequent development of complete feed for first-feeding European seabass larvae without any live prey supply is a considerable achievement which can remove a major bottleneck in the area of marine finfish rearing.

3.5. Feed technology and Management of Feeding Practices

Aquafeed development involves specific technologies in order to meet all the physical quality standards required for growing fish from less than a few mg to those weighing more than 5 kgs. Diet processing technologies have to be adapted to produce diets with particle sizes ranging from 100 µ to more than 9 mm in diameter, while maintaining all the nutritional characteristics in tact. Several other aspects such as water stability, palatability, texture, friability, fines, density, floatability, gelatinisation, fat coating also require specific technological adjustments (Kaushik, 2001). On a nutritional scale, development of high nutrient dense diets have indeed allowed the salmon culture to develop a very efficient production system. Currently, attempts are also being made towards development of improving fecal decantation characteristics in order to facilitate the removal of suspended matter from aquaculture operations.

Feed management is an area where concerted efforts are needed not only to improve economic efficiency, but also to avoid damage to the aquatic environment. Efforts over the past decade have led to the proper consideration of endogenous rhythms of the fish and towards development of feeding systems that enable very little feed wastage. Application of bioenergetic principles can indeed be useful in drawing adequate feeding charts provided proper information on the biomass under culture is available. Under pond culture conditions, simple self feeders such as those used in some carp culture conditions is an important advance in reducing feed wastage and thus improving the economics. The major motto here is to feed the fish but not the pond.

4. TRANSFER OF KNOW-HOW AND TECHNOLOGY

Besides knowledge acquisition in the field of fish nutrition by researchers, adequate feed development needs close interaction between the industry and farmers. Under the umbrella of the International Symposia on Fish & Shellfish Nutrition (IUNS), the committee on fish and shellfish nutrition and production has held a number of symposia almost every other year in different parts of the world. The charter of the committee is "Nutrition and Production of finfish and shellfish for better human health" in a better environment".

With regard to EU and Asia, there have also been cooperative research and training initiatives under the AADCP. Clear statements have been made at the Bangkok summit with regard to the importance of nutrition research and feeding for sustainable aquaculture development. Basic research should continue to exert its strength in terms of prospective research on scientific excellence rather than in response to demands. Cooperative research with the different stakeholders involved can comply with the demands of societal relevance.

To illustrate the efforts with regard to the questions on alternatives to fish meal and fish oil in fish feed, it is worth indicating here that under the V framework programme of the EU, several research projects are under way covering all aspects of biological significance as well as social issues involved.

REFERENCES

Broadhurst, CL., Cunnane, SC., Crawford, MA., 1998. Rift Valley lake fish and shellfish provided brain-specific nutrition for early Homo. Br-J-Nutr., 79: 3-21.

Bennetau - Pelissero, C., Bennetau B., Cravedi J.P., Helou C., Le Menn F., Kaushik S.J. 2000. Effect of genistein enriched diets on testosterone plasma levels in male and female rainbow trout during gametogenesis. In: Phyto-oestrogens: exposure, bioavailability health benefits and safety concerns. Publication Cost (EU) 916, pp 105-110.

Cahu, C.; Infante, J. Z.; Escaffre, A. M.; Bergot, P.; Kaushik, S. 1998 Preliminary results on sea bass (*Dicentrarchus labrax*) larvae rearing with compound diet from first feeding. Comparison with carp (*Cyprinus carpio*) larvae Aquaculture 169 1 1-7.

Charlon, N, Bergot, P., 1984. Rearing system for feeding fish larvae on dry diets. Trial with carp (*Cyprinus carpio L.*) larvae. Aquaculture, 41: 1-9.

Cho, C. Y.; Bureau, D. P., 1998. Development of bioenergetic models and the Fish-PrFEQ software to estimate production, feeding ration and waste output in aquaculture Aquatic Living Resources. 11(4): 199-210.

Cowey, C. B.; Cho, C. Y., 1991. Nutritional strategies and aquaculture waste. Proc. 1st Int. Symp. Nutritional strategies in management of aquaculture waste. Univ. Guelph, Guelph, Ont, Canada, 1990, 275p.

Crawford, M. A., Bloom, M., Broadhurst, C. L., Schmidt, W. F., Cunnane, S. C., Galli, C., Gehbremeskel, K., Linseisen, F., Lloyd-Smith, J., Parkington, J., 1999. Evidence for the unique function of docosahexaenoic acid during the evolution of the modern hominid brain. Lipids, 34 Suppl: S39-47.

Kaushik, S. J. 1990 Use of alternative protein sources for the intensive rearing of carnivorous fishes. In: Mediterranean Aquaculture, (R. Flos, L. Tort & P. Torres, eds), Ellis Horwood, UK. pp 125-138.

Kaushik, S. J. 1997. Nutrition/feeding and body composition of fish. Cahiers de Nutrition et de Dietetique, 32: 100-106.

Kaushik, S. J., 1998. Nutritional bioenergetics and estimation of waste production in non-salmonids Aquatic Living Resources. 11(4): 211-217.

Kaushik, S.J., 2001. Feed technologies and nutrient availability in Aquatic feeds. In: Advances in Nutritional Tehnology, Proc. 1st World Feed Conf, Utrecht, (A.F.B. van der Poel, J.L. Vahl & R.P. Kwakkel, Eds), pp 187-196.

Kaushik, S. J.; Cravedi, J. P.; Lalles, J. P.; Sumpter, J.; Fauconneau, B.; Laroche, M., 1995. Partial or total replacement of fish meal by soybean protein on growth, protein utilization, potential estrogenic or anti-genic effects, cholesterolemia and flesh quality in rainbow trout, *Oncorhynchus mykiss* Aquaculture 133 3 257-274

Luquet, P, Watanabe, T., 1986. Interaction "nutrition-reproduction" in fish. Fish Physiol. Biochem 2: 121-129

Naylor, R. L., Goldburg, R. J., Primavera, J. H., Kautsky, N., Beveridge, M. C. M., Clay, J., Folke, C., Lubchenco, J., Mooney, H., Troell, M., 2000. Effect of aquaculture on world fish supplies Nature, 405, n°. 6790: 1017-1024.

Nettleton, J. A. 1991 w-3 Fatty acids: comparison of plant and seafood sources in human nutrition. J. Am. Diet. Assoc., 91: 331-337.

Regost, C., Arzel, J., Robin, J., Rosenlund, G., Kaushik, S.J., 2002. Total replacement of fish oil by soybean or linseed oil with a return to fish oil in turbot (*Psetta maxima*). 1. Effects on growth performance, fatty acid profile and lipid metabolism. Aquaculture (In press).

Sargent, J. R., 1997. Fish oils and human diet. Br. J. Nutr., 78 Suppl: 1 S5-13.

Simopoulos, A. P., 2001. Evolutionary aspects of diet and essential fatty acids. World Review of Nutrition & Dietetics, 88: 18-27.

Effect of replacing fish oil and meal in aquaculture diets on growth, feed utilisation and product quality.

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ABSTRACT: For optimal growth fish require not only a minimum level of protein, but also that the essential amino acids are balanced to meet the requirement of each single one. This can easily be done by using fish-meal as the main protein source; however, the amount of fish meal on a world wide basis is not high enough to cover the need for the constantly growing aquaculture industry. Protein requirement varies between species, but is generally high (>30%) even for the most omnivorous species. For catfish (omnivorous) around 32% protein is required (Wilson R.P. 2001, pers.com.), and for this species all the protein (98%) can come from a mixture of plant protein - in commercial diets mainly soy-bean. Using this almost "all-veggie" feed still results in satisfactory growth and feed utilisation. In a study with Nile tilapia (*Tilapia nilotica L.*) (also omnivorous) indications of even better digestibility and feed utilisation were found when anchovy meal was fully replaced by soybean concentrate, again showing no need for fish meal in diets for this species. For the more strictly carnivorous species, such as Atlantic salmon, there is still a challenge to optimise dietary proteins focussing alternatives to fishmeal, and only special qualities of plant proteins, or low levels of these, can be used without any negative effects on production results. In intensive aquaculture in Norway (and EU) most species are strictly carnivorous, showing protein requirements from 38% and higher (dm), and giving the best production results when using high quality fish meals such as LT-meal with minor additions of other protein sources. In addition to well-balanced dietary amino acids, the protein digestibility and absorption rate of each amino acid are of utmost importance. To increase protein retention from the diet, the quality and mixture of different proteins and the inclusion of partly pre-digested proteins have shown good results.

Even more critical for the fast-growing aquaculture industry is the need for alternatives to fish oils. Several studies have shown that lipid digestibility, feed utilisation and product quality are highly influenced by the dietary lipid level and by the fatty acid pattern in the diet. Fish health, as well as human (consumers) health, will be influenced by intake of some of these fatty acids. In focus are both mono-unsaturated and poly-unsaturated fatty acids. There is a large EU-project going on where fish oils with high contents of PUFA are partly substituted by plant oils with higher levels of monoenes and where the contents of n-3 fatty acids are shorter (not PUFAs) (i.e. linoleic acid). Some results from this study will be presented and discussed in relation to beta-oxidation vs. retention of different fatty acids.

I. INTRODUCTION

The growth in aquaculture production in the last decade, the prognosis for expected growth, and the need for cost-efficient feed resources in addition to traditional fish oil and meal, have resulted in increased demand for alternative feed resources of similar qualities to fully or partly replace the traditional marine ingredients. Such alternative resources must ensure the same production results, in terms of fish growth, health and product quality as obtained when using high quality fish meal and oil as feed ingredients.

By changing to alternative ingredients the aim is economical and environmental friendly usage of feed resources, and to secure production of safe and healthy seafood.

2. ANALYSIS OF FEED COSTS

Feed costs account for around 50% of total production costs and are the single factor with greatest impact on cost-efficiency in aquaculture production. Both because of costs and limited availability of fish oil and fish meal, the industry stands to gain by having alternative resources giving the same growth, digestibility and impact on fish health and fillet quality, as when the traditional ingredients dominate feed composition. The availability of fish oil and meal is expected to be a limiting factor for cost-efficient production well within the next decade. According to IFOMA (International Fishmeal and Oil Manufacturers Association), 1.2 - 1.4 million tons of fish oil and 6 - 7 million tons of fish meal are produced in a "normal" year, with two thirds of these quantities being produced in Chile and Peru. This means a dramatic reduction in years when "El Nino" occurs, as in 1998 when fish oil and meal prices increased by 50% and 20% respectively. FAO (Food and Agriculture Organization of the United Nations) and IFOMA 2000-statistics show a yearly aquaculture production of 19.2 million tons, requiring 2.1 million tons of fish meal. From 1988 to 1998 utilisation of fish meal for aquaculture production increased from 10 to 30% of total fish meal production. Currently somewhat more than one half of world fish oil production is used in aquaculture feeds with salmonid feeds alone consuming more than one half of the total oil used for aqua feeds. IFOMA currently estimates that, given continuation of the current rate of expansion of aquaculture, global demand for fish oils for aqua feeds will equal the total global supply of fish oils by circa 2009.

3. ALTERNATIVE SOURCES/REPLACEMENTS FOR FISH OILS

3.1. Plant proteins and oils

Plant proteins and plant oils have been tested industrially as partial replacements for fish meal and fish oil in fish feeds ingredients for several years now, with considerable success. However, results on different inclusion levels and qualities of soya-beans, gluten from corn and wheat, and various plant oils have shown that changes can occur in gut morphology, digestion, protein and fat retention, fillet composition and fish health. This is especially the case when replacement is extensive, or if it generates imbalances in fatty acids or amino acids, or if the replacing materials are insufficiently refined. However, neither the amino acid patterns of plant proteins, nor the fatty acid patterns of plant oils, nor the protein or lipid classes in plants, match the composition of the marine ingredients. Therefore, more knowledge on sophisticated mixing of various quantities and qualities of these new ingredients is urgently required.

3.2. By-catch, by-product and untargeted fish species

As an alternative to fish meal, at least in Norway, is the direct (on-line) utilisation of either unexploited pelagic organisms, or utilisation of by-catches / by-products. Figure 1 shows growth performance of Atlantic salmon given either a control diet based on fish meal and oil, or two experimental diets, season and by-catch, both based on by-products of different mixtures. The results show the possibility to obtain the same growth performance using a by-product based feed and a tradition fish meal + oil diet.

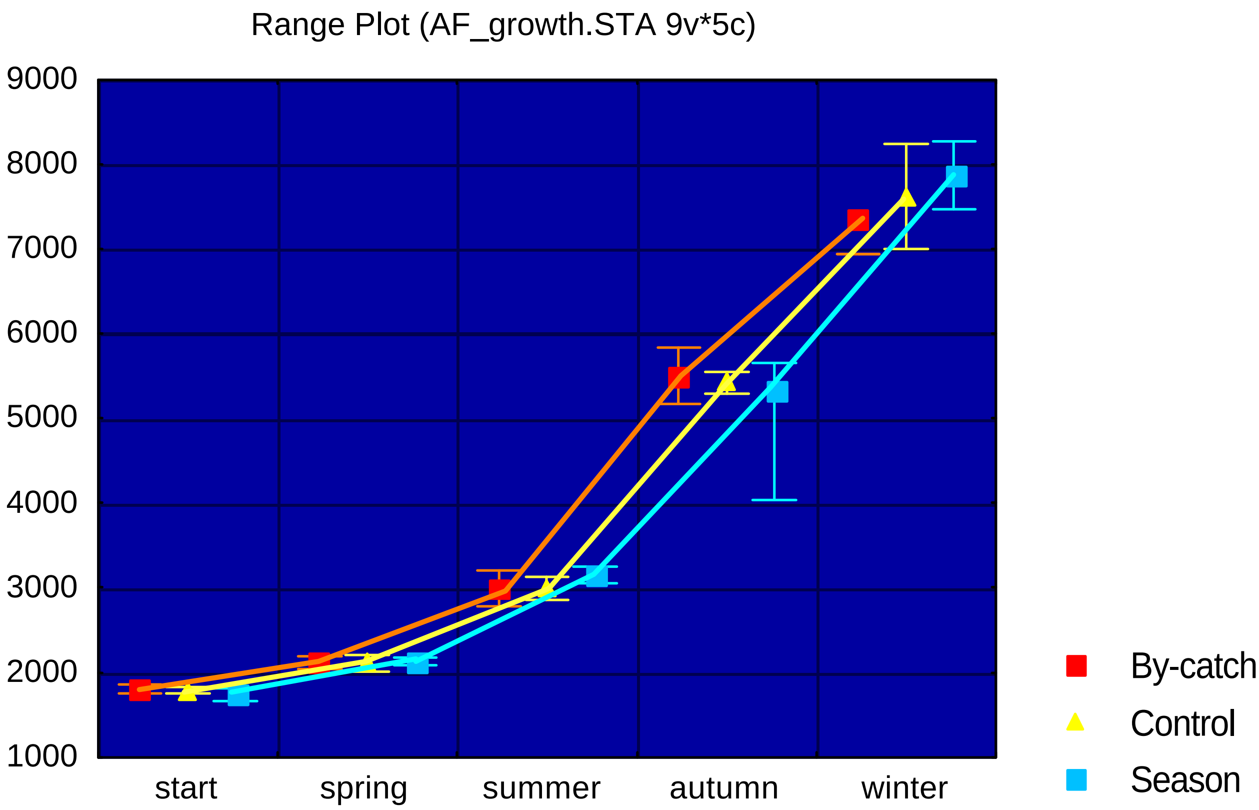

Figure 1. y-axis gram live weight, x-axis shows season, start is beginning of March (every season lasts for 3 months), the groups By-catch and Season are given by-product based diets, the control is given a fish meal and oil based diet. The salmon were fed in triplicate throughout one year.

Condrico AB and Ewos Innovation have tested suprex pea (special Condrico AB treatment of the plant protein) with good results (shown in Figure 2). Their results shows that it is possible to obtain the same growth and feed utilisation when pea-protein replaces more than half of the protein. These data were kindly given by Karl-Erik Slinning and Mattew Kouzeh - and are preliminary.

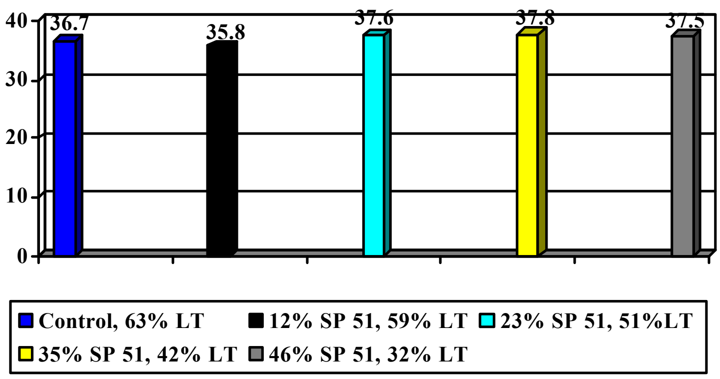

Figure 2. Growth of Atlantic salmon fingerlings, y-axis shows live weight gain (8 weeks). No difference were found between fish fed only LT-fish meal and fish fed a mixture of fish meal and suprex pea - up to 46% pea + 32% LT-fish meal.

3.3. Protein addition

There is also a possibility to further increase pure protein growth by clever additions of special protein qualities, thereby giving the opportunity to decrease dietary protein concentration still obtaining the same protein growth. Some results from dr. M.Espe's research where partly pre-digested protein is added in addition to the fish meal is shown in figure 3a (growth) and 3b (protein retention, PPV).

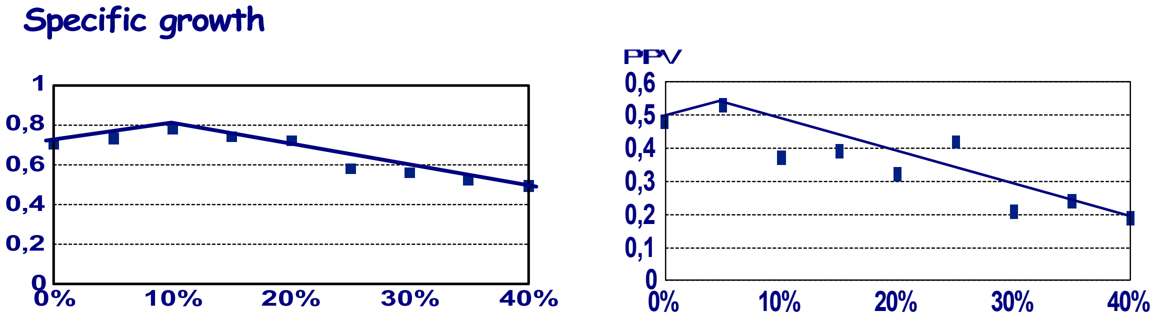

Figure 3. A (upper) shows specific growth rate of Atlantic salmon given diets with increasing additions of fish protein concentrate (FPC; partly digested), and B (lower) shows protein productive value (PPV) given the same diets. All diets held a protein level of 40% of feed dry matter.

3.4. Current trends in global demand for fish oil

Currently somewhat more than one half of world fish oil production is used in aquaculture feeds with salmonid feeds alone consuming more than one half of the total oil used for aqua feeds. IFOMA currently estimates that, given continuation of the current rate of expansion of aquaculture, global demand for fish oils for aqua feeds will equal the total global supply of fish oils by circa 2009. This means an urgent need for alternatives to fish oil.

Since dietary lipids are essential for energy and since, additionally, fish are not able to synthesise either the n-3 or the n-6 polyunsaturated fatty acids (PUFA) which are dietary essential fatty acids, these must be included in the diet. Preliminary results indicate however, that similar growth and feed utilisation can be obtained when substituting fish oil with mixtures of plant oils (Rafoa - EU report 2002). Nevertheless, substantial differences in relative fillet fatty acid compositions and the amount of fatty acids (mg fatty acid per mg fillet) are obtained.
An example is given in Table 1.

	Capelin	Capelin +Sunflower	Sunflower	Palm oil
Diet EPA	25.2	17.2	7.2	5.4
Fillet	44.1	34.0	23.4	29.4
Liver	4.5	3.3	2.3	2.4
Diet DHA	19.1	14.6	8.2	6.5
Fillet	50.8	43.1	35.2	42.1
Liver	8.4	7.0	7.1	6.9
Diet sum n-3	61.0	42.2	17.9	13.7
Fillet	141.0	113.0	83.5	103.1
Liver	14.6	11.7	10.2	10.1
Diet n-3/n-6	8.6	2.8	0.8	0.6
Fillet	5.8	3.5	1.8	2
Liver	13.6	7.1	2.8	3.3

Table 1. Concentration of selected fatty acids in Atlantic salmon fed different oil mixtures, given above colum. The concentrations of EPA (20:5n-3), DHA (22_6n-3), sum n-3 and ratio n-3/n-6 in diets are reflected in both fillets and liver.

The different oil mixtures also resulted in different energy utilisation (b-oxidation), or different capacity to oxidise lipids, as shown in Figure 4 (from Torstensen et al., 2000).

Mitochondrial b-oxidation capacity in red muscle

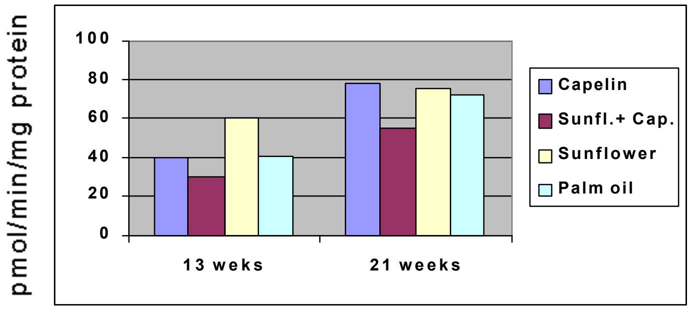

Figure 4. Atlantic salmon fed for 13 and 21 weeks with different oil mixtures, resulting in differential b-oxidation in red muscle.

4. CONCLUSIONS

- To summarise the very fine balance of essential amino acids in LT-fish meal, and that carnivorous fish have an obligatory need for protein also as energy, quite a large proportion of the marine protein may be substituted by various plant protein resources, but only if done cleverly.
- There is an urgent need for alternatives to fish oil.
- The final conclusion must therefore be that more knowledge is needed to meet the future demand for alternatives to fish meal and oil in aquaculture diets.

Building a Community of Peers

Can an Aquafeed Community be Formed? Exploring a way to promote knowledge sharing among many separate communities involved in feed and nutrition.

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ABSTRACT: There was once a vibrant Feed and Nutrition Network operating under the Asian Fisheries Society. It has ceased to exist. Recently, in two NACA - initiated regional forums, the Sixth Technical Advisory Committee Meeting and the Regional Aquafarmers/Aquabusiness Seminar 2002, respectively, the recommendation was made to organize a regional aquafeed and nutrition network. The former was specific as to the composition of the network i.e. an expert - or people - network which could be layered into the institutional network of NACA; the latter was a broadly worded suggestion coming from the private sector that included feed manufacturers, suppliers, and farmers that would be layered into a proposed Asian regional aquaculture producers organization, which was also endorsed by the meeting. Enabling all those involved in the development, manufacture, distribution and use of feed and its regulation, to share information that would improve their respective work is a huge task. Having them acting continuously as a single discourse community so that the science, regulation and use of feed are in harmony and truly promote aquaculture development is an even bigger challenge.

In light of the heightened concerns with food quality and safety, emphasized by recent developments that involve rejection of or ban on live or processed products or extermination of animals fed or suspected to have been fed a substance believed to impact on the health of the human who would finally consume it as food - and the impact of all these on the viability and growth of aquaculture development - the need to share knowledge and information continuously among those that have anything to do with feed is now an urgent imperative.

The new information technology will be an efficient instrument to facilitate this process. But promoting the formation of the discourse community and making it cohesive and committed is a more essential task. The presentation outlines a way to enable this task. It will provide some examples of past and ongoing information activities in aquaculture and draw on some lessons learned from these efforts.

1. INTRODUCTION

Of the nine recommendations of the feed and nutrition panel of the Aquaculture Conference in the 3rd Millennium, five concerned carrying out more research (i.e. improving understanding of a range of concerns from dietary requirements, nutrient retention efficiency, bio-availability, nutrition's role in health of farmed animals, and reducing toxicity of potential feed ingredients), two were on technology development (developing species - specific broodstock diets and improving use of by-products) and these of course were seen as in need of more research; one was about extension (i.e. promotion of good manufacturing practices and good on - farm management practices) and another one was regulatory - oriented (for science to provide the basis for-regulations on the selection and trade of raw materials for feed).

To look at the recommendations from another viewpoint: seven were addressed directly to researchers and technologists, one to users of technology, and one to those involved in policy formulation.

2. BACKGROUND

2.1. Establishment of Asian Fish Nutrition Network

It would not be surprising then that when an information network is set up, a society formed, or a discourse community established, the membership would be overwhelmingly made up of scientists and technologists. In retrospect, an Asian Fish Nutrition Network was established under the Asian Fisheries Society, with support from a development assistance agency, and flourished for about eight years from 1986 to the early 90s. One of the founding members explained that one reason for its fading away was that feed and nutrition research needed to respond to the many and, more critically, the various species-, location-, farming system-, production-system, and socio-economic context-specific issues, and the network failed to do so. Sluggish response inevitably leads down the road of irrelevance. Such slow response to production needs was probably also owed to its membership, which was mostly of researchers in universities and R and D institutions, although it made efforts to involve farmers in developing the applied research agenda of the Network. Hindsight also tells us that had the network had access to similar tools as today's Internet, it might have been more nimble in responding to problems and practical issues. It also suffered from lack of funds and a discontinuity in leadership, which are practical issues. Nonetheless, the accomplishments of the Asian Fish Nutrition Network opened the way to many opportunities: it showed that a network could pool intellectual resources to work effectively on a problem. It brought together isolated workers, it focused on applied and farm-level research, and it even worked farmer viewpoints into and generated farmer participation in the research program. The network also published a number of pioneering publications in feed and nutrition.

2.2. Development of new regional aquafeeds network

It was this consideration of the Asian Fish Nutrition Network's positive results (rather than its demise) that led the Technical Advisory Committee of NACA to endorse the formation of a regional aquafeeds network. Its remit would include nutrition, feed development and feed management. This received support from the farmers and business people who attended the Aquabusiness Seminar 2002 (held concurrent with the 13th NACA Governing Council Meeting in January) who recommended the formation of a regional aquafeeds network. Another consideration was the presence of a trained manpower base and a farm-made aquafeed programme initiated in ASEAN by the ASEAN-European Commission Aquaculture Development Coordinating Programme (AADCP), which operated in 1990-95.

3. RATIONALE OF NETWORK FORMATIONS

3.1. General networking issues

Outside of feed and outside of R and D, if we look around, there is a preponderance of operational networks based on an area or even narrower, a discipline - engineering, medical, producer - oriented, civil society networks, educators, etc. There is an underlying advantage in establishing a community whose members understand each other and have similar concerns. Communication is easier and coming to agreements might even be easier. It is different and always more difficult for different communities to understand each other. Communication across groups or communities is not easy to establish and even more difficult to sustain. While it may be possible to link various communities (policy, feed producers, farmers, suppliers, researchers and extension workers), and even make provisions to cross-feed information from one community to another, these different communities remain - in point of fact - separate, distinguished by and taking pride in talking in their own jargon. As expected they also view an issue from their own professional or scientific orientation.

On the other hand, there are many advantages in having a holistic view of a problem; in setting up mechanisms to "enhance participation and consultation among all stakeholders", and in "promoting enabling environments in support of whatever is being developed". This is seen as a process to bring everyone to talk of common issues and arrive at commonly acceptable science-based solutions. In practice, there are many variations. One is that the event is usually a one-off - exercise; a second variation is that the process is initiated - or eventually hijacked - by one dominant group serving its own interests.

3.2. Setting up a community (network) of peers

3.2.1. Conventional methodology

The question then is: can there be a way to establish a community that involves everyone concerned with say, an industry, or a set of issues; a holistic view so to speak? With everyone working on equal terms or feeling that they are peers?

3.2.1.1. Case Study in intensive shrimp farming (Thailand)
As an exercise to help expand on this point, what can the set of data below tell us?

Unit costs and returns in intensive shrimp farming in Thailand (US$/kg)

Item	1986	88	90[1]	90[2]	91 SE	92 E	94 E	96 E	96 IG	96 SE	96 SW	99 SW	00 SW
Feed	1.5	1.6	2.5	2.3	1.9	1.7	2.8	2.2	2.2	2.4	1.8	1.8	3.8
Profit	1.6	3.8	0.3	1.3	1.1	0.7	1.9	3.0	2.3	1.7	3.6	2.1	0.1
P/kg shrimp	7.1	8.2	5.3	6.0	4.8	5.6	6.6	7.0	5.7	6.2	6.7	5.7	5.6
Total Cost	5.5	4.4	4.6	4.7	3.7	4.9	4.7	3.9	3.5	4.6	3.3	3.6	5.5

[1] Office of Agriculture
[2] National Statistics Office
SE - Southeast provinces (i.e. Surat Thani, Nakhon Si Thammarat, etc)
E - East (Rayong, etc)
IG - Inner gulf (Samut Sakhorn, Samut Songkhran, Chachoengsao, etc)
SW - Southwest (facing Andaman Sea i.e. Krabi, Trang, Satun, Phuket)

3.2.1.2. First interpretation of data
Ostensibly, it shows that over the years and considered by region, feed cost efficiencies vary. We can discern some trends: in earlier years (in 1986-88, perhaps when ponds were new) it needed less feed (or it cost less feed) to produce a kilo of shrimp. The Southwest provinces (facing the Andaman Sea) had over a period of four years been quite efficient, but then in a single year (b/w 99 and 00) their feed cost efficiency suddenly dropped (1.8 $/kg of shrimp to 3.8$) and the cost of feed relative to the total cost of production was a whopping 70% (3.8/5.5). Compared to other regions, the Southeast has looked to be more efficient, especially in later years.

3.2.1.3. Alternative interpretations of data
We can try to move in closer to the reasons by understanding the context in which these occur - such as knowing that Southeast farmers have been in the business longer and are known to be relatively more organized; that inner gulf farmers, when they returned after the crash in the early 90s became more efficient by learning from painful experience. But there are hosts of factors that could very well impact on the feed efficiency: vigour of seed for instance, the switch to closed or limited water circulation, farmers' knowledge or lack of it, quality of feed, the state of the pond, the water exchange system employed, the state of health of the stock, the accuracy or relevance of the advice farmers received, even incentives for them to be efficient. This table indicates a good deal; it also reveals nothing. In short, many things are not clearly understood. Or not understood at all.

3.2.2. Alternative methodology

Blinkered by my being more of an information manager than a researcher, my concern is not how to understand the puzzles reflected by this set of data, but to find out who would have the knowledge to help understand and do something about them. What I would then want to know and then endeavour to get to work together are the following kinds of involved people:

- those who know and have already done something about it,
- those whose knowledge could be pooled to provide a satisfactory solution.

In the event of my failure to find anyone falling into the above categories, the approach is then to discover:

- those who know of others who might be able to point the way towards a solution
- those who know of the problems intimately and can characterize them more clearly for solvers to be able to understand them better
- those who have the power to obstruct or ease through a solution depending on how convinced they are of the need for it
- those who have to apply the solution

4. CHARACTERISTICS OF A COMMUNITY OF PEERS

4.1. Formation of a community

4.1.1. Membership range

I am arguing for the formation of a community - supported and linked by the new information technology - whose members represent the current major concerns on feed: research, development, manufacture, supply and use, and regulation. This would comprise a diverse medley of partners and it will not be easy to organize, but there is one distinctive feature of this community: everyone is on a par with everyone else. In short, all are peers. As a new acquaintance told a recently concluded NACA regional workshop (on trade risk assessment) it is amazing how peer pressure can often accomplish things that cannot otherwise be done. He was referring to a Fish Health Protection Committee in his state where members include administrators and scientists, coming together periodically to thrash out problems in fish health, mostly those that need enabling action through policy, which in turn need science to give it sense.

4.1.2. Advantages of peer groupings

Another way of looking at a community of peers is by the climate that it creates in fostering true partnership and openness where everyone can participate in an atmosphere free from the concept of seniority or rank. This kind of atmosphere does tend to promote sharing and learning rather than criticizing, and collective problem-solving rather than evaluating individual (or institutional) performances.

Finally, as the process involves the community, its results are collectively owned. By way of decision-making, a shared decision carries far greater influence than one imposed from above or outside.

4.1.3. Defining factors

What this community would be:

What it is: a community of peers; with diverse interests and expertise; unified by common interests and goals; working on clear purposes and deliverables

What it should become: Become self-sustaining

What it is not: a hierarchical structure; a consultative body; an information network

What it should not be: Linked by a common umbilical cord to what is hoped to be a single perpetual source of external assistance.

4.2. Types of Models of Peer group networks

4.2.1. Distributed tasks to achieve a common objective (e.g., Linux group)

An example of this type of network of separate and remotely located people, linked electronically, and working individually on a common problem is given in the programmers who worked on the Linux operating system. In that case there was a central focus for the work, Mr. Linux, who both initiated and served as the coordinator of the diverse talents and contributions. Otherwise everyone was working separately and linked only by a common interest, to produce one product, for which everyone possessed some special or even unique expertise that was needed to successfully produce it.

4.2.2. Collaborative work to achieve separate purposes and work toward some common goals

4.2.1.1. Example
An example here of a network of people layered over a network of institutions and agencies and anchored on a stable structure is Asia-Pacific Marine Fish Aquaculture Network (ex Asia-Pacific Grouper R and D Network). This (APMarFAN formerly APGN) is not the best but it is the best available actually operating model I can cite as an example:

4.2.1.2. Background of the APGN Network
The Asia-Pacific Grouper Network (APGN) was established in April 1998 at a meeting of grouper aquaculture researchers from throughout the Asia-Pacific region. The APGN has been coordinated by the Network of Aquaculture Centres in Asia-Pacific (NACA) and has been supported with funds from the Australian Center for International Agricultural Research (ACIAR) and the Asia-Pacific Economic Cooperation (APEC).

The APGN was originally established because of increasing regional interest in grouper aquaculture, mainly in response to strong demand and high prices, particularly Hong Kong SAR and China. But the growth and sustainability of grouper aquaculture has been constrained by the difficulty in producing grouper fingerlings in hatcheries. The APGN was one mechanism designed to improve the performance of grouper hatcheries by promoting stronger coordination and cooperation amongst researchers in the Asia-Pacific region, and facilitating communication between previously isolated researchers.

4.2.1.3. Results of this new approach
The outcomes - and the issues they address - from this new approach to networking aquaculture researchers have included the following:

- Publication of a 'Husbandry and Health Management of Grouper' manual aimed at grouper farmers, and translated into several local languages (coordinated by SEAFDEC's Aquaculture Department) - addresses extension.
- Electronic newsletter and grouper webpage - addresses information and technology transfer
- A pilot study to develop grouper aquaculture as a sustainable alternative livelihood to cyanide fishing for fishers in the Komodo region of Indonesia (a joint project between The Nature Conservancy, the Department of Marine and Fisheries Indonesia, and the Queensland Department of Primary Industries) - addresses socio-economic issues
- A regional survey of fry/fingerling supply and current practices for grouper mariculture was carried out by Dr. Yvonne Sadovy of the University of Hong Kong - addresses seed supply and culture practices issues.
- A regional research program on grouper viral diseases, implemented by the Fish Health Section of the Asian Fisheries Society in cooperation with the Aquatic Animal Health Research Institute of the Department of Fisheries of Thailand - health management.
- Training in hatchery technology at the Gondol Research Institute for Mariculture in Indonesia - addresses manpower and technology transfer issues
- Six workshops (with a seventh scheduled for Hanoi in Oct 2002) held since 1996, that involved researchers, government policy, farmers, industry and NGOs (Sabah Dec 1996, Bangkok April1998, HatYai Thailand April 1999, Medan, Indonesia April 2000, Cairns July 2000, Tigbauan, Philippines July 2001) - addresses policy and research and extension issues.
- Socio-economics of backyard hatcheries in Bali - addresses livelihoods issues
- Improved hatchery and grow-out technology for groupers - larviculture and feed issues
    - Improved survival of larval grouper (*Epinephelus coioides, E. fuscoguttatus, Cromileptes altivelis*) in hatcheries.
    - Development of pellet feeds using locally available feed ingredients.

This network was recently expanded to encompass other marine finfishes (cobia, snappers and pomfrets) in the region at the NACA Governing Council meeting in conjunction with the Regional AquaFarm Business Seminar and Exhibition (AfBiS 2002) held in Malaysia. The new Asia-Pacific Marine Finfish Aquaculture Network (APMarFAN) will promote the development of sustainable finfish mariculture in the Asia-Pacific region by expanding on the activities of the APGN.

4.2.2. Expansion of Network

4.2.2.1. Needs and Resources Assessment
Preparations for the expansion and formalization of the Network included a survey to assess resources in the region, know present and planned activities in R and D, determine needs and priorities for the Network to work on, and identify opportunities for the Network.

4.2.2.2. Survey findings and results
Forty-five institutes and all APEC Fisheries Working Group members were identified and surveyed and Institute facilities and human resources were assessed in respect of:

- Production technology - species and research activities in the institutions described: current and planned research on production technology - larviculture, nursery, grow-out, post-harvest, broodstock
- Non-production and husbandry issues: current and planned research - environment, marketing, food safety and certification, socio-economics and livelihoods
- Current and planned extension and training activities
- Current and planned fish health research activities
- Information on research and development on coral reef fish species
- What the institutes would like to have from and offer to the marine fish aquaculture network - information and staff exchanges, training, support to collaborative project development, seeking of resources
- Ideas and proposals for funding mechanisms - APEC, ACIAR, NACA, co-funding with private sector, network support in developing research projects on topics of common interest
- How can the private sector be more involved - work in research, commercialization/upscaling of research results, bringing their inputs to bear on research project development
- Status of research program - well-covered issues, gaps, new opportunities, species
- Opportunities for broadening partnerships - APEC-FMRWG, STREAM, UNEP's South China Seas Programme, CGIAR/ICLARM's challenge programme on reversing habitat degradation and increasing productivity in the coastal zone,
- Identification of expertise and responsibilities within the network

4.3. Structure and mechanisms of network

4.3.1. Structure

Designing and placing the Network structure and mechanism was next. APGN was absorbed into the NACA work programme and has formally become part of it, with this structure:

1. Steering committee - a small and informal steering committee responsible for overseeing the network activities, composed of NACA secretariat, individuals from selected collaborating centres and agencies;
2. A number of collaborating centres selected on the basis of present research and development activities, to engage the range of institutes and agencies involved in marine fish R and D in the region;
3. An inclusive and broader network of people, institutes and agencies involved in R and D of marine fish engaged largely through electronic means (eNACA), workshops, training and exchanges.

4.3.2. Support to the Network

Part of the building the structure is establishing/designating the management and information support to the network:

1. Secretariat - NACA
2. Website - www. enaca.org/grouper linked to the ACIAR Grouper project (enaca.org/aciar)
    a. Add discussion forum
    b. Update library, reference database
    c. Link to ACIAR allows access to all relevant project material in one location
3. Electronic newsletter
4. Aquaculture Asia magazine
5. Workshops - 3 since 1998 involving government, NGO, farmer, and R and D workers from various APEC economies and NACA governments

6. Training courses - grouper hatchery training course in Indonesia
7. Grouper exchange program - supported three exchanges (hatchery and nursery, feeds, socio economics and livelihoods)

4.3.4. Commitments to Network

The final element is to establish and agree on responsibilities of the participants. In this case, the terms of reference for collaborating centres which specify their responsibilities and confirm commitment to participate in the agreed program of work have been drawn up. Terms describe:

1. Responsibility for leading research on designated research activities
2. Provision of regular research and related activities update from the institute
3. Support to the activities of the network within the institute's competence
4. Participation in project development and resource mobilization
5. Information feed (publications, electronic versions, and copy)

4.3.5. Opportunities and future issues to address

Closer links to coastal development, coral reef management and private sector activities in marine fish culture

- Support to development of funding sources and cooperative project preparation
- Further institutional strengthening, training, mechanisms for policy influence
- Expansion to other species - finfish and non-finfish
- Cross feed to other regional initiatives:
- STREAM - livelihoods
- Education consortium

4.4. Lessons Learned

4.4.1. Attributes of the Marine Finfish Network

4.4.1.1. Strengths

1. Addresses a wide range of issues, many of which are complementary or interlinked.
2. Involves a wide range of institutional and people participants (intellectual and material resources) with diverse interests and competence.
3. Its purposes are clear and the deliverables are clear - identified and agreed on by consultation among participants.
4. The rules for participation are clear and agreed to.
5. The participants have collective ownership of the network.
6. The benefits are clear and there are, generically, two mutually reinforcing benefits: to improve the capacities of participants, to advance the range of agreed purposes and achieve the Network's common goals.
7. The mechanisms for working together are agreed to and in place, and the environment has been created for the participants to work together:
    a. there is an agent that coordinates the work - Secretariat of NACA
    b. there is support from "management" i.e. Governing Council
    c. it has champions - individuals in the Council and Friends
    d. It is supported by the new IT tools and methodologies (i.e. eNACA)

4.4.1.2. Weaknesses

1. Farmers, traders, civil society and consumers not strongly represented.
2. Links to policy - how policy can be more effectively influenced - not firmly established.
3. While information management and support is strong, there is no formal mechanism for knowledge management within the Network
4. A quick response - mechanism to emerging issues and emergencies not in place.
5. Need to wean it our of donor assistance - co-funding with private sector needs further exploring

4.4.2. Application

To address issues in feed production and management strategies: establish the AquaFeed Network .

4.5. Way forward

- Adopt the APMarFAN structure and mechanism
- Include as members the feed manufacturers, suppliers, NGOs, farmer associations, and government inspectors and regulators
- Organize small specialist groups within the network to tackle urgent problems and emerging issues
- Develop a knowledge management scheme for each specialist team
- Link the members electronically - provide a website and a discussion forum
- Each one, as much as possible, has a personal website developed by him or herself
- The Team would have the diversity of competence to address issues; group can co-opt the participation of any one outside the group who has the needed expertise; membership is kept open
- The Team would have a facilitator
- The Team establishes its set of objectives and deliverables when confronting an issue
- Provision is made for a team to meet face to face periodically
- Provision is made for the group findings and recommendations to be shared throughout the entire network.
- Provision is made for recommendations to be acted on immediately.

5. SUMMARY

1. Knowledge acquisition and transfer is an outmoded model - it presupposes a linear and even a one-way flow of knowledge, and is sluggish in responding to changes; knowledge management is the new paradigm in sharing and learning, solving problems, and arriving at solutions rapidly
2. Individuals with the relevant competence are the object of knowledge management; they operate as a network and work as a team
3. Being part of a formal network of institutions will also institutionalize the networks of people.
4. We have existing models for a network of institutions and networks of people.
5. Tools and methodologies are available (and getting sharper and better continuously) to enable us to operate them effectively.

Present status and developmental trends of aquaculture nutrition and feed industry in China

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ABSTRACT: This paper presents a review of the development of aquaculture in China during the past 50 years. Core species composition in mariculture and freshwater culture in the year 2000 are shown and key trends are predicted. In addition, probable factors threatening the development of sustainable aquaculture in China are evaluated and areas of study for the near future are recommended.

In order to support a responsible aquaculture in China, modern biotechnology should be applied in areas such as genetic breeding, hatcheries, disease diagnosis and prevention, environmental protection and restoration, nutrition, feed, etc. This is especially true with aquaculture nutrition studies and the feed industry in China. Consequently, they are discussed in more detail. It is estimated that the gap between supply and demand of formulated feed in China's aquaculture is 12 million tons a year. Currently, large quantities of raw feedstuff and trash fish are used in aquaculture ponds and net cages annually. We, therefore, scrutinize the possible reasons China has lagged behind other developed countries in the areas of aquaculture nutrition and feed manufacturing and suggest the future directions of these important issues.

Keywords: China, Aquaculture, Nutrition, Feed industry, Developmental trend

1. OVERVIEW OF AQUACULTURE IN CHINA

1.1. Change of fisheries and aquaculture in the past 50-years in China

It is well known that China is a country with the longest history of aquaculture in the world. The earliest recorded aquaculture in China can be traced back to 2000 years ago. Fan Li wrote the first book on fish farming in China in 15th century BC. Why was China the earliest country to engage in aquaculture? Fish, together with other aquatic products, must have been very important dishes since ancient times in China. Naturally, people tried to find methods to provide fish regularly. There is a Chinese philosophical saying, "Give a man fish and he will have fish for one day. Teach him to culture fish and he will have fish for the rest of his life." Hence, the development of aquaculture in China has had both a practical and a philosophical basis from the very beginning.

Even though there have been thousands of years of aquaculture development in China, the percentage of aquaculture in the total fisheries production was very low before the 1950s due to the abundance of natural fisheries resources both in freshwater and marine, as well as the primitive farming methods in use with relatively low productivity. Since the late 1970s, aquaculture has increasingly become more important because of overfishing and environmental deterioration, particularly in a country like China that has a huge population burden. Figure 1 shows the changing trend of the total fisheries production and the proportion of aquaculture to the total fisheries production over the past 50 years in China.

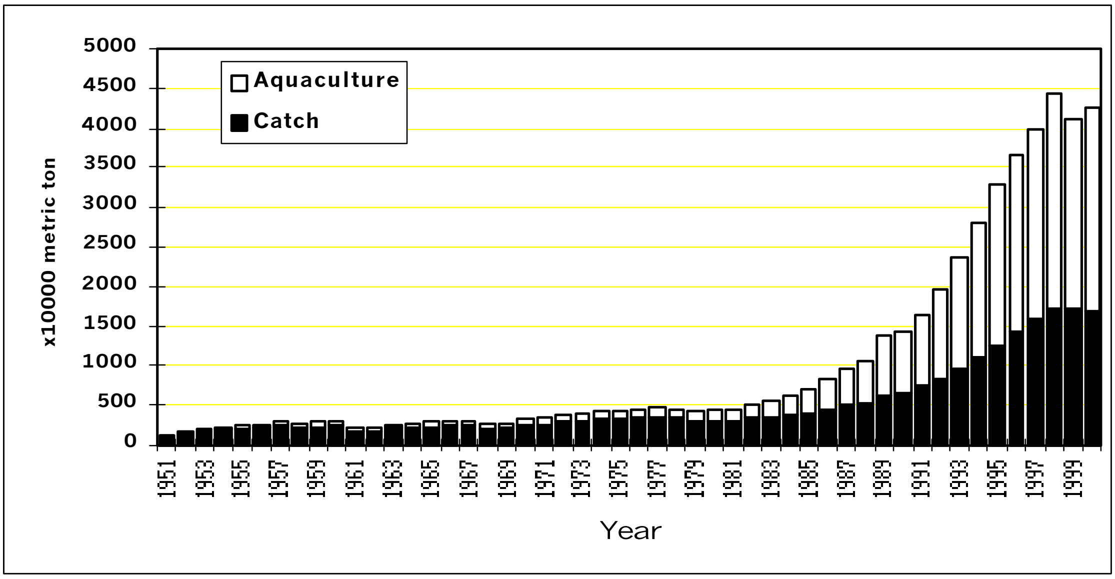


Figure 1. Fifty-year development of fisheries in China (1951-2000).

It can be seen from Figure 1 that aquaculture has been steadily increasing since 1970s, and sharply increasing since 1989. In the year 1988 the total fisheries production in China for the first time exceeded 10 million tons, and for the first time the percentage of aquaculture in total fisheries production was over 50%. So far China has still been the only country in the world, which aquaculture production is higher than capture production. Since 1993, the percentage of aquaculture has increased as high as some 60% of the total production.

1.2. Aquaculture production and main species of China in 2000

1.2.1. Aquaculture production - 2000

Aquaculture production of China in 2000 was 25.8 million tons, of which 15.2 million tons came from freshwater culture and 10.6 million tons from mariculture. The former accounted for 59%, and the latter accounted for 41%.

1.2.2. Freshwater production

The dominantly farmed species in freshwater are silver carp, bighead carp, grass carp, common carp, crucian carp, tilapia, white amur bream, black carp, Japanese eel, mandarin fish, Chinese river crab, giant river prawn, and soft-skin turtle (Table 1).

1.2.3. Mariculture production

There were 10.6 million tons of mariculture products in 2000 in China. However, 81.1% of it was molluscs and 11.3% seaweed. Fishes accounted for only 4% shrimp for 2.1% and crab for 1.2% (Figure 2). This means that most mariculture production came directly from natural productivity. The main species of marine fishes cultured in China are Japanese sea bass, large yellow croaker, Japanese flounder, red sea bream, black sea bream, red drum, turbot, cobia, mullet, puffer fish and groupers. The main species of cultured shrimp in China at present are *Penaeus chinensis*, *P. vannamei*, and *P. monodon*.

Species	Production (x1000 tons)	Percentage (%)
Silver carp & bighead carp	4842	31.9
Grass carp	3163	20.8
Common carp	2120	13.9
Crucian carp	1375	9.0
Tilapia	629	4.1
White amur bream	512	3.4
Black carp	169	1.1
Eel (Japanese and European)	161	1.1
Mandarin fish	99	0.7
Chinese river crab	232	1.5
Giant river prawn	97	0.6
Soft-shell turtle	92	0.6
Others	1677	11.0

Table 1. The major species of freshwater aquaculture in 2000 in China

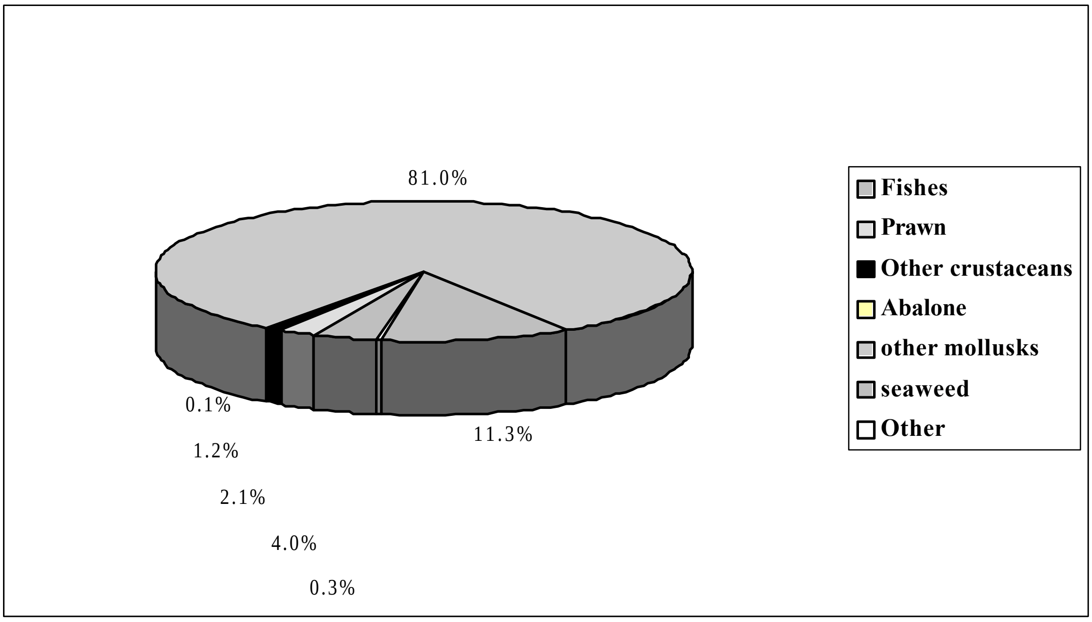


Figure 2. The composition of mariculture organisms in 2000 in China.

1.3. Problems and developmental trends in China aquaculture

1.3.1. Diversity of cultured species

One obvious characteristic of aquaculture in China is the diversity of cultured species and culture models. This is determined by the diversity of geographical environment of aquaculture, different developmental levels of productivity in different districts in China, and the eating habits of Chinese who always prefer to try something new. Little work has been done in genetic breeding and improvement for aquaculture species in China. People always like to introduce exotic species. Therefore, the diversity of cultured species and culture models will increase.

1.3.2. Low amount of mariculture production

Compared with the fish production in freshwater farming (14.8 million tons), the output (450,000 tons) of mariculture fishes remains very low. There are many reasons resulting in this difference in production totals between freshwater culture and mariculture in China. The history of marine fish culture in China is very short in comparison with that of freshwater culture. The methodologies and models used in freshwater culture probably cannot be copied directly to mariculture, and most marine wild fish probably cannot get used to the small ponds or cages used in freshwater culture. Limited supply of juveniles is a major factor restricting the development of marine fish culture because, so far, only a few species have been artificially spawned, hatched and reared successfully. Additionally, there is a much higher investment and risk of mariculture which are inhibiting factors in marine fish culture.

1.3.3. Traditional culture methods still widely used

Compared with the aquaculture industry in developed countries, aquaculture in China, including both freshwater culture and mariculture, is still traditional, scale-dependent, low technological value, and natural resource-consuming. These have been seriously threatening the development of sustainable aquaculture in China. In order to support a sustainable aquaculture in China, modern biotechnology should be applied in areas such as genetic breeding, improvement, hatcheries, disease diagnosis and prevention, environmental protection and restoration, nutrition, feed, etc. This is especially true with aquaculture nutrition studies and the feed industry in China. Consequently, they are discussed in more detail as follows.

2. AQUACULTURE NUTRITION AND FEED INDUSTRY IN CHINA

2.1. Classification of aquaculture species by feeding habits

It can be seen from Figure 3 that out of a total aquaculture production of 25.8 million tons in 2000, 52.1% is composed of filter feeders, 26.4% of omnivorous species, 12.3% of herbivorous, 4.7% of aquatic plants, and 4.5% of carnivorous species. Hence, the subtotal production of omnivorous, herbivorous and carnivorous species was 11.2 million tons. If all these species had been farmed using compound feeds, and the feed conversion ratio were 1.5, about 16.8 million tons of artificial feeds would have been needed. In 2000, however, there were only 5 million tons of formulated feeds produced for aquaculture, indicating that there is a gap of 12 million tons between supply and demand in aquaculture feed market in China. What supports the huge aquaculture production in China?

2.2. Major culture models and the status of formulated feed utilization

Freshwater culture in China mainly makes use of earth pond systems. Earth ponds are usually used for the common and cheaper species, such as various species of Chinese carps. There is also a small percentage of land-based tank systems and net-cage systems in lakes and reservoirs. These systems with higher investment are usually used for species fetching higher prices, such as eel, trout, sturgeon, soft-shell turtle, and other species of hard-shell turtle, etc. Most earth pond systems usually use fertilizers (either chemical fertilizers or manure) and directly feed raw materials, such as rice bran, wheat bran, rapeseed meal, peanut meal and soybean meal. Due to the huge farming area of earth ponds, however, 70% of the annual production of formulated feeds in China is consumed pond culture. The common species cultured by artificial feeds are grass carp, common carp, crucian carp and tilapia. Additionally, most net-cage and land-based tank systems use artificial feeds.

Crustaceans cultured in China are mainly marine shrimp, giant river prawn and Chinese river crab. Their culttvation usually utilises earth pond systems with high quality artificial feeds. Their feed conversion ratios are commonly between 1.2 and 1.6. High quality feeds have made an important contribution to the golden harvests of marine shrimp in recent years, particularly in the southern coast of China.

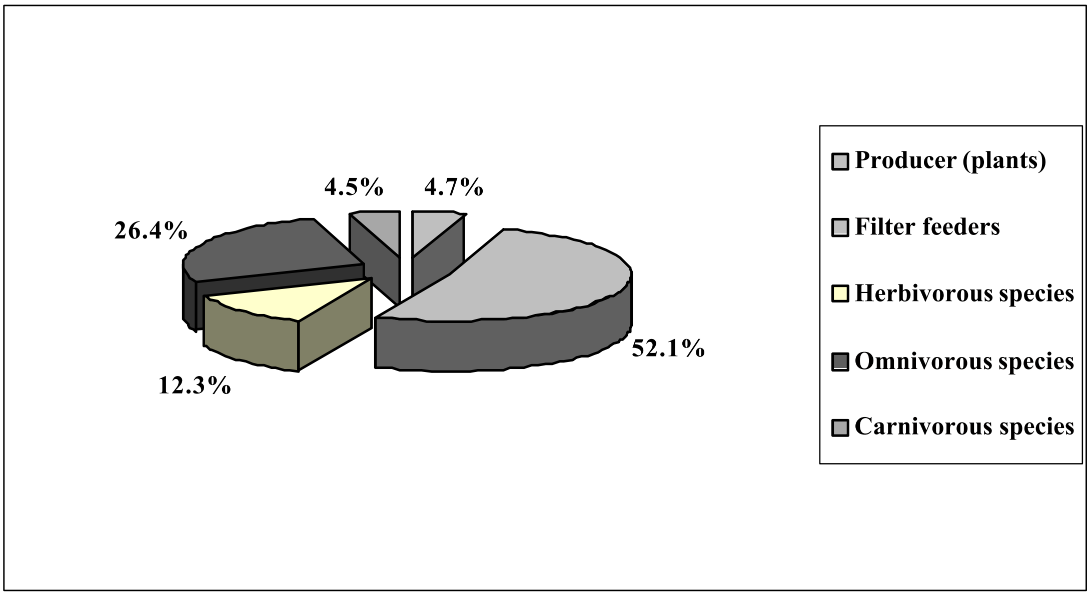


Figure 3. Classification of aquaculture species by feeding habit

Marine fish cultivation in China usually employs net-cage, land-based tank and earth pond systems. Up to now, 90% of marine fish culture in China still uses trash fish feed.

According to an incomplete estimation, about 30 million tons of raw feedstuff and 4 million tons of trash fishes are directly used as feeds annually by aquaculture in China. This not only wastes a good deal of feedstuff resources, but also pollutes the aquaculture environment, and multiplies pathogens in aquaculture systems. If this serious situation is not changed, the sustainability of aquaculture in China will face a severe menace.

2.3. Present status of aquaculture nutrition studies and feed industry in China

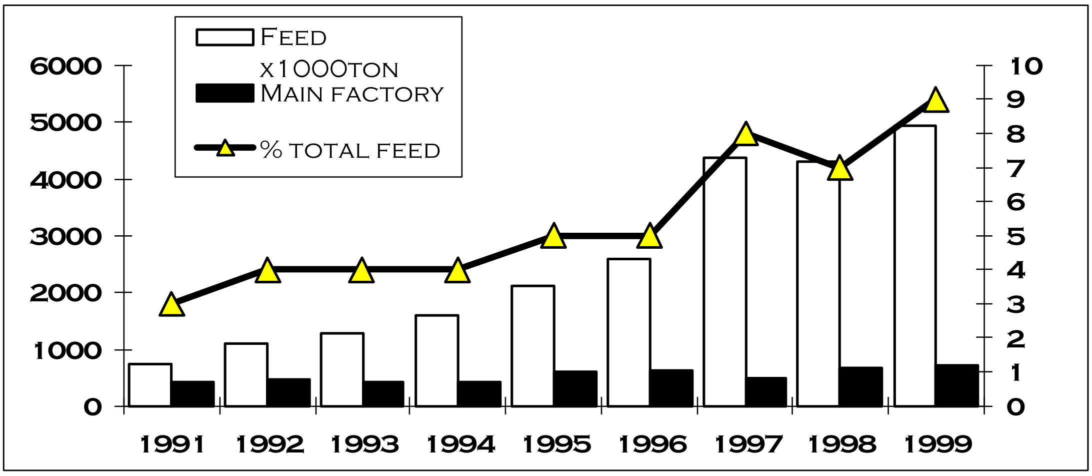
A few studies on aquaculture nutrition in China started in the 1950s. However, extensive studies for feed industry applications started in the 1980s as the market demands for effective artificial feeds for shrimp and fish cultivation rose. Most work has been done on general nutrient requirements (such as protein, lipid and energy), digestive physiology, evaluation of the nutritional values of common feedstuff in China, and feeding trials for feed formulation selection. Limited studies have been conducted on the basic nutrition and micronutrient requirements of aquaculture animals. Freshwater species studied include grass carp, common carp, black carp, tilapia, white amur bream, Chinese river crab, crucian carp, Japanese eel, mandarin fish, giant river prawn, soft-shell turtle, etc. Among these, the species most intensively studied was grass carp. Marine species studied include shrimp, red and black sea bream, large yellow croaker, Japanese bass, Japanese flounder, etc. Intensive work has been done on the Chinese shrimp, *Penaeus chinensis*.

The results of these studies, together with the internationally published data, provide a basic reference for formulating commercial feeds for cultured species in China. Due to market demand, certain important ingredients used in aquaculture feeds, such as premixes of vitamins and minerals, stable vitamins, amino acid chelated trace elements, mixed enzymes, phytase, probiotics, prebiotics, etc., have been introduced, studied and produced in China. In the 1980s, the technology and machinery of feed manufacture were mainly introduced from Taiwan, Europe and America. In recent years, the aquatic feed machinery has been made in China by joint ventures between Chinese and foreigners.

National, provincial and district centres of feed quality control have gradually been established to monitor and control the quality in nutrition, technique and hygiene safety of aquaculture feeds. A regular Symposium of World Chinese Scientists on Fish and Shrimp Nutrition has been held every three years since 1992, and a National Association of Aquaculture Nutrition Studies of China has been established since 1996. These activities strengthen information exchange and cooperation among the aquaculture nutritionists.

Figure 4 shows the changes in the numbers of aquaculture feed manufacturers, the annual production of aquaculture feeds and the percentage of aquaculture feeds to the total annual feed production in China during the period between 1991 and 1999. The aquaculture feed productions in 2000 was 5 million tons, and in 2001 was 6 million tons.

Figure 4. Manufactory, annual production and the percentage of aquaculture feeds to the total annual feed production in China between 1991 and 1999.



As mentioned before, the potential market capacity for aquaculture feed should be 16.8 million tons. Though the growth rate of aquaculture feed production in China is fast, obviously, there is still a huge gap between market capacity and supply. What are the problems hindering the development of aquaculture feed industry in China?

3. FACTORS HINDERING AQUACULTURE FEED INDUSTRY IN CHINA

3.1. Chinese feed industry a late development

China is a leading country in the scale of aquaculture, but not in feed industry. This agrees with the well-known fact that China is an agricultural country rather than an industrial one. Hence, as in many other industrial areas there are some similar reasons for feed industry not to be able to catch up the expansion of aquaculture. Studies on aquaculture nutrition started in China 40 years later than in developed countries. It was not until the 1980s that studies and feed development for aquaculture were brought into the national developmental plan of China.

3.2. Limited research funding

Fewer sophisticated scientists and limited governmental funding for studies on aquaculture nutrition and feeds certainly resulted in incorrect experimental designs, such as insufficient replicates for statistical analysis, improper formulation, too short experimental period, etc. These weakened the reliability and utilization values of the experimental data. Even though many species cultured in China were studied concerning some aspects of their nutrition, these studies were unsystematic: there were many more general and macronutrient studies than basic and micronutrient studies.

3.3. Feed machinery and feed additives component

As in other industrial fields in China, the feed machinery and feed additives industries also lagged behind. Some components, such as some vitamins and amino acids, are still dependent on import. More importantly, the aquaculture feed market was/is undeveloped, and market behavior is not normative. Chinese farmers have the traditional laggard consciousness: large fish live on small ones who live on smaller shrimp, and shrimp on soil. They know that this is a food chain in nature. However, they still do not realize the crisis they are facing. Due to the use of raw materials and trash fish in large quantity as feeds in aquaculture systems, whatever they culture get diseases and probably mass mortality. Consumers psychologically reject the products because they may have the memory that some aquatic products with pathogens caused serious diseases in human, and some diseased animals looked disgusting. Hence, we still need time and education to popularize compound feeds in aquaculture.

4. DEVELOPMENTAL STRATEGIES OF CHINA AQUACULTURE FEED INDUSTRY IN FUTURE

4.1. Need for developmental strategies

As discussed above, we must eliminate the factors that hinder the development of aquaculture nutrition studies and feed industry. It is suggested that the following developmental strategies should be adopted.

4.2. Recommended developmental strategies

- Research methodology in aquaculture nutrition should be standardized in China. There should be a guideline for experimental designs. This purpose can be achieved by publishing a guideline book, training courses, and higher education to train an experienced term of aquaculture nutritionists.
- Systematic studies should be carried out on the nutrient requirements of the representative, commercially important and native species cultured in China, concentrating on a few representative species, rather than attempting to cover all cultured species, because of the limited research funding.
- High quality feeds that are suitable for different farming models and species in China should be developed to meet the market. Special attention should be paid to the development of nutritionally balanced feeds at lower nutrient levels for low priced fishes. At lower nutrient levels, fish probably do not grow as fast as at optimal nutrient levels. However, their growth rates and feed costs are acceptable from the economic point of view, and higher profits can be obtained. From this point of view, this nutrition should be known as "market nutrition".
- Because the aquaculture environment in China is deteriorating sharply, environmental nutrition studies and environmentally friendly feed development should be put on the research agenda. Studies should be conducted to improve pellet quality, and on the utilizations of exogenous digestive enzymes and phytase to increase feed digestibility. More importantly, phytase with neutral optimal pH is more useful for Chinese carps that usually have no stomach and neutral digestive liquid. Studies and development of feeds with low protein (especially low fishmeal) and high energy should be carried out to reduce the pollution of nitrogen and phosphorus from uneaten feeds and feces. To improve the aquaculture environment and the animals' health, probiotics and prebiotics should be exploited.
- Due to ocean environment deterioration and overfishing, an increasing lack of fishmeal is unavoidable. Hence, it is farsighted to exploit new protein sources to replace fishmeal in artificial feeds as much as possible for aquaculture. This is particularly important for China, which has the largest scale of aquaculture in the world, but only limited fishmeal production (about 200000 tons a year). At present, China has to import 1.5-2.0 million tons fishmeal a year for feed industry. If annual production aquaculture feeds reaches 16.8 million tons as calculated above, 4.05 million tons of fishmeal will be needed as estimated in Table 2. To meet such a high level of fishmeal demand is impossible. Therefore, reducing fishmeal level in feeds and exploit-

ing new protein sources are the only way for sustainable aquaculture in China. Furthermore, considerable use of non-fishmeal protein sources definitely reduces the palatability of the feeds. Hence, not only the balance of essential amino acids but also effective feed attractants should be considered.

Feeding habits	Production Mt	Fishmeal in feed %	FCR (Supposed)	Fishmeal needed (Mt)
Carnivorous	1.16	40	1.5	0.70
Omnivorous	6.81	25	1.5	2.98
Herbivorous	3.17	8	1.5	0.38

Table 2. The potential annual demand of fishmeal for aquaculture feeds in China (based on the aquaculture production in2000)

5. CONCLUSIONS

In the past, we were always in pursuit of quantity rather than quality. With today's improvement in people's standard of living, those Chinese who are better off are now starting to seek after better quality foods. However, quality is not only concerned with food colour, flavour, taste and texture, but also with nutrition hygiene and safety. Consequently, research and development of nutrition and feed for aquaculture should shift from quantity to quality. In particular, after we have joined WTO, product quality should be put in the first place. Studies should be conducted on proper feed formulations, farming strategies and culture environmental management to improve product quality, on immune stimulants or enhancers to reduce the use of antibiotics, other harmful chemicals and their hangover etc.

Chinese farmers pursue higher profits in aquaculture than those in developed countries. Even though the labour cost in China is much lower than in developed countries, the price of high quality feeds is similar or even higher than that in developed countries. For example, the price of shrimp feed is slightly higher than that in the United States because the main feed components, like fishmeal, vitamins and other expensive additives, depend on import. More importantly, the main cost of aquaculture in China comes from its higher risk due to the deteriorating environment and frequent natural disasters that sometimes cause complete loss. Hence, improvement and restoration of aquaculture environment, precise forecast of natural disasters can reduce aquaculture risk, and subsequently cut down its cost. The control of the expansion of scale of aquaculture in China today is essential for environmental protection and restoration, by establishing a license system based on the carrying capacity of certain water areas. The feed cost can also be cut down by proper formulation, increasing production scale and product diversity per factory, and reducing management cost.

This is an important way to strengthen the cooperation between feed enterprises and research institutes and universities inside and outside of China.

Nutrition and feeding of black tiger prawn *Penaeus monodon*: a review study in Thailand

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ABSTRACT: Black tiger prawn, *Penaeus monodon* have been intensively cultured for more than 15 years in Thailand. Success in this species culture depends on good pond management, nutrition and environmental awareness. Quality feed with appropriate interval and quantity can maintain good water quality and bottom conditions that will lead to a good crop production. Shrimp feed quality has been developed to the optimal nutritional level with long water stability. During shrimp feeding approximately 10% of the diet will be lost to the water and becomes nutrients for bacteria and microalgae. With optimal feed management, shrimp and other organisms will live well in an equilibrium environment. Over-feeding will lead to nutrient load and eutrophication, with severe consequences for the pond water which may become difficult to manage and may necessitate the early harvesting of shrimp.

Shrimp require energy with primary on protein (~40%), fat (~7-10%) and carbohydrate (~30%). Changes in the amount of protein, fat or carbohydrate energy will affect their ratios in the diet. To ensure better growth and survival of shrimp, minor nutritional components, such as n-3 fatty acids (EPA and DHA), astaxanthin and/or other vitamin A derivatives, ascorbic acids and some minerals are needed. At present, probiotics have beeen introduced for shrimp culture in Thailand. Probiotics added to the feed provide good results in shrimp health and production. Probiotics will be used in shrimp culture to replace the use of antibiotics and will lead the shrimp culture industry to future organic farming. Details of shrimp nutrition and probiotics are discussed.

Paper not available

Endocrinological regulation of fish feeding-nutrition under domesticated conditions

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ABSTRACT: Food identification, acceptance, digestion and assimilation, make up a complicated procedure intending to cover fish demands in energy and nutrients. Physiology of growth and reproduction, tissue biochemical activity and body composition are the results of a combined effect of food intake and neuroendocrine function, regulated by fish genome and depending on environmental factors. The involvement of the nervous system is more obvious in food identification and acceptance (vision, taste, smell), while digestion and assimilation are mainly performed by the endocrine system.

Food availability (quantity and quality) interacting and assimilation are mainly performed by the endocrine system. with photoperiod, water characteristics and stress, should be considered as a major factor, in the regulation of fish metabolic hormone secretion and function. Evidences for hormonal involvement in association with fish food intake, mainly include ACTH and catecholamins, CCK, thyroid hormones, insulin, glucagon, growth hormone and IGFs, which express their action through several enzyme pathways.

In terms of both food supply (availability and diversity) and water properties, earth ponds could provide (under certain conditions) a rearing environment close to their natural one for several fish species. On the other hand, tanks are more easily associated with the creation of a stressful environment with numerous physiological effects, caused mostly by catabolic hormones, influencing fish nutritional status. However, it must be addressed that in both rearing cases, fish ecological and food ethological demands should be covered by the provision of high living standards, so that they can develop all their physiological activities.

It is obvious therefore that proper fish-controlled production has to be the outcome of an intentional rearing management, directed to a continuous existence of proper water quality and fish nutritional status, minimizing stress consequences. The understanding of the importance of food composition in the regulation of endocrine function could provide significant clues not only to manipulate water quality, but also to achieve a successful guide for artificial diets formulation, according to the ethology and nutritional habits of each fish species.

1. INTRODUCTION

Food identification, acceptance, digestion and assimilation, make up the successive stages of the complicated procedure of food intake intended to cover fish demands in energy and nutrients. Physiology of growth and reproduction, tissue biochemical activity and body composition are the result of a combined effect of food intake and neuroendocrine function regulated by fish genome and dependent on environmental factors.

In many biological processes the nervous and endocrine systems generally carry out certain functions acting in association, although a clear distinction of their separate involvements is almost impossible in some cases. However, the nervous system is more obviously concerned with food identification and acceptance, making use of the sensory capacities of sight, taste, smell, hearing and touch (the lateral line system). On the other hand, digestion and assimilation are mainly carried out by the fish endocrine system.

Under domesticated conditions and especially during the grow-out periods using formulated diets, the reaction of the fishes' nervous system to the acceptance of food is mainly expressed instinctively. However, the stages that follow food acceptance (digestion and assimilation) are carried out by the activation of several enzyme pathways controlled by the endocrine system reacting to food quality and quantity.

Food intake interacting with photoperiod, water characteristics and stress, should be considered as a major factor in the regulation of fish metabolic hormone secretion and function. Evidences for hormonal involvement in association with food intake, mainly include gastrointestinal endocrine system (CCK, bombesine, gastrine etc), ACTH and catecholamins, thyroid hormones, insulin, glucagon, GH and IGFs.

2. FOOD INTAKE-REARING CONDITIONS-STRESS RELATIONSHIP

2.1. Importance of environment

In general, extensive and intensive production systems make up the two major groups of applied fish controlled rearing conditions. The main recognizable differences between them are the types of food given, the types of construction in use, as well as the method of water manipulation currently employed.

Their specific characteristics in association with the application methods of the production systems, together make up the quality of the external environment of cultured fish, which normally involves fluctuating stress levels. This, in turn, affects food intake, internal environment, health, growth rate and the quality of the final fish product.

It is clear therefore that whatever is expected from the complicated procedure of all food intake stages, could be subjected to numerous alterations caused by environmental stress expressing several endocrinological functions. Thus, the neuroendocrinological regulation of fish feeding and nutrition corresponds to a complex biochemical net, including not only the so-called metabolic but also the stress origin hormones and other substances which act like hormones.

2.2. Extensive production systems

Extensive production systems may include earth ponds or other types of enclosures and apart from the natural food supply they can involve either continuously or periodically added food.

In these cases, the external environment of the fish could be considered as remaining fairly close to the natural one for many fish species, provided that the maintenance of proper environmental conditions is one of the farmer's top priorities. Biological, physical and chemical water parameters should be kept continuously at the most suitable levels. BOD, COD, oxygen and pH levels must be monitored regularly. Water should be free from untreated and unprocessed human, animal and industry waste. Water containing pesticides and related substances, which are usually the cause of a certain amount of stress level as well as a reduction of the quality of final product, should be avoided.

The provision of a natural food supply, ensuring the availability of certain amounts of phytoplankton, zooplankton, aquatic macrophytes, chironomids etc, usually results in an expected metabolic hormone reaction, and this contributes to the establishment of an almost normal fish internal environment. However, alterations should be expected to some extent when improper additional food (in terms of quality and quantity) and water supplies are used.

2.3. Intensive production systems

Intensive production systems are commonly carried out in tanks, raceways, net cages, recirculating systems and with an almost exclusive use of formulated diets.

Water origin and water renewal rates must ensure the appropriate levels of water chemical properties (O_2, NH_3 etc) while size, shape and colour, of rearing constructions and lighting - photoperiod as well as stocking density should cover the specific ethological demands of fish species.

Using only formulated diets, the hormone-nutrient interactions, could be manipulated to some extent by farmers and feed manufactures. This is due to the fact that fish accustomed to feeding for long periods on pellets of the same general external appearance do not easily recognize (if at all) whether the feed so easily ingested is in accordance with their actual needs. Thus, it is up to the farmer to manage the daily amount of lipids (specific fatty acids), protein (amino acids) and carbohydrates (glucose) that cultured fish should ingest according to their feeding habits.

So long as feed-hormone-enzyme and environmental factors interactions are not yet fully understood, fish farming under complete human control will require continuous progress of knowledge and continuous exploration of methods for its application in practice.

Farmers should be aware that in general, intensive production systems are more easily associated with the creation of a stressful environment with numerous physiological effects, caused mostly by catabolic hormones, influencing internal environment and especially fish feeding activity and nutritional status.

3. CONCLUSIONS

Demonstrably, controlled fish production must be carried out using proper management strategies. These must be focused on environmental factors, fish nutritional status and their interactions (the latter however need more clarification and knowledge improvement). Researchers should deal with more specific biochemical pathway investigations and increase the number of fish species studied. It is widely accepted that the acquisition of additional data on the effects of food chemical composition on neuroendocrine stimulation, not only under normal but also under stressed status, is progressively becoming more and more essential. Additional information on the influence of nutrients on neurotransmitters and hormone secretion, blood circulation, receptor binding and function at the cellular level of liver, adipose and muscle tissues, should be considered as most valuable. The understanding of the importance of these interactions could provide significant clues not only in the manipulation of water quality, but also for the development of successful guidelines for artificial diet formulation, according to the ethology and nutritional habits of each fish species. Feed and especially artificial diets should be characterized by anti-stress properties, promoting fish anabolic hormone synthesis and function and by high conversion efficiency, minimizing rearing water quality reduction and increasing farmer profit. It is reasonable to assume that this is an effective way to keep fish populations unstressed, healthy and "happy" and that fish happiness could considerably contribute to farmers and consumers' happiness as well!

THEMATIC AREA V

Does globalization of markets influence the Aquaculture challenge in Asia?

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ABSTRACT: The challenge of aquaculture in the present and near future is to balance the local social goals of equity and more even distribution of income and employment with the global development of markets. The challenge is not to implement present knowledge only - but to read the signs of markets and politics as well. The transition includes the risk of destabilisation of prices, incomes, employment and settlement patterns and the liberalization of fish trade might therefore create new market imperfections and anomalies. The aspects to be considered will cover the following topics: sustainability and management regime; multiple services and joint production; market development; social implications of policy; international policies.

1. INTRODUCTION

1.1. World challenges for Asia in aquaculture

The challenges for aquaculture in the current global competitive markets are manifold but center around the following major issues:

a) The need to balance local social goals of equity with growth when equity goals differ locally even within one region

b) To achieve a more even distribution of income and employment in areas of rapid market development.

c) To respond to the market and political consequences of an exponential growth in global production

1.2. What is Globalization?

1.2.1. An economic definition

Basically each author has his/her own definition of globalization. But common to all is an underlying acceptance of the neo-liberal driving forces of new markets open for a global consumer culture.

It could be said, therefore, that globalisation is a dynamic process in need of continuous attention and adjustment if one is to master the transition from small-scale, locally controlled systems to global market driven systems. In particular globalization and growth in production increase the risk of destabilising prices, incomes, employment and settlement patterns locally and globally.

1.2.2. A social definition

Waters (1995) defines globalization as a broad social term: "A social process in which the constraints of geography on social and cultural arrangements recede and in which people become increasingly aware that they are receding". Globalization is often perceived as if it is driven by the inevitable force of nature. Globalization is for some actors in the global market both intentional and reflective. For example; environmentalists as well as business planners move globally. However, many economic forces act impersonally, as the underlying "neo-liberal welfare seeking behaviour" only indirectly interlinks the local and global economic sectors, which in turn leads to the global interaction characterising "globalization". The process is iterative and self-perpetuating, as non-restricted factors-of-production will seek to optimise income irrespective of national borders.

1.2.3. Driving forces of globalisation

The key words to understanding the driving forces in the process of globalization are incentives and integration. The most visible outcomes in the process are the development of transnational corporations and international banks having principal control over the growing world trade in goods and services rather than governments (the world's 37,000 parent transnational corporations and their 200,000 affiliates control 75% of the world trade (UNRISD (1995), p.27)) and the growing capital flow accommodating foreign investments across national borders. In contrast to the rise in international trade and international capital flows there is a reduction in the traditional migration of people (particularly young men from poorer countries) to, for example, Europe, Japan and North America in response to an increase in cross-border and migration controls. Even though capital and goods are moving across borders (rather than people), the result is still higher economic growth, though accompanied by a greater risk of unforeseeable economic fluctuations (cf. the move of the electronic herd as discussed by Friedman (1999), p.112), greater inequality between nations, and an economic polarisation within countries (higher Gini-coefficients).

2. BRIEF OVERVIEW OF SYSTEM CHANGES

2.1. A Historical Perspective

The following table is an attempt to give an overview of the system changes experienced in the economic, political and cultural arenas over the last four centuries. The path of globalization may be viewed from a historical perspective and the major expected outcome of the two "crises" highlighted in the table, the first concerning the lack of growth potential in capitalism and the second concerning the "crisis" of the state (with fewer options for economic stimuli to curtail unemployment, slumps and inequality) paints a picture of a global society economically driven by lifestyle consumerism. The weaker state (Disétatization), where a national identity is exchanged for value politics includes global movement for the environment and human rights, and global reactions against, for example, social dumping or child labour. Global idealization is seen as the predominant cultural trend, side by side with the local cultural, religious and "class"-related subcultures.

Arena (trend)	**16-19th centuries**	**19-20th centuries**	**21st century**
Economy (liberalization)	Capitalist World-system	Multinational Corporatism	Lifestyle Consumerism
	↓ Crisis of capitalism ⇢	↓	↑
Policy (democratization)	Bourgeois state	International relations	Disetatization and Value politics
	↓	↓ Crisis of the state ⇢	↑
Culture (universalization)	Divided Subcultures	Integrated National Traditions	GlobalIdealization

Figure 1. The path of globalization

Source Walters (1995) p.159. Main path of globalization → Predominant pattern of causal efficacy - - - - →

2.2. Movement towards internationalism and consumer motivation

This model shows that society has moved from a national to an international perspective, which since the turn of the millennium is now typified as being international and consumer driven. In this society the opportunities for trade are determined by the consumer and not by the producer. 21st Century consumers have informed value politics and a global culture.

They may not be able to move physically across borders as easily as in the past, but they can move quickly in their purchasing habits and decisions: responding not only to questions of nutrition but also to ethical and environmental aspects of food production.

In saying this, however, the consumer is not being altruistic in their purchasing decisions. Their choices reflect the lifestyle consumerism and materialistic trend in society, where self-esteem is centred on your consumption possibilities and consumption behaviour and notions such as - "You are what you eat". From one perspective, even obesity can be viewed as a manifestation of this trend.

2.3. Traditional effects of globalization

It may be appropriate to underline the fact, that globalization is not really global. Many developing countries (particularly in Africa) seem to have missed the global train entirely. This polarisation part the world with respect to technology, education and administrative capacity. Leaving these countries out the discussion it is possible to make a rough balance sheet of the advantages and disadvantages of globalization.

Globalization is good for:	**Globalization is bad for:**
Japan, Europe, North America	Many developing countries
Output	Employment
People with assets	People without assets
Profits	Wages
People with high skills	People with few skills
The educated	The uneducated
Equal opportunity	Equality, cohesion
	Environment

Figure 2. Balance sheet of globalisation, (rough approximation) **Source:** Adapted after Streeten (2001), p.30

As can be seen from the above table, globalization increases the gap between different peoples and countries - with the income differentials experienced enhanced by the restrictions of migration. If, at the same time trade restrictions are present, which favour one region over another, the development will widen the economic gaps even further.

3. GLOBALIZATION AND ITS EFFECTS ON INEQUALITY AND THE ENVIRONMENT

In this next section I am going to address only the last two items on this table, the two I believe to be particularly relevant to this workshop - inequality and environment.

3.1. Globalisation and inequality

3.1.1. Debt to export ratio

The reason for including equality in the table is to focus attention on the change in emphasis on equality in global politics over the last few decades. The moral stance has changed to a silent acceptance of inequality since the end of the 70s. In the 70s movements towards "justice" in the north-south dialogue flourished on the international political scene. To use the words of Woods (1999, p. 14); «three accounts of international inequality in the 70s - neo-colonialism, dependency theory, and theories of distributive justice - put inequality at the top of the agenda of world politics and posited that the evolution and continuation of international order depended upon a greater degree of "justice"»[1]. The debt crisis of the 80s and 90s, however, changed the agenda for such institutions as the IMF and the World Bank. Redcliff and Sage (1999 p. 130) report that debt servicing by capital-importing countries rose from $90 billion in 1980 to $158 billion in 1992 and is still rising. The debt-to-export ratio remained extremely high for the remaining part of the 90'ies with 29 of the 32 most severely indebted countries having a debt-to-export ratio of more than 200 per cent, even though many bilateral relief measures - such as the cancellation of debt - have been implemented. The strong neo-liberal movement typified by Ronald Reagan, Margaret Thatcher and Helmut Kohl almost made the justice debate disappear from the international political arena. The underlying argument was, and still is, that there was equality of opportunity, which is hardly the case. The residual of this debate is the token attention to debt relief (IMF and World Bank) and especially poverty alleviation (FAO) - and the reduction / phasing out of tariffs and quotas on textiles (WTO - The Uruguay Round), clothing and agriculture products mainly hindering the development of export industry in the developing countries. On the other hand, Woods (1999, p. 19) reporting from an OECD study highlights that in 90 per cent of US and EU anti-dumping actions there was little or no threat to national industries. Further, the number of anti-dumping actions has actively risen over the last couple of decades.

3.1.2. Poverty-lack of opportunity or lack of incentive?

The neo-liberal worldview is strongly reminiscent of undergraduate textbook models of pure competition. All goods are private goods and the economy is an essentially frictionless system with perfect mobility of all factors of production. It is important not to forget that these assumptions are heuristic devices, invented to facilitate the analysis of the market economy as a whole. They are not realistic descriptions of the world as it is.

In the real world economic growth depends crucially on the adequate provision of public goods (e.g. infrastructure, education, research, etc.). Moreover, inequality is often the result of limited economic opportunities, whereas in the frictionless neo-liberal model, inequality is the primary source of economic incentive and hence an indispensable precondition for economic growth.

To the extent that poverty can be ascribed to lack of opportunity (rather than lack of incentives), policies designed to create or support alternative business and employment opportunities, or set up educational systems to facilitate labour mobility, may significantly improve the trade-off between inequality and growth without jeopardizing economic incentives.

3.2. Globalisation and the environment

Turning to the second issue - environment, the evidence of resource depletion and environmental degradation due to globalisation is not unambiguous. When the various aspects of production, processing, consumption and waste disposal are carried out in different locations, and even different countries, the resulting impacts are not readily obvious. Incorporation into the world economy effectively diminishes the capacity of local producers

1 Only the first two models try to explain why the inequality exists. The explanatory variables center around the very low income levels of the third world which maintain a loss by the exchange of goods to the developed countries and maintain the poor in poverty and the rich in wealth. Other explanations focus on the differences in technology and production capacity as the main cause for inequality. (Pers. com. prof. Villy Søgaard)

to exercise control over their choice of production system and the way that resources are to be managed. Instead, a web of decisions made many miles away, that might involve the imposition of externally derived macro-economic goals and market incentives, can exert greater influence over production systems and the local environment" (Redcliff and Sage, 1999, p. 133-34). Taking the other perspective, globalisation can also provide environmental impact mitigation opportunities, enabling the use of potentially less sensitive habitats and ecosystems for extractive and productive purposes.

4. INCREASE IN FOREIGN CAPITAL FLOW AND THE ECONOMIC OUTCOME

4.1. Increase in capital flow

The most significant trend in the globalized economy is the increase in capital flow across borders. Traditional economics predicts - under perfect competition - that in the case of a surplus of labour in one country and a surplus of capital and technological knowledge in another - both countries will benefit from foreign investment in the form of the factor of production in which they are lacking. This is not up for discussion. What is up for discussion is whether the condition for perfect competition are being met and under which conditions the income gap between countries will widen, or contract.

4.2. Effects of increase in capital flow

These foreign investments often have economy-wide income effects, which are often neglected in the short-term strive for investments, higher employment and income possibilities domestically. Unfortunately, this neglect can just result in negative long-term economic changes. Economic general equilibrium models (building on the Armington approach, (Francois et Reinert, 1997)) can analyse the economic outcome of capital flows, but

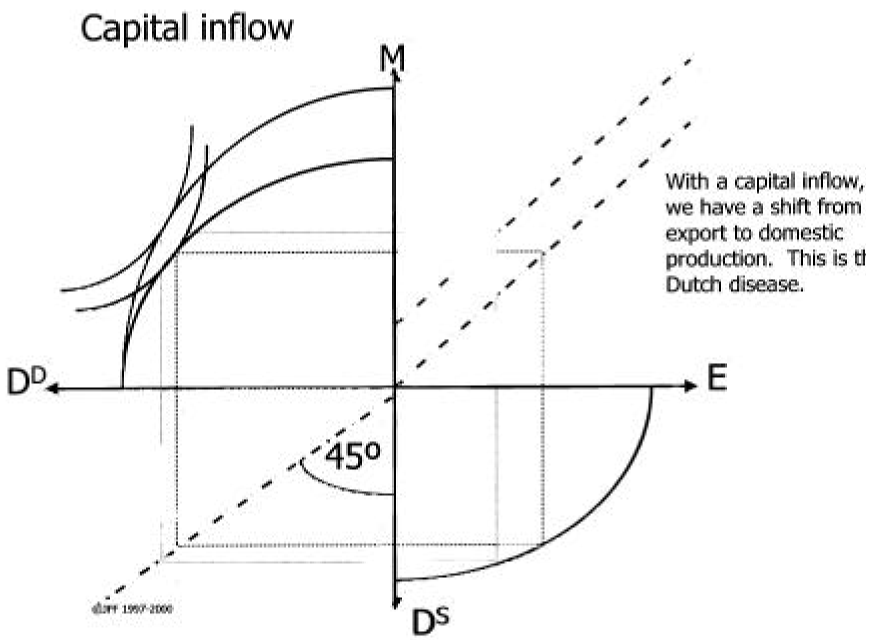

Figure 3. The "Dutch disease"

Q: Supply /demand for composite goods
C: Consumption
D^D: Demand for domestic goods
D^S: Supply of domestic goods
M: Import good
B: Balance of Trade
E: Export good
P: Domestic price

may also "cut against the grain of received wisdom". As Devarajan et al., 1997, pp 156 states: "For example, it is not always appropriate to depreciate the real exchange rate in response to an adverse international terms-of-trade shock; reducing import tariffs may not always stimulate exports; unifying tariff rates need not increase efficiency." The following example shows how an infusion of foreign capital influences the domestic consumption possibilities and the price-level of tradable and non-tradable goods sectors.

4.3. "Dutch disease"

The graph in Figure 3 demonstrates the concept of "Dutch disease". There are a number of ways in which this concept can come about. Dutch disease could occur if a country gains additional access to world capital markets or receives positive foreign aid. Alternatively, as Devarajan *et al* (1995) notes (p.164), it could also occur if there is a primary resource boom in a country where the resource is effectively an enclave, so that the only direct effect is the repatriation of export earnings (The original example stems from the Dutch Gas industry, therefore commonly named the Dutch decease). The outcome is a shift in the balance of payment, which in turn shifts the consumption possibility frontier up vertically. The new equilibrium in this simple general equilibrium model depends on the nature of the import aggregation function (how the consumer reacts to the choice of domestic and imported goods - the consumer's utility function). The expectation is - in all of these cases - that domestic prices rise relative to world prices - and the tradable sector contracts relative to the non-tradable sector. The terms-of-trade deteriorates and the country has attracted the so called "Dutch disease".

4.4. Long-term solutions

This makes it even more important to stress the fact that international transfer payments only marginally may influence the income inequalities of this world. A long term solution will only be possible if the objective of larger equality in the primary income formation is met. This implies in most instances large and long-term investments in infrastructure and human capital.

These facts widen the spectrum of outcomes of both foreign aid and direct investments in third world countries. Even though investors are drawn to countries with very low wage levels, the capital mobility may - everything else equal - have influence on the skills, income possibilities and development potentials of the receiving countries workforce. This may positively change the infrastructure and capacity to absorb new technology, which are necessary conditions for development.

4.5. A Norwegian example (salmon)

The development in mariculture production of salmon in Norway may give an example of how the transition from smaller scale production to large scale production changes the importance and economic conditions under which the industry may develop.

4.5.1. Overview of Norwegian production companies

Today over 30% of the export earnings of Norway come from fish production. The production volume has increased by 1400 per cent from 1985 to 1998. The costs have decreased continuously from approx. 50 NKR to approx. 15 NKR per kilo in the same period and the market price has decreased by nearly 70%, due first and foremost to an increase in supply (1995-price level, Bjørndal and Tveteras, Havbruk 2000). The small and medium sized companies have the lowest production costs, but the largest companies got a slightly higher price for their produce: 21.99NKR compared to 21.41NKR (1998, Asche et Tveterås, Havbruk 2000).

The companies work in so-called "industrial clusters" utilising their bargaining power in purchase of inputs, share know-how and result in a better coordination between individual production facilities. The number of multinational corporations in the sector is rising (e.g. Nutreco (Dutch, the largest in the market), Pan Fish ASA (Norwegian second in the market), Stolt Seafod, Fjord Seafood ASA (Norwegian third in the market) and Akvasmart)

Norwegian research shows a centralisation of ownership and an increase in production from 91 tons to 1465 for each company on average for the period 1985 to 1998 partly because of higher production at single localities, but also because of mergers in the sector. The need for a continuous research and development in production has been evident. Innovations have led to the production at more distant localities as more robust technologies have been developed. Further, the input factors have run through both a decrease in price, better quality and for labour; better education. It must be stressed that Norway i.e. due to oil-extractions in the North Sea have had the means and the political will to develop alternative long term sustainable industries to counteract any future decrease in welfare - when the oil reserves are depleted. It should be mentioned that Norway easily could have attracted the Dutch disease if these oil incomes were to have been used uncritically to raise the economic welfare of the present generation (see Figure 1 above)

Approximately half of the production of salmon in the EU (Scotland and Ireland) is controlled by Norwegian companies. This gives these companies a positive market power and reduces the risk for barriers to entry of Norwegian-produced salmon to the EU market.

4.5.2. Norwegian markets

The market faced by the Norwegian aquaculture industry is difficult. Norway does not belong to the EU and is therefore subject to trade restrictions when entering the European market. Even though EU is a net importer of fish and fish products, the direct and indirect subsidies to food production must be followed by some kind of protection of the home industry or the social gains of the subsidies would be undermined by competing imported product from countries outside the EU. The whole concept of subsidising food production and protecting the local industry from competition is from a welfare-economic point of view faulty. This will not be discussed here, but it follows that the consequences are that the market price of the EU is often higher than the world market price and the "anti-dumping" measures installed is presently for Norwegian salmon a minimum price which in case of lower world market prices put the Norwegian exporter to the expense of a duty of the difference between the world market price and the minimum price set by the EU. The outcome is higher prices to the EU consumer, income to the EU from duty, and a strong incentive both for the individual Norwegian exporter as well as for the EU-importer to try to cheat the customs authorities. The ways of trying to pass the border without paying duty is reported from Danish Ports: The registered weight of the fresh salmon on the truck is underreported, indicating a higher price per kilo in the load. The truck carry smoked salmon in some of the crates pretending it exports fresh salmon and getting a higher price per kilo on the load. The driver carry two different invoices - one for the importer and one for the customs authorities - the latter show a higher price per kilo.

To day the price difference between EU minimum price and the world market price substantial (approaching 10 NKR per kilo) and the incentive to bypass the payment equally high.

The studies reported on competition to Norwegian fish (Asche *et al.* 2001 gives an overview) and salmon in particular reveal a strong both actual and relative price decrease for farmed and wild caught salmon. Compared to other high value fish product there is some evidence indicating that different high value fish species are substitute goods to salmon as results show an interrelationship between the price development in these markets. It is reported that meat products do not show the same substitution, indicating that these are not substitute goods in the minds of the consumers.

The results may be viewed as at a very early stage of research as most of the data included stem from a period with very rapid growth in production.

5. DISCUSSION

To answer the first question raised in this paper: the answer is that globalization will have an influence on the aquachallenge of Asia. Economically the producers will be faced with a constant need to adapt to market changes. Socially the neo-liberal economic forces may lead to quite dramatic changes in the production sector, as decreasing prices also influence the profitability of small farmers and even subsistence farmers. The latter will experience a decrease in their relative income and the income gap will widen in society. The means accessible for management to counteract this development is weakened in this process.

An objective of cohesion as opposed to the equal opportunities/poverty alleviation objective may re-enter the international political arena. The open question is whether the weakened national states can and will empower the international institutions to instigate regulations beneficial to the cohesion objective on the grounds of fairness and international "justice". This can give rise to a different development path from that driven by market forces alone. This is stated not to underestimate the potential of national and regional (i.e. EU) policy measures. Some management tools only work on an international level, but it is still evident that par example environmental protection, investments in infrastructure and other public and collective goods are a national responsibility.

The developed countries have over decades invested in human resources and accumulated human capital. These human resources are today considered the most valuable and scarce income generating factor of production.

The consistent call for structural changes is not always a question of tight macroeconomic policy. The process of economy of scale, frequent trade in property rights to aid the concentration of enterprises and introduce cost saving but capital intensive technologies, can only be achieved within a society, where the bank-system, the public management system and the legal system is working independently and not giving rise to sudden unexpected and counterproductive changes and economic risks. Human resources - i.e. well educated, trained and skilled people - are the precondition for these transitions.

Globalization also create opposite forces in society. The recent first round of the French presidential election gave second place to the nationalist leader of Front Nationale; Le Pen. His programme evoked a response in that part of the French people which feels threatened by the globalization forces, a response also seen in most other European Societies. This political stance is directed towards minorities, be it ethnic, religious or other segments (intellectuals are often seen as arbiters of taste and preventing the people from exercising their democratic rights[2]) of society. This development further aggravates the existing inequality and does not give any help to the forces fighting for a more equal distribution of incomes and resources between regions, nations and segments of populations.

2 The Danish Prime Minister, Anders Fogh Rasmussen in a speach to the Danish people, according to memory.

LITERATURE

ACP-EU Fisheries Research Report No. 7, *ACP-EU Fisheries Research Initiative*, Proceedings of the INCO-DC Workshop on Markets, Global Fisheries and Local Development, Bergen, Norway, 22-23 March 1999, Brussels September 2000

Asche, Frank and Sigbjørg Tveterås, *On the Relationship between Aquaculture and Reduction Fisheries*, IIFET 2000 Proceedings

Asche, Frank, Trond Bjørndal and James A. Young, *Market Interactions for Aquaculture Products*, SNF, March 2001

Bjorvatn, Kjetil, FDI in LDCs: Facts, *Theory and Empirical Evidence*, SIØS, nov. 2000

Bjørndal, Trond, *The Competitiveness of Chilean Salmon Aquaculture Industry*, Working Peper No. 37/01, SNF, August 2001

Bjørndal, Trond, *The Economics of Salmon Aquaculture*, Blackwell Scientific Publications, 1990, London

IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP, *Planning and management for sustainable coastal aquaculture development*, GESAMP Reports and Studies No. 68, Rome 2001

Hurrel, A., Woods, H. (eds) *Inequality, globalisation, and world Politics*, Oxford University Press, 1999

Krugman, Paul R. and Maurice Obstfeld, *International Economics, Theory and Policy*, Addison Wesley Longman, Inc. Reading, Massachusetts 1995

Waters, M. *Globalization*, Routledge, London, 1995

Steeten, P., *Globalisation Threat or Opportunity?*, Copenhagen Business School Press, 2001

Friedman, T. *The Lexus and the Olive Tree*, HarperCollinsPublishers, London, 1999.

Devarajan, S., D.S. Go, J.D. Lewis, S. Robinson, P. Sinko, *Simple General Equilibrium Modeling*, in Francois, J.F. and K.A. Reinert (eds.), *Applied Methods for Trade Policy Analysis*, A Handbook, Cambridge University Press 1997.

UNRISD (1995) States of Disarray; *Social Effects of Globalization*, Geneva

Frieden, J.A. and D.A.Lake, *International Political Economy, Perspectives on Global Power and Wealth*, 3rd edition, London, 1995

Yeung, Henry Wai-chung and Kris Olds (eds.), *Globalization of Chinese Business Firms*, MacMillan Press Ltd., London 2000

Hatch, Upton and Henry Kinnucan (eds.), *Aquaculture, Models and Economics*, Westview Press, Oxford 1993

EC Fisheries Cooperation Bulletin, Vol. 14 no. 1-4, Dec. 2001, Commision of the European Union.

SNF Bulletin Nr. 4 2001, Tema Havbruk (in Norwegian)

Delgado, C.L., Claude B. Courbois, Mark W. Rosegrant, Mahfuzuddin Ahmed, *Issues in Modeling Fish to 2020 within a Global food Model*, International Food Policy Research Institute and ICLARM - The World Fish Center, 2000

Berlingske Tidende, *Norsk lakseeksport drukner i prisaftaler*, Mandag 21.januar 2002 (in Danish)

Børsen, *Prisaftale på laks under pres*, Tirsdag den 2. april 2002 (in Danish)

Politiken, *Grønnere dambrug*, Tirsdag 2. april 2002 (in Danish)

CD-ROM: *World Fisheries and Aquaculture Atlas*, FAO 2001

Hassan, Salah S., and Erdener Kaynak (eds.), *Globalization of Consumer Markets, Structures and Strategies*, International Business Press, 1994

Boyer, Robert and Daniel Drache (eds.), *States Against Markets, the limits to globalization*, Routledge, 1996.

Seafood Labelling Trends

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ABSTRACT: This presentation draws on a number of studies and initiatives underway in the USA and Europe, demonstrating trends and preferences for seafood labelling. Product labelling performs both an information provision and product differentiation role. Studies have shown consumers' preferences for product labelling, particularly in terms of quality assurance and assurances as to the sustainability of harvesting and management. Tying into such preferences offers market opportunities.

1. INTRODUCTION

This paper presents a brief overview of a number of studies and initiatives underway in the USA and Europe, demonstrating trends and preferences for seafood labelling. Product labelling performs both an information provision and product differentiation role, which studies have shown consumers to exhibit preferences for, particularly in terms of quality assurance and assurances as to the sustainability of harvesting and management. Though tying into such preferences offers market opportunities, the opportunities are not universal, nor proven at this time.

Concentrating on European and American markets, the paper initially considers recent and present trends in seafood product labelling and the story behind the trends, focusing on quality and eco-type labelling (N.B. In his paper, the term 'seafood' includes all fish and seafood products). Some of the initiatives undterway are highlighted during the discussion. The second part of the paper considers two recently completed studies which examine consumers' preferences and willingness to buy and pay for certified and labelled seafood products. Some of their key findings are drawn out and, as noted above, implications drawn.

2. TRENDS IN LABELLING

2.1. Absence of product labelling

Traditionally seafood products have been marked by an absence of product labelling with regard to seafood origin, manner of production and quality of product, so that consumers have had little explicit information on which to base their choices, or to act in ways that might support fisheries management agendas or even personal health interests. Many studies have revealed a lack of skills or knowledge in consumers to use intrinsic cues for quality and freshness, for example. Consumers appear to rely on criteria such as brand and price, which are highly unreliable cues. These deficiencies in labelling procedures are, however, being remedied.

1 Council Regulation (EEC) No. 880/92

2.2. Some current labelling schemes

That changes are being introduced into the system is partly due to seafood related issues, but they have also come about a result of a general increase in environmental awareness among consumers. The following labelling schemes are manifestations of consumers' preferences for more environmental information to inform their purchase choices: the European Community ecolabelling scheme[1] (Ecosite 1999), the German Blue Angel, the Nordic Swan label, Austrial eco-label and the Dutch Milieukeur, all of which are voluntary schemes. At the turn of the millennium, the oldest and most successful of these was the German Blue Angel. Created in 1978 which has become a significant environmental mark, with 51% of west Germans and 30% of east Germans looking for products that carry this label (Umweltzeichen 2002).

As with the Nordic swan label and Austrian eco-label, the Blue Angel label is mostly concerned with non-food products. The Dutch scheme likewise focused initially on non-food products. However, since 1995 it has incorporated a growing proportion of agricultural products and food stuffs within its scope, including fisheries-related products (Milieukeur 2002).

2.3. HACCP and ISO food safety initiatives.

The labelling of food products, and in particular fisheries products, has been slower to develop, but is now well underway, supported by a raised awareness of food safety issues and the way in which food commodities are treated and handled during the production and transportation processes.

These concerns are manifest, for example, in the HACCP and ISO food safety initiatives. HACCP stands for the Hazard Analysis and Critical Point scheme, which is a process- orientated quality management system, based on the identification of hazards and critical points during food processing and handling, and then targeting quality management at those points. It was first developed in the USA, but since the Sanitary and Phytosanitary Agreement concluded during the Uruguay Round of the (WTO) World Trade Organisation, it has been endorsed by national governments and international bodies as the basis of ensuring food safety (Caswell and Hooker 1996, OECD 1999).

The ISO initiative, the International Standard's Organisation 9000 series of standards, also follows a process-orientated approach, but one which is entirely voluntary. The standards stipulate the elements that a quality management should have in place to ensure the consistent quality of the end products (OECD 1999). Companies engage in the certification process to obtain and use the logo of the scheme to endorse their products. It should be noted here, that as neither of these schemes certify the quality of the end products, and are concerned only with the processes involved in their production, neither HACCP or ISO 9000 procedures result in end product labelling. Certification can only be utilised on a company-to-company basis.

2.4. Organic labelling schemes

Health and food safety concerns are also demonstrated by the growing number of organic labelling schemes, globally, and moves by several governments to supplement private schemes with government-endorsed schemes (as in Germany, the European Community generally and the USA). The following are merely a few examples of schemes already in place: Germany's Bioland and Demeter schemes, the private and US Department of Agriculture organic labelling schemes in America, the Soil Association's scheme in the United Kingdom and Norway's Debio scheme. In contrast to the HACCP and ISO schemes, in this instance the status of the end product is regarded as identifiable. As a consequence, consumers can find 'organic' labelled products in the shops, and a growing number of European and US consumers look for these labels when making their purchase choices. One report projects that demand for organic products globally will reach $80 billion US by 2008, a dramatic rise on 2001 figures of $26 billion US (Organic Monitor 2001). Europe and the USA are dominant players within this global organic market and the growing market share.

3. LABELLING OF SEAFOOD PRODUCTS

3.1. Early developments

It should be noted that the labelling of seafood products is a relatively recent innovation. As previously noted seafood labelling has traditionally been somewhat minimal. However, in the late 1980s, the Soil Association in the United Kingdom produced draft organic aquaculture standards in response to requests from various fish farming operations, who wished their better practices to be recognised. Although, due to other priorities, activities were then put on hold in the United Kingdom until the middle of the 1990s, this represented one of the first moves towards the eco-type labelling of seafood products. Since then, organic fish farming initiatives have developed in, for example, the USA, New Zealand, Norway and Ireland. The International Federation of Organic Agriculture Movements (IFOAM), in its capacity as global umbrella body for organic food and farming, has drawn up Basic Standards for Organic Aquaculture, which were approved as Guidelines in its 1998 General Assembly (Soil Association 2002).

Also around the late 1980s the dolphin by-catch associated with the Eastern Pacific yellowfin tuna fishery came to the attention of the media, generating such a consumer response in the USA that in April 1990 three of the largest tuna canners adopted a dolphin safe policy, followed quickly by others. The US government also passed legislation on the labelling of canned tuna as dolphin-safe. The concept and labels spread quickly to other parts of the globe, even though some of the tuna species labelled had no natural association with dolphins (as with Skipjack tuna) (Anzer 1993, 1995, Pickering et al. 2002).

3.2. Influence of environmental interest groups

Food safety and by-catch, however, are not the only issues facing fisheries of which consumers are becoming increasingly aware. Over-fishing and falling catches have also received media coverage. However, the development of labelling in response to these issues has been led not by consumer demand, but by environmental interest groups, concerned fisheries management authorities and commercial organisations who see traditional fisheries management measures as failing to adequately maintain stocks and supplies of fish to the market (Deere 1999). The most high profile labelling initiative to evolve out of these concerns has been the Marine Stewardship Council.

The Marine Stewardship Council was created in 1996 by Unilever, one of the world's largest purchasers of fish, and the World Wide Fund for Nature (WWF), one of the world's largest conservation bodies. The two organisations had different motivations, but both saw their future interests threatened unless the decline in fish stocks were to be halted. By creating a standard, certifying fisheries and marketing the certified products to consumers, the Marine Stewardship Council aims to encourage responsible fishing practices and to provide a chain of incentives throughout the supply chain. The first fisheries started coming forward for certification in 1999 and some of the first certified products are already in the market place: Alaskan salmon, the Western European rock lobster, the Thames Blackwater herring and the New Zealand hoki. Other fisheries are also currently going through the certification process (Marine Stewardship Council 2002).

The Marine Stewardship Council is not the only initiative along these lines. There are also other schemes looking to certify fisheries on the basis of sustainability and eco-principles, mainly in the Nordic countries, where there has been some scepticism as to the independence of the Marine Stewardship Council from its founding organisations. There are several government-endorsed schemes in development at the moment in Denmark, Sweden and Finland, for example (Krogsgaard 1999, Nordic Council 1998). It is evident that the concept of utilising eco-type labelling as a tool of fisheries management has gained some prominence over recent years, with labelling possibly here to stay, although its effectiveness has yet to be proved.

4. EVIDENCE OF CONSUMER PREFERENCE

4.1. Evidence from literature

4.1.1. Information sources: economics, marketing and psychology

Labelling schemes for marine products, even in respect of organic farmed fish, are in their infancy, and therefore evidence as to their effect does not yet exist. However, in the absence of evidence from the schemes themselves, there is a wide body of literature relevant to consumers' behaviour with respect to seafood products from which inferences and lessons can be drawn. This body of literature draws on a variety of academic disciplines, but most notably economics, marketing and psychology. A review of the relevant material can be found in Pickering et al., (2002).

4.1.2. Two recent studies (USAA/Norway and UK/Denmark)

Of particular relevance to the topic of this paper are two recent studies in Europe and the USA looking directly at the question of the quality and eco-type labelling of seafood products and consumer preferences. The first is a collaborative effort between Cathy Wessells of Rhode Island in the USA and Frank Asche of Stavanger University College, Norway, which involved over 3.5 thousand household telephone interviews being undertaken over the period 1998-1999, split between the USA and Norway, targeting the consumers' willingness to buy and pay for certified cod and shrimp. The criterion for certification in this instance was that the certified seafood were caught under "strict controls that prevent too much fishing" (Wessells, pers. com. 19 April 2002).

The second study is an EC funded project, involving a collaboration between CEMARE, University of Portsmouth, United Kingdom, and a partnership of Danish institutions: the Institute of Environmental and Business Economics (IME, formerly DIFER), University of Southern Denmark, and the Danish Institute of Agriculture and Fisheries Economics, Copenhagen (DIAFE), Denmark[2]. This study targeted 2,400 households with in-house interviews during 2000-2001, split between the UK and Denmark, to establish consumers' willingness to buy and pay for seafood products either certified on the basis of high quality or on the basis that the seafood came from a sustainably managed fishery. Six combinations of species and product form were included in the study.

4.2. Studies' results

4.2.1. General trends

The research undertaken as part of these two projects, in the United Kingdom, Denmark, Norway and the USA has revealed that, on the basis of stated preferences, while general trends and observations can be drawn, there is a lack of consistency in response to the introduction of certified/labelled products, both in terms of quality and aspects of eco-type labelling (notably, sustainability)[3].

4.2.2. Preferences for certified products

In both studies, consumers generally preferred the certified products to the uncertified products. In the United Kingdom and Danish studies it was found that the chosen products were almost always the certified versions, with little difference exhibited between preferences for products certified for quality and those certified for sustainability. It was also found that both frequency of purchase and quantity purchased increased when the certified products were offered. For the United Kingdom this increase reflected, in part, households who did not previously eat seafood at home, being willing to do so. This observation offers up a potential for market expansion.

2 EC Fair CT98-4255 "Market-driven Incentive Structures for Sustainable Fisheries Management", co-ordinated by Helen Pickering, CEMARE, University of Portsmouth.
3 Given the brevity of this paper and the lack of opportunity to appropriately elaborate on the studies, their results and caveats, the discussion of the findings of the two studies reported here should not be re-quoted.

However, it was found that preferences and choice differed in relation to price. For example, Norwegian consumers were more sensitive to price than American consumers, although Norwegian consumers attributed greater importance to ecological attributes generally. This observation could be attributed to Norwegian consumers being more familiar with certified products and the price-premiums they can extract.

4.2.3. Preferences between species

Preferences also differed between species: the certification of cod for example, had a greater influence than that for shrimp in the 1998-1999 study. In the 2000-2001 study, there were marked differences in consumers' willingness to pay between different product forms, being generally less willing to pay a price premium for the cheaper, more convenience-type product forms. In both studies, it was evident that there was little consumer awareness of the state of the respective fisheries or issues in aquaculture, their perceptions having little basis in reality.

4.2.4. Country-specific variabilities

Household and consumer characteristics (such as household budget, income and gender) also influenced the consumers' choice of certified product, how much they would buy and how much they were prepared to pay, although not necessarily in a predictable manner, nor consistently. There was a marked country-specific variability in the influence of household and consumer characteristics on consumer preferences and choices.

4.2.5. Levels of consumer trust

Of particular interest for the Marine Stewardship Council, it was found that the nature of the certifier was a factor in consumer choice, reflecting the level of trust held by the consumer in the certifier. In the USA and particularly, Norway, trust lay with governmental certifiers rather than with the alternatives presented, notably the Marine Stewardship Council and World Wide Fund for Nature. In Denmark, the opposite was found.

4.2.6. Importance of labelling of seafood origin (wild/farmed:domestic/foreign)

Of particular relevance to aquaculture, it is pertinent to expand on two other aspects of the study conducted in the UK and Denmark, which did not focus solely on quality and sustainability labelling. Other aspects of seafood labelling were also included, in particular, the origin of the seafood: farmed or wild caught and domestic or foreign. Under European legislation, all seafood products should be labelled in one of three ways: 'caught at sea', 'caught in inland waters' or 'farmed'. Unfortunately, as was found in the UK and Danish surveys, consumers' have a general preference for wild caught fish over farmed fish. Research carried out by Omnimas/Taylor Nelson Sofres for the Seafish Industry Authority has also shown this to be true, revealing that consumers have 'overall negative attitudes' to fish farming, viewing the products as less natural. It is such a strong perception that there is great reluctance among retailers, particularly in the UK, to label their fish as farmed, as there is an anticipation that sales will plummet. The retailers have been trying to use alternative wording to 'farmed fish' to provide a more positive image, but this procedure breaks EU regulations. To expand on this point, it seems that, given the number of food scares surrounding invasive farming practices in Europe in recent years, consumers are not very happy to have their food 'mucked around with'. The GMO debate is at the extreme end of this trend.

In terms of the domestic and foreign origin of seafood, it was found that UK consumers would choose domestically caught or sourced seafood over seafood caught or sourced abroad. In contrast, Danish consumers chose foreign caught or sourced seafood over domestic supplies. A large proportion of Danish catches are exported, not destined for the domestic market, and consumers may be aware of this. These findings, however, have implications for imports, especially from regions which consumers associate with lower food standards and health concerns.

4.3. Findings from University of Stirling study

In addition to the two studies just mentioned, a third study is of particular relevance to labelling and aquaculture. This study is also a EC-funded project, on this occasion focusing on consumers' attitudes to organic fish in various countries in Europe (EC FAIR CT98-3372 "Organic Salmon Production and Consumption: Ethics, Consumer Perceptions and Regulation") coordinated by James A. Young, University of Stirling. This study found that whilst moves towards making fish farming more organic were welcomed by European consumers, there were mixed reactions to the use of the 'organic' label on farmed fish. In particular, committed organic consumers regarded the semi-intensive farming practices, use of cages and cage loadings as being incompatible with the 'organic' principle. It should be noted that the interpretation of the term 'organic' varies between labelling schemes and consumer groups. The debate over the legitimacy of applying the 'organic' label to farmed fish is legitimised by the certification agencies[4], who stress that their standards for 'organic' fish farming are 'interim' and could see further restrictions. There is concern among the organic movement that the trust they have built up with consumers could be undermined by the less rigorous standards currently applying to 'organic' fish farming.

5. CONCLUSIONS

The findings of these studies reveal the potential for developing market niches for certified seafood products, both in terms of quality and sustainability. However, the opportunities are not universal, with distinct country-specific influences and product form variation, so that the use of certification as a fisheries management tool has its limitations. Also as noted, given the very recent introduction of certified products into the market place, these findings have yet to be tested in reality. For robust conclusions to be drawn, the stated preference techniques utilised in these studies would need to be supplemented by revealed preference analysis once certified products have gained some market exposure. Irrespective of effect, however, at least in the short-term, seafood quality and eco-type labelling looks likely to develop further.

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4 For example, the Soil Association

REFERENCES

Anzer, W. 1993. *Market trends and import regulations in the European Economic Community*, 3rd Infofish Tuna Trade Conference, Bangkok, Thailand, pp. 98-99.

Anzer, W. 1995. *EU Import Regulation and Markets for Tuna*. Proceeding of the IVth Infofish Tuna Trade Conference. Manila, Philippines. pp.119-21.

Caswell, J. A. and Hooker, N. H. 1996. *HACCP as an international trade standard*. American Journal of Agricultural Economics, 78 August, 775-779.

Deere, C. 1999. *Eco-Labelling and Sustainable Fisheries*. IUCN, Washington DC.

Ecosite. 1999. http://www.ecosite.co.uk/depart/ecolabel.html. 25 November 1999.

Krogsgaard J. 1999. Sverige arbejder intenst på miljømærkning, artikel i Fiskeritidende 15.

Marine Stewardship Council, 2002. www.msc.org 19 April 2002.

Milieukeur, 2002. www.milieukeur.nl/english/ 19 April 2002.

Nordic Council of Ministers 1998. Fiskeriets nye markedsvirkelighed: nye udfordringer for det nordiske fiskeri, *TemaNord Fiskeri*. 1998: 523.

OECD, 1999. *Food Safety and Quality: Trade Considerations*. Organisation for Economic Co-operation and Development, Paris.

Organic Monitor, 2001. *Global organic sales reach $26 billion*. 6 November www.purefood.org/organic/org26bill111301.cfm 19 April 2002

Pickering, H. 2002. *EC Fair CT98-4255 Market-driven Incentive Structures for Sustainable Fisheries Management - Final Report*. CEMARE, University of Portsmouth.

Soil Association, 2002. *Fish Farming and Organic Standards: Briefing Paper*. www.soilassociation.org 19 April 2002.

Umweltzeichen, 2002. http://www.umweltbundesamt.de 19 April 2002.

Consumption trends and habits for aquatic products in China

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ABSTRACT: Aquatic products, a main source of protein in human food consumption are also an important item in Chinese food consumption. In the last twenty years, especially, Chinese fishery has made great strides forward, the total volume of aquatic products has increased very rapidly, and the overall production capability has been greatly strengthened in fisheries. Since the 1980s, the average annually increasing rate of fisheries harvesting has reached 8.8% in volume. The landing volume of aquatic products of China has ranked first among the world fisheries countries since 1990. The total output of aquatic products of China in 2000 reached 42.79 million MT in volume, 60% of which was contributed by freshwater aquaculture and marine aquaculture.

China is a large developing country with 1.29 billion of population, where the per capita income is continually rising; the population is also increasing, so that the demand for human edible consumption of aquatic products is increasing significantly. In recent years, despite the steady increase in domestic aquatic products, more and more imported aquatic products have appeared in the China's fish markets.

1. FISHERIES PRODUCTION IN CHINA

1.1. Introduction

China is a major fishing nation with a huge marine resource area of her own. Four seas span from tropical to temperate zones, the Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea, with a surface areas of approximately 4.83 million square kilometers. The marine fisheries resources consist of more than 150 species, with greater and little yellow croaker, largehead hairtail and cuttlefish (squid) were the four traditional species that are the basis of Chinese marine fishing industry in the past several decades.

China also has a long history in freshwater aquaculture, and the dates could be backed to more than 3000 years ago. China has more than 18,000 kilometers of coastline, and about 13,300 square kilometers of shallow waters (inshore waters) and flat mud areas that could be used for marine aquaculture.

1.2. Production over the last two decades

The Chinese fisheries production has been rapidly progressing in the last two decades. Table 1. shows the annually Output of Chinese Fisheries by production category from the year of 1996 to 2000.

1.3. Overall importance of Chinese production

The production volume of Chinese aquatic products ranks it among the first among the world fisheries countries since 1990. The total production volume of Chinese aquatic products reached 42.79 million MT in 2000, that is more than seven times that of 1978, and the harvesting of aquaculture increased 15.6 times over the same period. In 2000, the ratio of aquaculture's volume was 60% of total volume of aquatic products in China, though it had only been 26% in 1978. The per capita consumption of aquatic products has been increasing yearly, standing at 33.8 kg in 2000, a startling increase from 4.8 kg in 1978.

In 2000, the annual increase of total national landing of aquatic products was 3.8%, while it reached 8.9% in marine aquaculture. Marine aquaculture was the fastest-increasing fisheries sector in recent years.

	1996	1997	1998	1999	2000
Total Fishery's Output	32881	36018	39067	41224	42790
Marine Fishery's Output	20129	21764	23567	24719	25387
Of which: Fishing	12490	13854	14967	14967	14774
Aquaculture	7639	7910	8600	9743	10613
Inland Fishery's Output	12752	14254	15499	16505	17403
Of which: Fishing	1763	1887	2280	2285	2233
Aquaculture	10990	12367	13219	14220	15169
Marine Fishery's Output	20129	20129	23567	24719	25387
Of which: Fin-Fish	8235	9642	10560	10581	10327
Crustacean	2046	2256	2586	2771	2970
Shellfish	8527	8242	8705	9591	10389
Algae	929	980	1041	1194	1222
Other	391	644	676	582	479
Inland Fishery's Output	12752	14254	14254	16505	17403
Of which: Fin-Fish	11883	13249	14259	15168	15786
Crustacean	364	480	602	707	860
Shellfish	403	374	460	435	480
Other	101	151	179	194	276

Table 1. Annually Output of Chinese Fisheries by production category from the year of 1996 to 2000 ('000 MT)

1.4. Rate of increase has led to environmental measures

Because of the constraints on the natural environment, fishery resources, aquatic product processing methods and industrial investment, the type of harvesting in Chinese fisheries production has been changing. In making a comparison of the harvesting volume in 2000 to that in 1999, the following facts emerge:the output of marine fin-fish decreased 254.0 thousand MT, which rate of decrease was -2.4%; the output volume of shellfish products increased to 798.6 thousand MT, with the rate at 8.33%; the output volume of shrimp and crab products increased to 199.3 thousand MT, a rate of increase of 7.19%. In addition, in order to protect the natural environment and utilize wild fishery resources in an appropriate manner, the Chinese government has launched severe restraints on the production of capture fisheries since 1999. However, it is clear that the negative increment of the annually harvested volume of marine and inland capture fishing will be continually increasing in the near future in China.

It is estimated that the harvesting of Chinese domestic aquatic products will keep increasing, but most of the incease will came from fresh water aquaculture and only a small amount from marine aquaculture.

2. CONSUMPTION OF AQUATIC PRODUCTS IN CHINA

2.1. The Chinese market

China is a developing country with a large population and extensive land areas with vastly different natural environments. At present, the fisheries production is still greatly affected by the conditions of the natural environment. The consumption of aquatic products is affected by people's traditional customs, population constitution, resident' disposable income level, the product's distribution channels and method and so on.

2.2. Adoption of Open Policy

China adopted the Open Policy more than twenty years ago, and there have gradually formed some different consumer groups among the aquatic products' consumers in mainland China, because of the diversity of disposable income in different areas and different consumers. People are not satisfied with their ability to purchase any type of fish: they want to choose different species and different qualities of aquatic products, according to their standing in individual consumer groups. Most consumers are now beginning to choose what they consume, namely consumption is based more on the quality and species of aquatic products than before.

2.3. Effects of rise in disposable income

According to the household sampling survey of 500 families carried out by the survey groups of Statistic Department of Shanghai in 2000, the annual average expenditure per capita in Shanghai was US$ 1,072, an increase of 7.5% in comparison with the previous year. Since this was higher than that of disposable income, that means that the average person's living standard was increasing. According to he survey the citizens of Shanghai paid more attention to the increase of living quality than before. "Paid for health" has become a fashion trend for Shanghai residents, therefore expenditure per capita for health-care products, including food consuming was 55.8% more than that in previous year. Moreover, because of the diversity of residents' incomes, a multi-polar expenditure in citizens' consumption obviously appeared. In 2000, among the 500 families which were surveyed, in which about 10% of the lowest income families had a lower level of consumption, the annual average expenditure per capita was US$ 649.6, while in about 10% of the highest income families, the annual average expenditure per capita was US$ 1797.4. The average consumption value of the 10 % lowest income families was equal to only 36% of that in the 10% highest income families. More and more higher income families have more opportunity to eat in restaurants or outdoors, and they are consuming more expensive food. So there is increasing demand for high-value aquatic products and higher price with higher quality imported seafood, which is little or never satisfied by domestic fishing fleet. With reinforcing open policy in Chinese economy system, especially in the western part of China, increasing disposal income per capita and improving citizen's living standards will be more rapidly in most part of China in near the future.

2.4. Other factors accounting for change in expenditure levels

While per capita income level played an important role in determining a city's per capita expenditure on seafood, eating habits and easy access to seafood also affected expenditure levels.

Table 2. shows that different percentage of per capita expenditure of aquatic product to disposable income in seven cities in 1997.

Residents in coastal cities, such as Shanghai, Guangzhou, Dalian and Qingdao, on average per capita spend a larger percentage of their annual income on seafood than their counterparts in inland cities, such as Beijing, Chengdu, and Chongqing. In 1997, seafood expenditure expressed as a percentage of annual income for residents in Shanghai, Guangzhou, Dalian and Qindao was 7 percent, 4 percent, 6 percent, and 5 percent respectively, compared to 2 percent for residents in Beijing, 1 percent for Chengdu, and 1 percent for Chongqing.

The annually per capita average consumption value of aquatic products within the country as a whole was as follows:

Name of cities	%
Shanghai	7
Guanzhou	4
Dalian	6
Qingdao	5
Bejing	2
Chengdu	1
Chongqing	1

Table 2. Percentage of per capita expenditure of aquatic product to disposable income in 7 cities in 1997.

(Unit of value is RMB Yuan, and one US dollar equals to about 8.27 RMB Yuan)

Area	**1986**	**1997**	**1998**		**1999**	
	Value	Value	value	%*	value	%*
Town and city (per capita)		140.98	142.46	3.29	143.96	3.12
Rural area (per family)	15.48				21.62	

%*: Mean percentage of annual consumption value of aquatic products to total expenditure for residents in cities and towns.

Table 3. The annual per capita average consumption value of aquatic products within the country taken as a whole.

The annual per capita average domestic consumption value of aquatic products for different parts in China were as shown in Table 4.

2.5. Nature of change in aquatic food consumption

The Eastern part of China is one of the main traditional aquatic production areas, and average per capita domestic consumption volume has not increased in recent years; Moreover, there is a group with higher incomes accounting for 10% of the population in those cities, whose way of life and social activities are changing, with a resultant increase in the consumption of aquatic products in restaurants rather than at home. This type of clientele tends to consume higher-value aquatic products. Therefore, in 2000, among China's overall imported aquatic products, high-value aquatic products occupied a more prominent position than in the past so that there will be a larger potential market for middle and lower value aquatic products.

(Unit of value is RMB Yuan, and One US$ equals to about 8.27 RBM Yuan)

Area	Population (the year of 2000)	% of population to total population in whole country (2000)	% Volume of Aquatic production (MT) (2000)	1986	1999	Increment (%)
Eastern part	0.514 (billion)	39.7	80	29.80	39.44	32
Middle part	0.482 (billion)	37.3	18	7.7	14.63	90
Western part	0.298 (billion)	23.0	2	3.80	7.54	98

Table 4. The annual per capita average domestic consumption value of aquatic products for different parts in China.

As presented by the random sampling survey in Shanghai, Beijing, Guangzhou, Dalian and Qingdao in Jun and July of 2001, about 10%~40% of people who were investigated had consumed imported salmon.

An investigation into consumer behaviour and knowledge of imported salmon was undertaken in June and July of 2001 in Shanghai and Qingdao. A random selection of 1000 and 122 completed the questionnaires in Shanghai and Qingdao respectively.

The survey results for the one of the questions are summarized as follows:

Question: Did your family consume any salmon or salmon products? If did, where did the salmon came from?

(1) Shanghai

Answer chosen	Yes	Percentage %
Consumed, Norwegian salmon	68	6.8
Consumed, Alaska salmon	32	3.2
Consumed, Not sure	265	26.5
Never consumed	635	63.5
Sum	1000	100

(2) Qingdao

Answer chosen	Yes	Percentage %
Consumed, Norwegian salmon	4	3.3
Consumed, Alaska salmon	2	1.6
Consumed, Not sure	1	0.8
Never consumed	115	94.3
Sum	122	100

It is generally believed that the majority of consumers ate seafood at restaurants, although there was a growing trend for home consumption.

2.6. Value of imports

In 2000, in comparison with previous years, the rate of increase of imported aquatic products was quite high and the increasing rate of imported aquatic products was much higher than that of exported aquatic products, both in volume and value. The annual import value was US$ 1.85 billion, up from US$ 1.29 billion in 1999, and it increased by 42.3%, up from 26.6% in 1999. Deducting the industrial products including fishmeal, the actual volume of import aquatic products reached 1.328 million MT, up from 0.67 million MT in 1999, increased by 97%. Also, the actual import value reached US$ 1.27 billion, up from US$ 0.93 billion in 1999, increased by 36.6%.

2.7. Importance of quality

At present, quality, rather than price, is considered to be the most important factor affecting seafood purchasing decisions of Chinese consumers. Chinese consumers were believed to have certain quality perceptions about seafood from different national sources, but the majority of the consumer-oriented promotional activities were considered to be important marketing tools for seafood suppliers to create awareness and generate interest for their products.

According to investigations concerning potential consumption and imported seafood wholesale in mainland China, it is consider that, at present, the consumption market of imported high-value seafood is still in the initial stages. Due to lack of the perceptual knowledge on the quality of imported high-value seafood, such as salmon, by the consumers and even by wholesalers and retailers, consumers and wholesales are paying more attention to the species and price, rather than quality, of the seafood. So there is a need to cultivate a healthy seafood market quickly, to increase ability to recognize the quality of high value seafood, to enhance trust between consumers and sellers and wholesalers in mainland China.

2.8. Effect of China's accession to the WTO

China's accession to the WTO will undoubtedly speed up the standardization of international seafood trade and aquatic product markets in China. China's seafood imports will be expanded so as to meet the continuously increased need to high-value seafood for Chinese high-income residents. For instance, although the aquatic product consumption per capita in Shanghai is about 60% of that in Hong Kong, and the population in Shanghai is 2.47 times of that in Hong Kong, but the imported chilled fresh salmon in Shanghai in 1999 was only 60 MT, while that in Hong Kong was 5500 MT. In 2000, however, Shanghai imported 245 MT of Fresh and chilled salmon, a 400% increase from 1999. It is undoubtedly true that the same trend will appear or has appeared in Beijing, Guangdong province and other East Regions of China.

From now on, as a result of increasing Chinese population and the increased consumption per capita, the total increase of imported middle and high-value seafood will surpass that of other countries in the world. China's accession to WTO will help to expand the international trade between China and other countries, to improve the species constitution of seafood conflicts between domestic seafood supply and demand.

3. CONCLUSION

China is a large developing country with 1.29 billion of population, where the per capita income is continually rising; the population is also increasing, so that the demand for human edible consumption of aquatic products is increasing significantly. In recent years, despite the steady increase in domestic aquatic products, more and more imported aquatic products have appeared in the China's fish markets.

China has great potentialities to consume aquatic products; it can be taken for granted that China will become the largest fish market in the world.

THEMATIC AREA VI

Best Environment Practice (BEP), health, monitoring and regulations, codes of conduct.

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ABSTRACT: Guidelines for responsible aquaculture development are now becoming commonplace. Such guidelines are being packaged as principles of Codes of Conduct. The Codes of Conduct are frameworks based on international and national legislation, ethical rules and developed through a process of consultation, negotiation, and agreement within a group of stakeholders all directly involved or affected by the topic. But in most cases a Code of Conduct only over-arches a sector, leaving the industries or subindustries to generate their own detailed Codes of Best Practice (CBP). CBP is more specific and can be defined as a collection of recommended practices *at farm level*. The framework for CBP is related to the environment in many respects. The aquatic ecosystem and aquaculture include many factors such as water management, the physical and chemical environment, biotic factors, regulation and monitoring of water. The authorities propose environmental quality standards (EQS) for every industry and farmers who intend to start new aquaculture ventures are obliged to make an environmental impact assessment (EIA) of their sites before licences are granted. The monitoring of discharged water from aquaculture facilities is stipulated by authorities. The farmer is forced to apply the latest progress in feed and feeding practices, considering the feed quality both with regard to the fabrication and the composition of the feed. Feeding regimes are as necessary as the quality of the feed and it is important to apply the new development with computer programs to optimize feeding in relation to fish behaviour. Reduction in bio-wastes is possible by using various technical devices to collect feed wastes, nutrients, organic material and dead fish from production units. Diseases must be combatted by using preventive measures including approved veterinary medicines, drugs and chemicals. But traditional antibiotics have now largely been replaced by vaccines, and even these will probably be replaced by probiotic feeds.

The food quality of aquaculture products compete in an open market and must therefore be of the highest possible quality and has a taste appealing to consumers and free of any health hazards. Therefore regulations and protocols for the use of chemical and antibiotics in the production of farm animals must be strictly followed. Post-harvest treatment must comply with regulations for proper and humane treatment of animals and processing must comply with accepted hygienic and safe practices for the handling of food for human consumption.

1. INTRODUCTION

Guidelines for responsible aquaculture development are now becoming commonplace. They have been formulated by International conventions, such as the Bangkok Declaration - by producer organisations, such as the Federation of European Aquaculture Producers (FEAP) and national farming associations and by legislation and regulations, coming in the form of EU directives and national regulatory agencies. All of these have the stated aim of creating a sustainable aquaculture sector which is also environmentally responsible and publicly acceptable.

2. CODES OF CONDUCT

2.1. Background

Such guidelines promoting responsible aquaculture, no matter what their origin, are emerging as the guiding principles behind the establishment of Codes of Conduct.

It is recognised that this voluntary measure, if used responsibly by Producers' Associations, can exercise restraints which lead to a significant amount of quality control. The FAO developed the concept of responsible fisheries within a Code of Conduct, and followed this up with the Code of Conduct for Aquaculture Development (FAO 1997). The FAO Code sets out principles and international standards of behaviour for responsible fisheries and aquaculture practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. An acceptable Code of Conduct should be able to cross any frontier and remain free of local and national considerations. All Codes should involve a process of consultation, negotiation and agreement within a group of stakeholders that are either directly involved or affected by the subjects. The diversity of stakeholders is considerable, involving: i) government authorities, policy-makers, planners and regulators; ii) producers, farm operators; iii) manufacturers and suppliers to aquaculture; iv) processors and traders of aquaculture products; v) consumers; vi) banks and investors; vii) special interest groups and non-governmental organisations (NGOs); viii) researchers, social and natural scientists; ix) international organisations (regional, global) and; x) media. It is important to show that such Codes, though not legally enforceable, do carry a certain amount of moral weight and have indeed exercised a good deal of influence. Codes of Conduct such as these have been shown to generate good collaboration between legislators, regulators and the producers, based on an involvement of the Producers Associations and recognition of fish farmers activities and needs.

Faced with the increasing difficulties of regulating aquaculture activities because of the number of interests involved, the variety of institutions involved, the diversity of natural resources involved, what has been called "the tangled web of laws and regulations", as well as the series of initiatives to direct the industry towards environmentally friendly and socially sustainable practices, increasing importance has been given to Codes of Conduct and Codes of Practice built on best environmental practice (BEP) and best management practice (BMP). Such recommendations are not legally binding but constitute a Code of Practice to be consulted and used by countries to promote environmental protection when formulating national policies and legislation governing aquaculture and fisheries activities.

3. CODES OF BEST PRACTICE

3.1. Differences between Code of Conduct and Code of Practice

The Codes of Conduct are frameworks based on international and national legislation, ethical rules and developed through a process of consultation, negotiation, and agreement within a group of stakeholders all directly involved or affected by the topic. In most cases a Code of Conduct only over-arches a sector, leaving the industries or subindustries to generate their own detailed Codes of Best Practice (CBP). Codes of Practice/Codes of Conduct may constitute a type of institutional and regulatory framework that is appropriate for the special needs governing aquaculture activities and production. A Code of Practice is more specific and can be defined as a collection of recommended practices *at farm level.* (Table 1)

Table 1. Basic Principles of Codes of Practice (irrespective of species, location or culture technology)

1. Protecting human health and safety

Checklists for: Employee training (boat or equipment handling, Life-saving and First Aid, Diving,Alarm systems, Radio communication, Hazardous materials and waste, Handling chemicals and therapeutants)

2. Protecting the livestock and animal welfare

Checklists for: routine inspections of farm stocks to observe behaviour and indicators of health problems and stress, precautions to be taken during handling and harvesting

3. Operational data for efficient management

Checklists needed for:

- ✔ Number of eggs, juveniles and adults
- ✔ Origin of deliveries
- ✔ Disease-free certification
- ✔ Number of fish lost and harvested
- ✔ Diseases and treatments
- ✔ Post-mortems and health control

4. Handling artificial feed on the farm

- ✔ Maintain complete records of origin, type and quantity of feed to improve Food Conversion Rates
- ✔ Use feeds with high digestibility
- ✔ Use feeds with correct levels of Phosphorus and Nitrogen
- ✔ Minimise uneaten food and, if possible, remove sediments

5. Handling bio-wastes on the farm

- ✔ Collect mortalities daily
- ✔ Dispose of mortalities correctly by incineration or in silage
- ✔ Collect, treat and correctly dispose of kill water and blood water
- ✔ Collect and correctly dispose of waste (offals, etc)
- ✔ Recycle wastes whenever possible
- ✔ Buy and use recyclable packaging materials whenever possible

6. Handling chemicals, drugs and veterinary medicines on the farm

- ✔ Keep records of purchase, use and removal
- ✔ As far as possible use proactive prevention - vaccines, immunostimulants, etc
- ✔ Buy chemicals and medications through authorised channels
- ✔ Use only authorised chemicals and medication
- ✔ Follow manufacturers instructions - dose rate, frequency and time duration
- ✔ Neutralise unused or residues of chemicals
- ✔ Use non foaming and biodegradable detergents
- ✔ Use only authorised antifoulants on nets and boats

7. Handling general farm wastes

- ✔ Where possible try to collect faeces and sediments below the cages.
- ✔ Have screened area for storing spare or discarded equipment materials
- ✔ Collect and dispose of rubbish daily and correctly
- ✔ Separate biological matter from other matter and incinerate
- ✔ Organise regular litter collection from around onshore site and below cages
- ✔ Prevent escapees (see No.8 below)

8. Preventing genetic risks

- ✔ Prevent escapes as far as possible
- ✔ Prevent Gamete loss as far as possible
- ✔ Treat outlets of hatchery broodstock tanks to kill gametes
- ✔ Where possible harvest fish from cages before spawning season
- ✔ Use methods to delay or prevent spawning - photoperiod, triploid, etc.
- ✔ Use local strains of fish
- ✔ Minimise genetic selection for single traits

9. Integrating with the public

- ✔ Where possible and practical, integrate onshore facilities with local aesthetics (landscaping, cleaning, etc)
- ✔ Avoid possible offensive activities (post-harvest handling, incinerating mortalities, rendering, etc) in public

10. Integrating with the environment

- ✔ Make a baseline study of the environment around the site before operations begin
- ✔ Monitor the environment regularly
- ✔ Maintain all records and make available for authorities and regulators
- ✔ Use predictive models or computer programmes to highlight potential risks
- ✔ Alternate sites where possible
- ✔ Assist in site recovery
- ✔ Use single production tuns
- ✔ Use biological management rather than chemical solutions where possible
- ✔ Certify/register compliance of the site with government regulations

3.2. Framework for CBP (environment)

The framework for CBP is related to the environment in many respects. It is easy to forget that the husbandry process, especially for aquatic animals, is very complex. However, it should not be forgotten that aquaculture technology is very diversified as well as quite complex (Ackefors 1999) (Table 8). It covers: i) different technical systems such as still-water systems, flow-through water systems, closed recirculating systems; with ii) various biological systems such as extensive, semi-intensive, intensive systems and integrated systems; and with iii) herbivorous, omnivorous and carnivorous animals

Therefore producing a CBP is not a simple task, and may have to be constructed from a series of operational elements.

3.3. Diversity of aquaculture as indicated by Production Elements

Here is an overview of the many factors in the rearing process. These include:

- Biological factors such as genetics and breeding, nutrition and pathology are very important as well as the knowledge of the ecology, physiology and behaviour of the animals
- Technical-biological factors comprise mechanical engineering (water supply, water treatment, container design, feeding, aeration, temperature control), Electrical engineering (environmental controls), Electronic engineering (monitoring and control), Agricultural engineering (integration with other farming systems)
- Technically-economically feasible methods such as the cost of water, energy, feed, material, labour, land and plant investments as well as legal aspects; financial management (cost efficiencies, book-keeping)
- Socio-economic conditions and marketing include several very important factors: post-harvest technology (processing and packaging), Marketing (sales and market analysis), Public Relations (business transparency).

3.4. Legislation and regulation

3.4.1. Importance of environmental quality standards (EQS)

The aquaculture industry is dependent on the legal framework for its development. Environmental authorities propose environmental quality objectives (EQOs) and corresponding environmental quality standards (EQSs) for the industry and decide which water bodies can be used for the cultivation of aquatic organisms.

In many countries, environmental quality objectives (EQOs) are determined and established so that the environment can be managed in such a way that these objectives would be achieved. Environmental quality standards (EQSs) are then set for specific variables in order that the objectives are attained. Therefore, quality standards are now implicit within any process of regulation, enforcement and quality control. In those countries they are believed to be important to protect the consumer, the environment and also the product. Many countries now operate the EQO/EQS system in their approach to managing the environmental impacts of different activities. The uses of the aquatic environment are set, e.g. consumer protection (edible aquatic species may be safely eaten), protection of aquatic life, protection of water quality for industrial use, water sports and nature conservation. Standards or criteria are then established to protect these uses and applied by the competent authority in regulation. Quality standards may be set nationally, for example List I and List II and Red List substances (e.g. under the Dangerous Substances Directive (76/464/EEC) and its Daughter directives, for example, the Cadmium Directive (83/513/EEC)), or they may be locally derived from available data (e.g. sediment quality) to provide operational guidelines.

The authorities propose environmental quality standards (EQS) for every industry and farmers who intend to start new aquaculture ventures are obliged to make an environmental impact assessment (EIA) of their sites before licences are granted.

3.5. Environmental considerations

3.5.1. Site selection

A good site selection is the prerequisite in which quantitative and qualitative aspects must be considered. There are three fundamental issues:

- Environmental factors affecting the choice of site, technology, and husbandry, including prior constraints that require some sort of understanding or technological solutions, such as the pre-treatment of water;

- The environment within the culture system, including the possible effects of production upon health and safety of the operation, and secondary constraints that either limit the efficiency of the farm or require additional treatment to render the stresses acceptable;
- Discharges from the system that may require some measure of control to minimise their potential impact on the environment downstream or on adjacent enterprises.

3.5.2. Water management

Water supply and water management is fundamental to all aquaculture. The technology as well as other factors must be adapted to the available water resources. Pre-treatment of incoming water is essential in some cases, particularly when the farmer shares water with other stakeholders - industry, forestry, agriculture and other types of aquaculture.

In many areas the water is too acidic (PG1) for an optimal culture medium, e.g. for rearing juveniles of salmon for later stocking in the seas. In such cases liming of the water source might be necessary. In other cases the water contains too much iron, manganese or other metals. Sand filters or simple aeration might mitigate the concentration of these metals. Supersaturation of gases like carbon dioxide is another problem if water is pumped from a well. Degassing of the increased carbon dioxide concentration is necessary.

The supply of water might also be affected by other users such as industries, agriculture, forestry or by other aquaculture farmers. The pre-treatment of water is in this case more tricky. The farmer has to investigate the kind and concentration of the pollutant in order to make adequate measures to clean the water if possible. The coastal zone is utilised by many stakeholders and is of great importance for food production.

3.5.3. Physical and Chemical environment

The temperature regime has a very important bearing on the species to be reared. The temperature range as well as the optimal temperature for growth differs from species to species and sometimes also for different strains of the same species. For various species it is also important to know the temperature range for survival. Temperatures below - 0.7°C are lethal for salmonids Sites in certain parts of the sea with salinities between 20 and 30ppt may get super-cooled water in winter time and are not suitable for rearing salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*)

Salinity is another parameter of paramount importance. Some species have a wide tolerance, such as salmonids after the smolt stage and Mediterranean sea bass (*Dicentrarchus labrax*), but others may be restricted to a certain salinity level such as Gilt head seabream (*Sparus aurata*).

Wave action and strong currents may be limiting factors. Growth rates, food conversion efficiency, and resistance to disease can be impaired by mechanical stress such as wind-generated wave action. Wind exposure areas require certain moorings and stable cages to withstand high waves and ice loads in winter time.

Depth conditions influence the site location with regard to mooring and temperature. The very deep net cages down to 20m depth may mitigate high and low temperature regimes found in extreme summer, and winter conditions.

Current and water exchange influence the conditions in the cages as well the prerequisites for mussel (*Mytilus edulis*) cultivation. For the latter, the continuous supply of phytoplankton and organic material is important. Turbidity and suspended sediments may favour the growth of filter feeders such as mussels.

3.5.4. Biotic factors

For some species, bacteria may be harmless and used as feed, but for others bacteria may cause disease and impair growth rate. Such organisms may also be harmful to the consumer and affect human health. Shellfish may accumulate and concentrate bacteria and viruses and for this reason water quality standards are in place for the culture of aquatic organisms. The bio-quality of water is usually based on the number of faecal coliform bacteria per 100ml water.

Toxic microalgae cause many problems in waters used for mussel or oyster (e.g. *Cassostrea gigas, Ostrea edulis*) cultivation. Usually the mussels remain unaffected while consumers of the products are affected. Causative organisms for diarrhetic shellfish poisoning (DSP) are the dinoflagellates of the genera *Dinophysis* and *Prorocentrum*. DSP causes nausea, vomiting and diarrhoea if consumers eat poisonous mussels. Paralytic shellfish poisoning (PSP) is another disease caused by planktonic alga such as *Alexandrium tamarense*. PSP is more serious for humans as the toxin attacks the nervous system and the respiratory organs. Amnesic shellfish poison (ASP) sometimes causes problems for the mussel industry. Associated symptoms, after mussel consumption, are nausea, vertigo and memory loss. The problems associated with toxic algae dictates that regular sampling of mussels and analyses of the amount of toxins is required.

Phtyoplankton may also be hazardous to fish. Fish farmers in many countries have experienced mass mortalities of culture stocks due to phytoplankton blooms, e.g. *Chrysochromulina* in Sweden and Norway (Rosenberg et al., 1988). Four distinct lethal mechanisms have been discovered: i) excessive oxygen demand; ii) excessive oxygen concentrations; iii) mechanical damage of the gill tissue; and iv) toxins produced by the algae (Black et al., 1991).

Predators are an additional problem for the aquaculturist. Marine salmonid farmers are troubled by seals and birds. In the 1990s, increasing cormorant (*Phalacrocorax carbo*) populations became a problem, particularly in the inland waters of Europe (EIFAC 1994). Seals are normally protected, as well as cormorants, either by conventions or national jurisdiction. The antagonism between fishermen and authorities concerning controlled hunting is similar to the situation with regard to farmers

3.5.5. Monitoring of discharged water from aquaculture facilities

Monitoring of coastal aquaculture operations is proposed by several authors (e.g. GESAMP 1996a).
It embraces:

i) Regulation - compliance with terms of licence, protection of the natural environment and safeguarding water quality;

ii) Farm management - optimising husbandry practice, control of water quality, limiting interference from other aquaculture operations; and

iii) Public health - protection of product quality.

The starting point of this section is the technology used when assessing the impact of a discharge of waste water from an aquaculture production unit. It is more difficult to treat the outgoing water and mitigate the waste products from farming in open water systems such as cages. For this reason it is necessary to consider i) the level of production; ii) the feeding technology; iii) the quality of feed; and iv) the capacity of the recipient.

3.5.6. Benthic fauna

Environmental criteria include the composition of the benthic faunal community and various standard recommendations for bottom sediment and water column quality. It is essential to calculate the anticipated discharge of nutrients and organic waste from future aquaculture operations with regard to the capacity of the recipient (Ackefors and Enell 1990; 1994). Such calculations have been done in various districts of the Norwegian westcoast with regard to the load of nitrogen in cage farming of salmon in the socalled LENKA project (Pedersen et al., 1988; Ibrekk 1991. Contamination with bacterial, chemical or natural toxins is avoided by analysing water quality and being vigilant with regard to the outbreak of toxic algal blooms. EQSs are also related to good husbandry in order to prevent disease outbreaks or to provide measures against disease outbreaks through vaccination or other actions.

3.5.7. Better feed quality

The feed coefficient ration (FCR) and the content of phosphorus and nitrogen in the feed are two important factors to consider when assessing the environmental impact of aquaculture. Mass balance calculations are used to calculate the discharge of pollutants. By calculating the feed coefficient versus the content of phosphorus and nitrogen in feed minus the retained quantity of those substances in the harvest, Ackefors and Enell (1990; 1994) described the development from 1974 to 1994. In marine environments, the feed coefficient has decreased from 2.3 to less than 1.3. At the same time, the nitrogen content in the feed has decreased from 7.8% to 6.8% and the phosphorus content from 1.7% to less than 1%. This means that the discharge of phosphorus per tonne produced fish has decreased from 31kg to less than 9.5kg and the nitrogen discharge from 129kg to 53kg from 1974 to 1994. Current practice shows that it is possible to reduce the discharge of nutrients even more e.g. the largest cage farm operations in Sweden discharge only 6.4kg phosphorus and 55kg nitrogen per tonne produced fish

3.5.8. Reduction of discharged material to the environment

Various technical devices have been designed to collect feed wastes, nutrients, organic material and dead fish. The ability to collect and treat wastes are greater from land-based rearing units (such as ponds and tanks) than from open cage systems. Simple treatment units are settling ponds, swirl tanks or specially designed tanks for collecting waste and wastewater. Other methods include various kinds of sieves and filters. The constraints with the aforementioned treatment units are that the polluted water is diluted from aquaculture farms and that there is a high flow rate. In addition, dissolved substances are much more difficult to collect than particulate matter.

Recirculation technology allows a more complete control of the aquaculture operation with regard to the discharge of waste and water. This method is aimed at land-based systems and is used mainly in hatcheries and for raising "expensive" fish in the grow-out phase. It is especially used in temperate climates to rear warm water species such as eel (*Anguilla anguilla*), African catfish (*Clarias gariepinus*) and sturgeon (*Acipenser sp.*) which require a temperature above 20°C throughout the year for optimal growth rate.

Simple recirculating systems consist of fish tank units and treatment units like gravel, trickling or other biofilters. The system is linked to a tank for suspended solid removal. More comprehensive systems have attached denitrification units as well as a special UV unit for the disinfection of bacteria. An ozonation unit can also be applied to break down organic molecules which then can be attacked by the bacteria in the biofilters. The system is rather complicated and expensive to build. The advantage with this technology is that you save water (it is recycled many times) and energy (tanks are isolated or/and the unit is indoor) and it is easy to control the waste. The system may also prevent the spread of disease from outside sources or between separate units of the system.

3.5.9. Improvement of feeding technology

Optimal feeding can be achieved by studying fish behaviour, obtaining information on the environmental conditions (such as temperature) and the size of the fish and improving the quality of the feed. Several computer programmes have been designed to optimise the amount of feed given to the fish during various parts of the day and under various lighting conditions.

The type of feed as well as the way it is fabricated is thus of utmost importance to reduce waste from aquaculture farms.

The composition of the feed is a factor of great importance. Altering the composition of the constituents in the feed such as fat, protein, carbohydrate and energy has contributed very much to reduce the output of wastes. Fat content in feed produced for salmonids has increased from 8% to 30%, protein has decreased from 58% to 40% and carbohydrate from 24 to 13%, and finally the energy content of the feed has increased from 14.8 to 19.2 MJ/kg during the period 1975-1989 (Johnsen and Wandsvik 1991; Talbot and Hole 1994).

This means that the nitrogen content in the feed has decreased from 7.8% to 7.1% (Ackefors and Enell 1994) and that the fish can utilise the fat for energy requirements instead of using protein for this purpose, hence less nitrogen components are excreted. Johnsen and Wandsvik (1991) showed that when fat levels in the feed increased from 22% to 30%, the ammonia concentration in effluent water from a land-based salmon farm in Norway decreased by 38%. With the low fat level the effluent water contained 0.234 mg N/l and with the higher fat level only 0.146 mg N/l.

At the same time the phosphorus content in the feed has decreased from 1.7% to 1.0% which means less excretion of phosphorus components (Ackefors and Enell 1994). Dietary phosphorus requirements for optimum growth of rainbow trout and Atlantic salmon range from 0.5 to 0.8% in the feed. The phosphorus content of whole fish is approximately 0.4 to 0.5% of fresh weight (Lall 1991). The bio-availability of dietary phosphorus is influenced by several factors including chemical form, digestibility of the diet, particle size, interaction with other nutrients, feed processing and water chemistry.

3.5.10. Reduction in the use of medication and chemicals

Diseases are easily spread in water and cultured fish in cages can therefore be contagious to wild fish if disease becomes prevalent in the dense school of fish inside the cage. In addition, stressed fish and a less nutritious feed might also contribute to increased sensitivity to disease.

However, disease can also be a problem in well maintained operations. The eradication of disease is necessary in order to cure the fish and limit the losses for the farmers. In the 1970s and 1980s numerous antibiotics were used. Due to current knowledge and developments, it is possible to vaccinate as a preventive measure and the use of antibiotics is currently very limited in aquaculture. In addition to vaccination, the knowledge of probiotic feed is increasing. Micro-organisms are included in the feed, or a mixture of micro-organisms are put in the water because microflora in the gut plays an important role with respect to the well being and health of fish (Trust and Sparrow 1974; Ali 2000).

3.5.11. Improvement of food safety and product quality

Aquaculture producers operate on an open market with customers and their requests. The farmers must therefore produce fish and shellfish of the highest quality - a fresh and nutritious product with the characteristic composition of protein, lipids and carbohydrate as comparable to wild fish of high quality. The product must have a good taste and not contain pollutants, bacteria or viruses that may be harmful to the consumers.

Rules and procedures for chemicals used in the production of animals must be followed. Withdrawal time after use of antibiotics should be followed according to the Directives from the Food and Hygiene Authorities. The slaughter technique should be in accordance with experienced technology. Hygienic and other rules for the processing and distribution of products must be followed.

4. CONCLUSIONS

Codes of practice must be designed around the interests of the farm animals themselves as well as the interests of the local people and consumers. The interests of farm animals must take into account their life histories, physiology and behaviour, together with the proposed culture technology and pre- and post-harvest handling. In certain areas, general rules can be followed by all farmers but the industry is very complex when considering the large diversity of species and for these reasons special rules (almost an individual CBP) must be created for various parts of the aquaculture industry.

REFERENCES

Ackefors H. and Enell M., 1990: Discharge of nutrients from Swedish fish farming to adjacent sea areas. Ambio 19(1), 28-35

Ackefors H. and Enell M., 1994: The release of nutrients and organic matter from aquaculture systems in Nordic countries. J. Appl. Ichthyol. 10(4), 225-241.

Ali A., 2000: Probiotic in fish farming: evaluation of a bacterial mixture. Umea, Sweden: Vattenbruksintituionen, Rapport 19, 63pp.

Black E. A., Little J. M., Brackett J., Jones T. and Iwama G. K., 1991: Co-culture of fish and shellfish, the implications for antibiotic contamination of shellfish. Copenhagen, Denmark: ICES CM, Mariculture Committee, 1991/F: 23, 1-21

EIFAC, 1994: Effects of cormorant predation on fish populations of inland waters. Tromso, Norway: EIFAC / XVIII/94/ Inf. 8 Rev.

FAO, 1997: Aquaculture development. Rome, Italy: FAO Technical Guidelines For Responsible Fisheries 5. 40pp.

GESAMP, 1996: Monitoring the ecological effects of coastal aquaculture wastes. scientific aspects of marine environmental protection. Rome, Italy: Reports and Studies GESAMP No. 57, 38pp.

Ibrekk H. O., Kryvi H., Elvestad S., 1991: Nationwide assessment of the suitability of the Norwegian coastal zone and rivers for aquaculture. In: N. De Pauw, J. Joyce, (eds), Aquaculture and the Environment. Gent, Belgium: European Aquaculture Society Spec. Publ. 16, 413-439.

Johnsen F. and Wandsvik A., 1991: The impact of high energy diets for Atlantic salmon. Effects on pollution. In: C. B. Cowey, C. Y. Cho, (eds), Nutritional Strategies and Aquaculture Waste, Ontario, Canada: University of Guelph, 51-63.

Lall S. P., 1991: Digestibility, metabolism and excretion of dietary phosphorus in fish. In: C. B. Cowey, C. Y. Cho, (eds), Nutritional Strategies and Aquaculture Waste. Ontario, Canada: University of Guelph, 3-19.

Pedersen T. N., Aure J., Bertelhelsen B., Elvestad S., Ervik A. S., Kryvi H., 1988: LENKA - A nation-wide analysis of the suitability of the Norwegian coast and watercourse for aquaculture. A coastal zone management program. Copenhagen, Denmark: ICES. C.M. 1988/F11, 17pp.

Rosenberg R., Lindahl O., Blanck H., 1988: Silent spring in the sea. Ambio 17(4), 289-290.

Talbot C. and Hole R., 1994: Fish diets and the control of eutrophication resulting from aquaculture. J. Appl. Icthyol. 10(4), 258-270.

Trust T. J. and Sparrow R. A. H., 1974: The bacterial flora in the alimentary tract of freshwater salmonid fishes. Canadian Journal of Microbiology 20, 1219-1228.

The Role of Codes of Conduct in Aquaculture

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1. INTRODUCTION

1.1. The FAO Code of Conduct for Responsible Fisheries

In the late 1980s, the over-exploitation of wild fisheries resources, considered to "have become a market-driven, dynamically developing sector" (FAO, 1995), led to the recognition that sustainable fisheries were not possible without new approaches to fisheries management.

Such considerations formed the focus of the 1992 Cancun Conference on Responsible Fishing, where the Member Countries of the Food and Agriculture Organisation of the United Nations (FAO) asked the FAO to draft a Code of Conduct for responsible fishing. The process involved lengthy consultation, discussion and negotiation between a wide range of representatives and organisations to address the concerns raised. Many non-government actors were involved in the preparatory process[1]. The FAO Conference adopted a Code of Conduct for Responsible Fisheries (CCRF) in 1995. At a later stage, parts of the text were expanded in order to provide general advice in support of Article 9 (Aquaculture development (by the Fisheries and Legal Departments of the FAO (FAO, 1997)).

This Code of Conduct sets out principles of action and standards of behaviour that are seen to enable and assure sustainable exploitation of the resources while respecting conservation, management and development objectives.

One of the key intentions of the CCRF was to establish basic principles for responsible fishing. It also provided an instrument of reference that would allow States to adopt the principles of the Code in their own legislative structures, policies and plans.

While primarily addressing the State, the CCRF also addressed those who are involved in or concerned by aquaculture. It also recognised that the provision of an "enabling environment" for sustainable aquaculture development could be a vital potential function for such a Code (Barg et al., 1999). Recognition of the value that can be obtained through acknowledged "good" or "best" practice brings the role of such instruments to the fore.

Key headings within the CCRF, which are directed at aquaculture, include the promotion of:

1. The responsible development of aquaculture, including culture-based fisheries, in areas under national jurisdiction
2. The responsible development of aquaculture, including culture-based fisheries, within trans-boundary aquatic ecosystems
3. The use of aquatic genetic resources for the purposes of aquaculture, including culture based fisheries
4. Responsible aquaculture at the production level.

1. Details on the origin and elaboration of the Code of Conduct for Responsible Fisheries are given in the Preface of the CCRF.

Additional articles that also relate to aquaculture include attention given to post-harvest practices, trade and monitoring[2]. 'Responsibility' is invoked through the application of control and regulatory actions while inter-State cooperation, as well as the active participation of the production sector, is promoted by means of the establishment of responsible management practices.

1.2. Development trends in aquaculture

During the last 20-30 years, aquaculture has evolved as an alternative to the exploitation of wild stocks through capture fisheries and, at the global level, represents one of the fastest-growing food production systems. Between 1984 and 1998, an overall annual growth rate of 11.4% was achieved for the cultivation of fish, shellfish and crustaceans. This compares to 3% for terrestrial farm animal meat production and 1.5% for landings from capture fisheries over the same period[3]. From 1990-1998, the technical success of modern fish farming contributed to an average annual growth rate of 12.3% at a global level[4].

In European countries (including both EU and non-EU States), the annual rate of growth of fish farming, from 1994 to 2000, has been 11.5%[5]. Annual production now exceeds 1 million tons. In real terms, the ex-farm value of European fish farming is currently estimated as exceeding MEuros 3,500. At the same time, the average value per kg. of fish produced by European fish farming fell from 3.21 Euros in 1994 to 3.11 Euros in 2000. It is clear that aquaculture is even more of "a market-driven, dynamically developing sector" than fisheries.

1.3. Food safety

Much increased attention, particularly in the developed countries of the world, has been given to assuring food safety for the consumer. Legislative and institutional aims have traditionally been to provide food that is hygienic and free of pathogens and contaminant substances that could cause ill health.

The extreme concern given to the incidence of BSE (Bovine Spongiform Encephalitis, popularly known as 'Mad Cow disease') and the occurrence of dioxin and PCB contamination have contributed to wide public awareness of this topic, accompanied by appropriate legislative actions[6]. However, both of these issues have an additional dimension, an increased public consciousness of the procedures used in farming. In these examples, the very nature of the components of the feeds has been highlighted, raising doubts as to the viability of the materials used and to the integrity of livestock feed manufacture. Additional complex issues have entered the debate; for example, the potential use of genetically modified feed materials and fish is being discussed and questioned by many different interests.

Such basic but multi-faceted issues led the European Commission to prepare a comprehensive White Paper on Food Safety[7] and the creation of a European Food Safety Authority[8]. The goal of the actions foreseen in the White Paper is to transform the Food Policy of the European Union into an instrument that will ensure a high level of human health and consumer protection. The Authority is to be the centre for scientific excellence in matters of food safety, providing clear scientific advice as well as information to consumers.

1.4. Environmental Impact

Environmental respect has become a core element of global legislation, resulting from the recognition that human enterprise and society can cause unacceptable damage to the environment.

2. See CCRF: Introductory Articles (1-5) and Article 6 (General Principles)
3. Tacon A. and Barg U. in press - Source FAO data.
4. FishStat (April 2000) - FAO Fisheries and Aquaculture Database
5. Based on data communicated to FEAP by European National Aquaculture Associations
6. Directive 2002/2/EC of the European Parliament and the Council (28/01/2002) and Council Directive 2001/102/EC (27/11/2001)

The considerations concerning the environmental impact of aquaculture are numerous, wide-ranging and well documented. The EU proposal for a Water Framework Directive[9] provides a comprehensive review of the anticipated requirements for water use in the future in Europe. However, the 243 amendments tabled[10] for this proposal and the difficulties of the Second World Water Forum[11] to establish a cohesive Declaration have also highlighted the wide-ranging concerns as to how far imposed 'command and control' legislation can actually go. The European Directive[12] establishing a framework for Community action in the field of water policy was finally decided in October 2000.

In Europe, a wide-ranging battery of actions has been developed to improve and assure environmental protection. These include the 'Natura 2000', the Habitats Directive, a range of Biodiversity Action Plans and Integrated Coastal Zone Management planning as part of a non-exhaustive list.

1.5. Perception of Food Production

Society's increasing awareness of these considerations has given rise to the wide expectation that the food production sectors should behave and act responsibly. The call for responsible actions and attitudes is the basic tenet of the CCRF, in both aquaculture and capture fisheries. Attaining this means that effective procedures for management and development have to be ensured, assuring production requirements while supplying food that is nutritious and safe, and minimising environmental impact.

In the European Union, additional factors affect the public perception of the acceptability of livestock farming and the marketing of the products. For instance, egg production from 'battery' hens is to be banned from 2012 and the transport conditions for moving live animals have also undergone strict review.

In the atmosphere created by the combination of these issues and the publicised justifications for legislation, it is not surprising that public perception and appreciation of the food production sector have been affected negatively. Calls for tighter control procedures and appropriate new legislation have abounded even though it remains unclear whether State or European control measures can be effective.

To pinpoint one example, an examination of the control procedures for individual farms during the dioxin crisis in Belgium in 1999 indicated that each farm could anticipate, on average, a visit from an inspector every ten years. Furthermore, the proposed European Food Authority will seek to provide a reference point but will not be an inspectorate. This does not reflect a lack of will in the public sector to control but underlines the problems of realising effective public sector control.

2. SELF-REGULATION

2.1. The need for effective self-regulation

Self-regulation is seen as providing one answer to the complex situation encountered by both the modern livestock farmer and the legislative bodies. Appropriate tools and guidelines need to be developed and adopted by the farming sector if public credibility is to be improved. Indeed, it seems increasingly necessary that livestock farming and food production have to be 'acceptable' at all stages of the 'farm to fork' process, if such progress is to be achieved.

7. White Paper on Food Safety: COM (1999) 719 final (12/1/2000)
8. Regulation (EC) No 178/2002 of the European Parliament and of the Council (28/01/2002)
9. A Framework for Community action in the field of water policy (COM (97) 49 final)
10. Amended proposal for a EUROPEAN PARLIAMENT AND COUNCIL DIRECTIVE establishing a framework for Community action in the field of water policy COM(1999) 271 final (17.06.1999)
11. The Second World Water Forum was held in the Hague (Netherlands) in March 2000
12. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000

2.2. The role of the Federation of European Aquaculture Producers (FEAP)

The Federation of European Aquaculture Producers (FEAP), an international body composed of the National Aquaculture Associations responsible for fish farming in Europe, believes firmly in the need for strong self-regulation. Judging that there was a clear requirement for a peer document that treated aquaculture alone, and that this should be endorsed fully by the profession, the FEAP Assembly appointed a Working Group, consisting of professional people of different nationalities and of different backgrounds in aquaculture, to draft a Code of Conduct for European aquaculture, concentrating on the issues raised by and affecting European fish farming and examining the acceptability of the sector.

'Acceptable' is the key word. For instance, it is generally observed that 'acceptable' levels of contaminants in products decrease as analytical procedures increase in sensitivity. What is 'acceptable' in one culture is not acceptable in another. Who should decide what is 'acceptable'? Should it be the legislator, the scientist, the NGO, the producer or the public?

Inevitably, decisions concerning 'acceptability are often the result of a balancing act between, for example, the fact that any human activity has an impact on the environment and that any industry has to be profitable to survive. The type of discussion that takes place and the lack of trust that has developed between the production sector and the green or consumer organisations must change in the future. Broader and more realistic perspectives have to be agreed.

2.3. Need for a Code of Conduct

The FEAP standpoint is that "aquaculture should give the best, most healthy and nutritious product possible, with the lowest impact on the environment possible, using procedures that are economically viable."

Agreement and adherence to such a statement by all sides would save a good deal of work, time and money. Setting such broad goals forms one of the elements of a Code of Conduct, serving to increase the understanding and trust that should exist between aquaculture and the public.

One major reason for embarking on such a process arose from the fact that many fish farmers were genuinely astonished at the criticisms made of their activities. Most farmers are very proud of what they do as well as the way in which they carry it out. Consequently, they have found it very difficult to accept both the general and certain specific accusations levelled at their activities. Increasingly voluble accusations, and attention brought by the press and pressure groups, have also focused the attention of the producers on how best to respond to such criticisms.

The FEAP took the position that a Code of Conduct, agreed at the European level, should be the first step in providing a coherent position for the production sector.

2.4. Aims of a Code of Conduct

The prime goal for the development of a Code of Conduct was identified as being the establishment of a common base for sectoral responsibility within society, by moving towards effective self-regulation. The Code also had to demonstrate clearly the attitudes of the producers towards the fish they rear, towards the environment and the consumer. As a result, the first points that had to be established concerned what should be contained within a Code of Conduct, and how such a Code could be made to work. It was also necessary to identify its position within the hierarchy of influence.

2.5. A Code of Conduct - definition and status

2.5.1. Definition of Code of Conduct

The preferred definition of a Code of Conduct is the following: "A voluntary and non-binding document (also called soft law), drawn up in response to self-regulated sectoral development".

This definition raises an important question: if there are no legally binding obligations and adherence to the Code is not mandatory, why should anyone abide by the Code?

One answer is simply that adherence to the Code will promote the improvement of sectoral performance. However, this position is insufficient on its own. There has also to be a clear understanding of the expected outcomes and consequences of developing and applying a Code. Although this may seem to be merely a conceptual exercise, it can perhaps be best demonstrated by defining the hierarchy within which a Code of Conduct is placed.

2.5.2. Legal status of Codes of Conduct

At the top level of the hierarchy is the Law, be it International, National, Regional or Local. Adherence to law and to legally binding instruments is mandatory, determined by the political process, and enforced by society, so that non-adherence will normally result in the imposition of sanctions or other penalties.

A Code of Conduct does not reside at the top of the legal hierarchical structure as thus described but acquires its validity and authority in a different way and by means of a different process, in the way that 'precedent and customary' law operates, where a peer group *condones* a series of actions held to be in society's interests. Such Codes should reinforce the implementation of principles and standards that are considered to be of good quality. A Code of Conduct should, generally speaking, be able to cross frontiers and not bow to local or national considerations.

All Codes of Conduct should involve the processes of consultation, negotiation and agreement within a group of stakeholders who are either directly involved or affected by the subject. Of equal importance is their role in the publication and implementation of Codes.

The following list is a guideline to the categories of stakeholders who are of importance to aquaculture.

1. Governmental authorities/officials, policy-makers, planners and regulators
2. Producers, farm operators/workers; "aquaculture experts"
3. Manufacturers and suppliers of inputs for aquaculture
4. Processors and traders of aquaculture products
5. Consumers
6. Banks and other financial institutions, investors, insurance companies
7. Special interest and advocacy groups (professional associations, NGOs and others)
8. Researchers, social and natural scientists
9. International organisations (regional, global)
10. The mass media

2.5.3. Codes of Practice - definition and status

A Code of Practice should define the principles of Good or Best Practice and be, by extrapolation, more detailed than a Code of Conduct; in other words, Conduct is how you should behave, Practice is what you do. A Code of Practice should both explain and interpret standards that can be adopted within a sector or a specific activity. As with a Code of Conduct, a Code of Practice should be developed by a peer group. However, it should be directed more towards technical issues where the inclusion of technical expertise becomes essential. Though adherence is also voluntary, Codes of Practice are often used by industry for the promotion of operational and technical standards.

In effect, Codes of Conduct tend to be sectoral while Codes of Practice focus on more specific and technical issues within the sector. Consequently, while a Code of Conduct can treat the subject of aquaculture, a Code of Practice would address, for example, how to raise trout.

2.5.4. Guidelines

Underpinning the Code of Practice, are Guidelines, of a general or technical nature. Guidelines have, by definition, an advisory status and are voluntary. General Guidelines resemble Codes of Conduct, in that they tend to refer to what should be done, and provide positive, constructive recommendations which serve to give directions and perspectives on major issues. General Guidelines may often be developed through a public forum.

Technical Guidelines provide instructions as to what activities are necessary and how they should be carried out and, with respect to aquaculture, should be specific to an activity, a site or a species. By definition, technical expertise for development and peer review for acceptance is essential for such technical documents. Those guidelines which provide the greatest detail often become instruction manuals, developed and written by technical experts and tested by practitioners, that is to say, the producers.

The active involvement of those who actually implement the technology and who are responsible for the business activity is important in the preparation of all of these items discussed.

To summarise: there are significant differences, in perception and preparation, in content and in technical detail, between Codes of Conduct and Codes of Practice and between Codes of Practice and Guidelines or Instruction manuals.

2.5.5. Quality and certification schemes

Quality and Certification Schemes must also be mentioned in this context. These schemes guarantee the provision of a product that has been made and prepared to defined and measurable standards. This specificity regarding the product differentiates such protocols from those used in Codes and Guidelines. To be a member of such a Scheme, adherence to defined standards is mandatory and controlled (by the Scheme itself as well as State); penalties, generally imposed by the Quality Scheme organisation, can be severe if the standards defined are not respected.

Furthermore, certification and labelling are becoming increasingly important, particularly with the development of 'organic' and 'bio' products. The certification and control of genuine schemes is a clear requirement for approval (e.g. by Government or Government-approved authorities).

Alongside the issue of improving sectoral performance, for example through adherence to a Code of Practice or actually reading the instruction manual, is that of the acceptability of the activity by society. This is perhaps the most important area of influence for well-developed Codes.

2.6. Trade and Harmonisation

As international trade has increased, so have the number and scope of international agreements that address harmonisation. Defining internationally accepted standards is difficult but extremely important and the FAO/WHO[13] Codex Alimentarius is the accepted basis for food safety. The integration of standards within the criteria for trade has thus become an accepted concept, as demonstrated by the "Agreement on the Application of Sanitary and Phytosanitary Measures"[14].

Within the EU, however, the legislation that affects the aquaculture sector directly or indirectly has increased significantly in the last decade. While there is no specific Framework legislation for aquaculture in the EU, the legal governance of aquaculture is primarily covered by the laws concerning food safety, the environment, agriculture and fisheries (notably for markets).

In many countries, the role of government is changing and devolution and the increased delegation of responsibilities are taking place. As these changes take place, one result has been that the scope of self-regulation by the private sector has increased. Within the food supply sector, the first comparable system to be adopted was the preventive mechanism of HACCP (Hazard Analysis and Critical Control Point), which is now mandatory within the European Union[15].

3. DEVELOPMENT OF THE FEAP CODE OF CONDUCT

3.1. Background

The development of Codes of Conduct or of Practice should allow the establishment of desirable, acceptable and predictable actions and behaviour by decision-makers and stakeholders within a sector. This statement applies to both to the public and private sector. Codes can be seen as the first step towards the introduction of formal instruments and demonstrate the voluntary will of a sector to self-regulate. Evidently, a good industry-led Code will also supply Government with a Framework that is already acceptable to the industry, thereby reducing the need to develop regulatory interventions for control.

Furthermore, it is increasingly necessary to assure consumers, as well as importers, wholesalers and retailers, that a sector or an activity is not harmful to the environment and respects operating procedures of the highest possible standard.

The response of the FEAP was to act positively and develop a Code of Conduct for European Aquaculture, based initially on the considerations of the production sector. Although its development was seen by the FEAP as being an extension of the CCRF, it also incorporated related factors from different sources, including the Holmenkollen Guidelines for Sustainable Industrial Fish Farming and for Sustainable Aquaculture[16] and documents prepared under the auspices of ICES[17], EIFAC[18] and the Farm Animal Welfare Council (UK)[19].

3.2. Goals of the FEAP Code of Conduct

The primary goals of the FEAP's Code of Conduct are to promote:

- the responsible development and
- the responsible management of

a viable European aquaculture sector, and to assure a high standard of quality food production for the consumer where the prime goal is the promotion of correct sectoral development that is largely self-regulated.

13. World Health Organisation
14. General Agreement on Tariffs and Trade (GATT) 1994
15. Council Directive 91/493/EEC

3.3. Emphasis on Self-regulation

The FEAP Code was thus conceived with the notion that the aquaculture production sector is itself responsible for assuring the sustainability of production, while acknowledging its dependence on inputs that it cannot control directly.

Additional responsibilities of the producers include:

- interactions of aquaculture with the environment
- the welfare of the livestock
- the product that is supplied to the consumer
- the people that work in the sector

These points can be summarised as being the production of the healthiest possible product, having the lowest possible impact on the environment, in an economically viable way.

A most important comment made concerning this issue was that the producers themselves should have a clear view as to what constitutes good conduct and that in addition they should be able to communicate this view to interested parties or individuals outside the production sector.

3.4. Structure of the FEAP Code of Conduct[20]

3.4.1. General overview

The Code of Conduct was divided into five main sections, covering the following topics:

- GUIDING PRINCIPLES (Section A)
- FISH HUSBANDRY (Section B)
- ENVIRONMENT (Section C)
- SOCIAL AND ECONOMIC RELATIONSHIPS (Section D)
- CONSUMERS (Section E)

The Code of Conduct tried to position the activity of aquaculture within society, covering the diverse responsibilities of the producer when practising his profession.

A major difficulty within such a diverse activity, dispersed in terms of the species, the geographic location and scale of the individual enterprises, is to accommodate the detail anticipated by third parties. The hierarchy of the different Codes and Guidelines discussed explains how such detail can be developed and integrated.

Consequently, if one compares the CCRF with the FEAP Code, the latter is more detailed in respect of aquaculture. However, the FEAP Code is considerably less detailed than a specific Code of Practice, such as that of the British Trout Association for trout farmers[21]. The FEAP Code thus addresses the responsibilities attributable to the producer while providing general recommendations on conduct, planning and interactions with other activities.

16. The Holmenkollen Guidelines for Sustainable Industrial Fish Farming (Oslo - 1994) and The Holmenkollen Guidelines for Sustainable Aquaculture (Oslo - 1997)
17. The ICES Code of Practice on the Introductions and Transfers of Marine Organisms. International Council for the Exploration of the Seas (Copenhagen 1994)
18. Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms. European Inland Fisheries Advisory Commission (FAO -1988).
19. The Report on the Welfare of Farmed Fish (Farm Animal Welfare Council (U.K.) - 1996)

3.4.2. Fish husbandry (Section b)

As a livestock farmer, good husbandry is the basis of the activity and the subjects addressed include:

1. Use of water
2. Fish stocks (including considerations for employing genetically-modified organisms)
3. Fish health
4. Food and feeding
5. Handling and transport of live fishpredators
7. Stocking density
8. Slaughter
9. Monitoring and record-keeping

While the details contained within this section may seem obvious to many experienced farmers and technicians, it is important to understand that such matters are not necessarily obvious to the public, the consumer or the legislator.

3.4.3. Environmental issues

The main topics and themes addressed are

1. Water Use and Quality
    a. Abstraction and Discharge
2. Site Selection
3. Site Management
4. Escapes
5. Therapeutic actions

As for the Husbandry section, most of the points raised may appear to be evident yet require to be stated publicly and be reinforced by approval.

3.4.4. Social and economic relationships

It is rare that legislation deals with such matters and one of FEAP's goals was to clarify the anticipated role of aquaculture in society and the contributions that can be made. In consequence, the main points raised are

1. To increase awareness of the social contribution required of aquaculture activities.
2. To encourage employee safety and a stable workplace.
3. Provide training that is appropriate to responsibilities.
4. To improve inter- and intra-sectoral communication for improved stability.

This section targets stability and development, including better knowledge of what aquaculture does and what it should be doing, referring to its anticipated contribution to society, including the workforce.

20. Multilingual versions of the FEAP Code of Conduct can be found on www.aquamedia.org
21. Code of Practice for the production of Rainbow Trout. British Trout Association (1995)

3.4.5. The consumer

This section describes the responsibility of the producer towards the consumer. There may be several intermediaries involved in purchase processing and distribution and responsibilities in this area are shared. Nonetheless, the responsibility of the aquaculture producer is defined as providing:

1. A protein source of high dietetic quality
2. Products that should be nutritious
3. Continuous availability
4. Guaranteed freshness of products
5. Products with a good taste

It is firmly believed by the FEAP that the successful attainment of viable aquaculture requires balanced and sustainable development, while assuring transparency for the consumer and the legislator.

4. IMPLEMENTATION OF THE FEAP CODE OF CONDUCT

The measurement of the success of any voluntary measure, such as a Code of Conduct, is difficult since, as stated earlier, Codes are non-binding. Nevertheless, they can provide a comprehensive basis for understanding and allocating responsibilities. Acceptance of a Code by the operators and by third parties is therefore paramount.

However, success and effectiveness can be measured if the operators are committed to the original objectives and the application of the contents. Quantification of success will also include the realisation of more detailed measures within the profession and the recognition, by third parties, of its capacity for effective self-regulation. Measurable success will be enhanced if the Code is developed further and accompanied by additional proactive actions taken within the sector.

These actions would include, as examples, the further development of Codes of Practice (e.g. by Associations), statements of Best Management Practices (e.g. by Producer Groups and Cooperatives), and recognised Quality Schemes (e.g. Scottish Quality Salmon) and approved labelling and certification Schemes (e.g. 'bio' and 'organic').

The detail and the responsibilities of each measure need to be appreciated by the producer, the legislator and the public. This requires efforts of promotion and publication both inside and outside professional aquaculture.

The importance has been recognised, within related sectors, of reassuring consumers, intermediaries and other stakeholders, about the procedures, environmental interactions, the respect for labour and other public matters. Achieving this is known to have the potential for enlarging demand in national and international market (FAO, 1997, FAO, 1999). On the other hand, not achieving this can be potentially disastrous where voluntary disaffection of the consumer can lead to market collapse.

The public increasingly cares about what it buys, where it is produced and under what circumstances. The aquaculture sector has to realise, understand and respond to this interest - a Code can only be part of the overall response but is definitely a cornerstone for building the future.

In taking the step to establish this Code of Conduct, the FEAP also recognised that this had to be a continuous process, stating within the published document that the statements were not definitive. At its General Meeting in 2002, the Assembly reconstituted the Working Group to assess and revise, where appropriate, the original document and it is hoped that this will be completed in 2003.

The Code of Conduct was adopted at the Annual General Assembly of the FEAP held in June 2000 in Izmir (Turkey), where the 28 National Aquaculture Associations comprising the Federation met. Following adoption, the Code has been translated and circulated to the aquaculture profession. Indeed, the ultimate goal for the FEAP is that each fish farmer will have a copy of the Code in his office and that he will be proud to indicate his adherence to it.

It is important that actions and measures such as this be taken further, with appropriate inputs from interests outside the production sector, while targeting realistic goals. The FEAP does not see this Code as being the final document on the matter; it is part of an evolutionary process. What is acceptable today may not be acceptable tomorrow.

The profession can show, through the adoption of this Code of Conduct, that it is ready to participate actively in the balanced and sustainable development of aquaculture and to assure its transparent development, to the benefit of the consumer and of society.

REFERENCES

Barg U., Subasinghe R., Willmann R., Rana K. and Martinez M., 1999. In: Green B.W., Clifford H.C., McNamara M. and Montano G.M., (Eds.) V Central American Symposium on Aquaculture 18-20 August 1999, San Pedro Sula, Honduras. Asociacion Nacional de Acuicultores de Honduras (ANDAH), Latin American Chapter of the World Aquaculture Society (WAS), and Pond Dynamics/Aquaculture Collaborative Research Support Program (CRSP), Choluteca, Honduras. pp: 64-81.

FAO, 1995. Code of conduct for responsible fisheries. Rome, Italy: 41pp.

FAO, 1997. Aquaculture development. Rome, Italy: FAO Technical Guidelines For Responsible Fisheries 5. 40pp.

FAO, 1997. Technical Consultation on Policies for Sustainable Shrimp Culture. Bangkok, Thailand, 8-11 December 1997.

FAO, 1999. Fisheries Report No. 572. (Supplement): 266 pp.

AQUACHALLENGE WORKSHOP PROGRAMME

BEIJING 27-30 APRIL 2002

DAY 1 Saturday, 27th April 2002

Welcome A. Eleftheriou (Project Coordinator, IMBC, Greece)

Welcome EU Representative (J. Sanders, EU, China office)

Welcome Greek Government Representative (A. Spilioti, GSRT)

Welcome Chinese Government/Aquaculture Officer

DAY 2 Sunday, 28th April 2002

The Bangkok Declaration 2000 - Aquaculture R & D Priorities in the New Millennium:
Prof. P. Sorgeloos, (Ghent University, Belgium)

Thematic Area I Towards More Environmentally Responsible Grow-out Systems in Aquaculture

Introductory presentation: Prof. J. H.Primavera, (SEAFDEC Aquaculture Dept., Philippines)

Ye Jinyun, (Zhejiang Province Freshwater Institute, China)

R. Platon, (SEAFDEC, Philippines)

M. New, (President Elect, EAS)

Y. Harache, (IFREMER, France)

J. Verreth, (Wageningen University, The Netherlands)

T.T. Nghia, (Can Tho University, Vietnam)

Thematic area II The need for integrated management including the aspects of ecosystem health and biodiversity considerations

Introductory presentation: Prof. H. Rosenthal, (Institut fur Meereskunde, University of Kiel, Germany)

A. Boghen, (Advisory Service, University of Kiel)

Tang Qisheng (Yellow Sea Fisheries, China)

M. Shariff, (University of Putra, Malaysia)

Dong Shuanglin, (Oceanography University, China)

DAY 3 Monday, 29th April 2002

Extra presentation by Prof. H. Fushimi, Fukuyama University, Japan.

Thematic area III Biotechnology and Genetics in Aquaculture: Status, Promises and Issues.

Introductory presentation: Prof. T. Lam, (National University of Singapore)

A. Magoulas, (Institute of Marine Biology of Crete, Greece)

Zhang Peijun, (Qingdao Oceanography Institute, China)

Liu Shaojun, (Hunan Normal University, China)

H. Komen, (Wageningen University, The Netherlands)

Thematic area IV Nutrition and Feeding: Knowledge acquisition and transfer of knowhow in feed production and management strategies

Introductory presentation: Dr. S. Kaushik, (Fish Nutrition Laboratory, IFREMER France)

G.I. Hemre, (Directorate of Fisheries, Norway (observer status))

P. Bueno, (Thailand)

Mai Kangsen, (Qingdao Oceanography University, China)

S. Piyateratitivorakul, (Chulongkorn University, Thailand)

S. Papoutsoglou (Agricultural University of Athens, Greece)

DAY 4 Tuesday, 30th April 2002

Thematic area V World economics, marketing and distribution

Introductory presentation: Prof. E. Roth, (University of Southern Denmark)

H. Pickering, (CEMARE, University of Portsmouth, UK)

Zhang Xiang-guo, (Shanghai Fisheries University, China)

Thematic area VI Best Environment Practice (BEP), health, monitoring and regulations, codes of conduct

Introductory presentation: Prof. H. Ackefors, (University of Stockholm, Sweden)

C. Hough (FEAP, Belgium)

Overview of each Thematic Area

Avenues available for positive action towards the goal of sustainable aquaculture

Closing session with Final Statement on emerging directives and strategies by:

C. Nauen, P. Sorgeloos, A. Eleftheriou.

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AQUACHALLENGE WORKSHOP

BEIJING 27-30 APRIL 2002

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